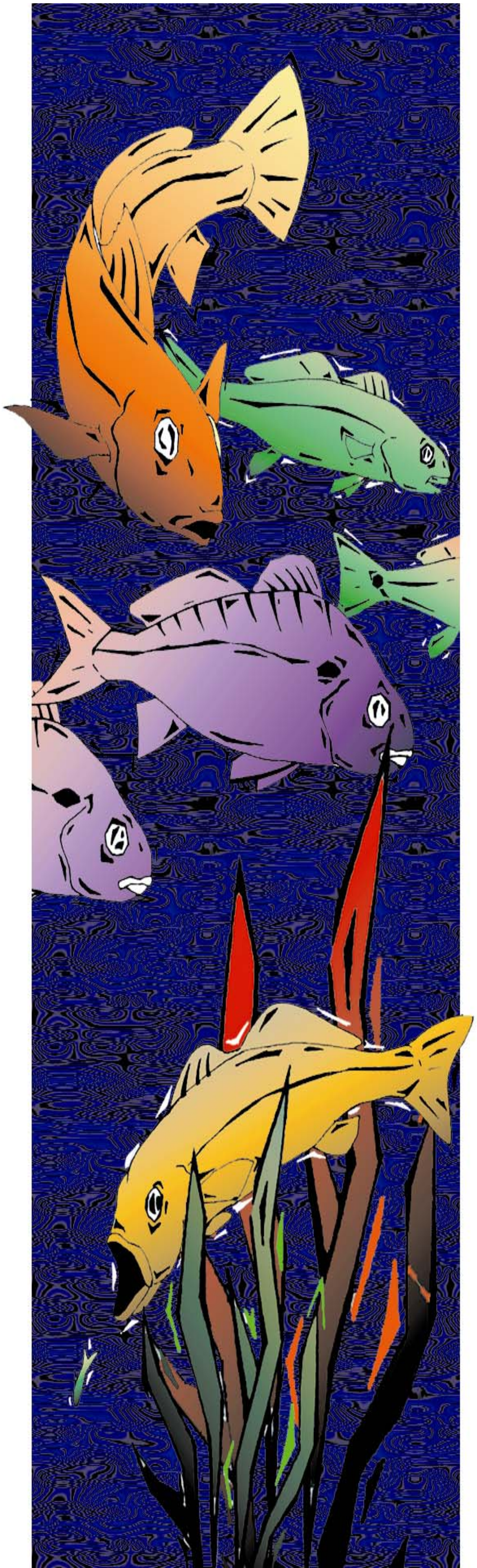

Atlantic States Marine
Fisheries Commission

Beach Nourishment:
A Review of the Biological and Physical Impacts

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by

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INTRODUCTION

Many beaches along the east coast of the United States are eroding, which threatens habitat, property, public infrastructure, and the tourist industry. Loss of sand can be attributed to natural factors such as storms, sea level changes, waves, currents, tides, wind, bathymetry, shoreline geology, sand supply and quality, and sand movement among dunes, beach, and offshore bars (Bird, 1983; NRC, 1990a). Shortages of sediment can also arise from man-made activities including construction of harbors, groins, jetties, and seawalls; shoreline development; dredging of tidal inlets; damming of rivers; and beach nourishment (London *et al*., 1981; Kana, 1988; NRC, 1990).

Of all the forces that contribute to erosion, sea level rise is one of the major global concerns that will likely affect coastlines throughout the world in the coming years. Sea level is estimated to rise approximately 20 cm by the year 2050 (IPCC, 1996), which translates to an average of 1 meter of shoreline erosion per year (Leatherman *et al.,* 2000). Some sources estimate the total U.S. shoreline subjected to erosion will be close to 80%, while others put the total at 100%, if stable or accreting shorelines are considered short-lived (Pilkey and Dixon, 1996). Some areas will experience greater impacts than others from sea-level rise, due to local geologic rise or fall of land areas relative to global sea level changes, local geological structures, and other factors.

Coastlines move in response to many of the natural forces that simultaneously act upon them in an attempt to maintain equilibrium (Williams, 2001). Shoreline erosion can lead to a loss of habitat for sea turtles, birds, fish, plants, and a host of other organisms that use the beach during some portion, or all, of their life cycle. Along barrier islands, shoreline erosion could more accurately be termed "shoreline retreat," because the beach is not actually eroding, but is moving landward in response to a rising sea level (Pilkey, 1996). This concept applies when the barrier island is able to retreat, and there is simultaneous sand accretion on the sound side of the island. In situations where the shorefront is unable to migrate landward, the term "shoreline erosion" would be accurate. In the Mid-Atlantic Region, barrier beaches migrate in a north-south direction (Dixon and Pilkey, 1991).

Erosion is also problematic when there are structures that lie in harm's way, which require protection against impending waves and sea level rise (Pilkey, 1996). Man has attempted to halt retreating shorelines for decades in an effort to save these structures. The first documented beach nourishment project took place in this country during 1922-1923 at Coney Island, New York (Farley, 1923). During the 1930's, the federal government became involved in dune construction activities along the Outer Banks of North Carolina. It was not until 1962, following the devastating Ash Wednesday storm that caused severe damage from Florida to New England, that the first congressionally-authorized beach nourishment project was undertaken by the U.S. Army Corps of Engineers ("Army Corps," or "Corps"). By 1987, over 400 miles of U.S. shoreline had undergone beach nourishment, using at least 400 million cubic yards of sand in the process (Pilkey and Dixon, 1996).

The 21st century will likely witness increased beach nourishment activity as more coastal towns and cities use this management approach. If done properly, it can effectively safeguard coastal structures, restore habitat, and provide a wider recreational area for beachgoers. Unfortunately, there are still many uncertainties concerning effects to the marine and beach environment. Some states have conducted more environmental monitoring than others have, but the effects to many taxa are yet unevaluated. Monitoring studies are often based on unreplicated field surveys, have not been peer reviewed by third parties, and are not published in scientific journals (Lindeman *et al*., 2000). The impacts to fish and their habitat are still poorly understood and cumulative effects are inadequately addressed. The Atlantic States Marine Fisheries Commission (ASMFC) has a strong interest in protecting the 22 fish species they manage against any negative impacts that may result from beach nourishment.

Since the frequency of beach nourishment projects is expected to increase in the future, it is worthwhile to review the current level of knowledge regarding impacts and to identify areas where information is lacking. This paper outlines the basic issues surrounding beach nourishment: 1) coastal erosion and possible management approaches; 2) how beach nourishment is carried out; 3) federal and state activities; 4) the environmental effects at the mine site and the target beach; 5) research needs; and 6) recommendations for improving monitoring studies. Some of the issues discussed in the mine site section may also be applicable to the target beach section (and vice versa) in instances where habitat and species are the same. To avoid repetition, the key points are usually discussed in only one section.

Various monitoring studies have been conducted over the years, with impacts ranging from essentially benign, to long-term consequences to the marine environment. The majority of east coast beach nourishment studies conducted to date, have taken place in the Southeast and there is a need to carry out more studies in the Mid-Atlantic and the Northeast region. This paper will review major studies that have concluded insignificant impacts, with a brief discussion of the findings. Those beach nourishment studies that have found the effects to be more serious, or non-beach nourishment studies and laboratory experiments whose results suggest potential impacts, may be discussed in greater detail. This will allow state's the opportunity to follow up on studies that may be pertinent to their locale.

This information will provide states with a basic understanding of what beach nourishment is, the level of each state's involvement, and how these activities are affecting the marine and beach environment. If these actions are deemed to be having possible deleterious effects on Commission-managed species and their habitat, the Habitat Program may respond by developing measures to address these problems. Finally, this paper can serve to educate the general public and provide sources that can be further examined to gain an in-depth knowledge of beach nourishment.

MANAGING SHORELINE EROSION

There is no single, agreed-upon definition for a beach. One definition refers to a beach as "… an accumulation of wave-washed, loose sediment that extends between the outermost breakers and the landward limit of wave and swash action (Leatherman, 1988)." Another definition includes "the area between the permanent vegetation line seaward to the point of the next geomorphic feature (Davis, 1994)." The boundaries of a beach can change with seasonal wave activity, sea level rise, and a reduction in sediment supply to the beach (Pilkey and Dixon, 1996). The beach is often divided into the following four zones: 1) upper beach – area between high tide and primary dune; 2) midlittoral zone – wet sand area that constantly remains moist, but not saturated, from incoming tide; 3) swash zone – area where waves rush up the face of the beach and retreat seaward (usually remains saturated); and 4) surf zone – area where the waves break, between the water line and where breakers form (Reilly, 1979; Charvat, 1987).

Coastal engineers typically rely on three types of strategies to protect structures from shoreline erosion: 1) hard stabilization; 2) non-structural alternatives, such as relocation or retreat; or 3) soft stabilization (Pilkey and Dixon, 1996). A brief description of these shoreline protection measures is presented below to illustrate some of the other options available to coastal states. Some of these techniques may be used in conjunction with beach nourishment; others, such as shoreline retreat, are sometimes offered as alternatives to beach nourishment.

Hard Stabilization

For decades, hard structures were the preferred approach in the United States and elsewhere. Often referred to as shoreline armoring, hard structures are intended to be permanent. There are a number of sites where hard structures have effectively protected property along the shoreline, but often at a cost to surrounding areas.

Examples of hard structures are seawalls (includes bulkheads and revetments), breakwaters, and groins and jetties. Seawalls are constructed parallel to the shoreline to support the base of the coastal property and to deflect incoming waves. Revetments are typically constructed of large boulders along the eroding shoreline to absorb some of the incoming wave energy. Some of the negative effects associated with seawalls and revetments include a loss of beach access, and destruction of beaches due to increased wave backwash. There is also potential danger to beachgoers.

Offshore breakwaters are constructed parallel to the shore to reduce incoming wave energy and longshore transport of sand along the beach. These structures often cause erosion to adjacent shorelines by impeding longshore transport of sediment and preventing sand from returning offshore following storms. They can create dangerous currents and debris may aggregate in the lee side of structures. Groins and jetties run perpendicular to the shorefront and are used for trapping sand at specified locations. Groins are often arranged in series, running from the beachface out to sea. Jetties are usually placed in pairs at the entrance of inlets and channels to reduce shoaling in the channels. Jetties and groins can cause sand accretion on the updrift side and sand erosion on the downdrift side. In general, hard structures reduce the regional supply of beach sediment, which further increases erosion problems. Because they are rarely dismantled, other management alternatives, such as retreat, cannot be implemented in the future. (NRC, 1995; Pilkey and Dixon, 1996)

Sand transfer plants are another means of providing sand to sediment starved beaches. Sand that accretes on the north side of northern jetties (on the East Coast) is pumped via a submerged pipe to the south side of southern jetties. This action keeps sand recycled in the longshore system and prevents it from building up in the inlets. There do not appear to be negative environmental effects associated with this technology and it may be a potential solution to sand shortages in some areas (Lindeman, 1997).

Non-Structural Alternatives

Land use controls, such as retreat programs, include the removal of structures or relocating them further landward, to avoid costly repairs from storm damage and erosion. Coastal construction setback programs limit structures within a specified distance of the shoreline. Shoreline retreat was first introduced in 1972 by the National Park Service (NPS) in response to the discovery that barrier islands moved shoreward in response to rising sea level (NRC, 1995). One of the most notable NPS projects was the relocation of the Cape Hatteras Lighthouse 1,600 feet inland in 2000.

Relocation can be effective in undeveloped and underpopulated areas, but may be impractical in highly developed waterfront locations where cost and physical constraints make relocation unrealistic (USDOC/NOAA, 2000). Such areas may be so densely developed that there is little room to move structures back from the waterfront. Setback programs may also be politically difficult to implement in these areas because of the demand to continue developing (NRC, 1995).

Soft Stabilization

Soft structural stabilization techniques include beach nourishment, beach bulldozing (beach scraping), dune creation (including sea grass planting), restoration, and reshaping. The term "beach manipulation" could be used to describe any of these activities, which are often used in conjunction with each other to combat coastal erosion. Many states have shifted from hard structure approaches to policies that favor soft structures, specifically beach nourishment and beach bulldozing. Some states have even outlawed shoreline armoring (i.e. New Jersey, North Carolina, South Carolina, Maine) (Walton and Sensabaugh, 1979; Pilkey and Wright, 1989).

BEACH NOURISHMENT

Beach nourishment can be defined as "the process of mechanically or hydraulically placing sand directly on an eroding shore to restore or form, and subsequently maintain, an adequate protective or desired recreational beach (USACE, 1984)." Oxford defines nourishment as "sustenance, food;" nourish is defined as "sustain with food, promote the development of (the soil, etc.)" (Oxford Univ. Press, 1998). The use of the term "beach nourishment" is considered by some to be a misnomer, given that nothing is actually being nourished. The addition of sand (not sustenance) on the beach does not constitute nourishment in the true sense of the definition; however, since this has become the generally agreed-upon term by academia and industry, it will be the term referred to throughout this paper.

Beach bulldozing or scraping is the process of mechanically redistributing beach sand from the littoral zone to the upper beach to increase the size of the primary dune or to provide a source of sediment for beaches that have no existing dune. Sand is usually taken from the intertidal zone and pushed landward to protect the structures along the beach; no new sediment is added to the system (Wells and McNinch, 1991). This method of shoreline protection is not actually beach nourishment, but is nonetheless, used along some stretches to add an extra measure of protection, especially during storms. Research by Peterson *et al*. (2000a) indicates that this practice provides little or no benefit to the threatened structures landward of the dunes, while having negative impacts to the resident biological community (Peterson *et al*., 2000b).

Some of the advantages associated with beach nourishment include: 1) a wider recreational beach; 2) protection to shoreline structures; 3) possible beneficial use for dredged material from nearby sources; and 4) the ability to switch to other beach management methods in the future (as long as increased coastal development does not preclude this) (NRC, 1995). Beach nourishment can also protect threatened or endangered plants in the dune area, and restore habitat for sea turtles, shore birds, and other transient or permanent beach organisms (LeBuff and Haverfield, 1990; Melvin *et al*., 1991; Spadoni, 1991).

Beach nourishment may not be cost-effective for short stretches of beachfront, or those with high erosion rates (NRC, 1995). Success rates for different replenished beaches can be highly variable and high cost overruns are not uncommon (Pilkey, 1996). Beach nourishment can also encourage further development along unstable shorelines which can further reduce future alternative management options, such as shoreline retreat (Pilkey, 2000). Some states have created specific guidelines for beach nourishment projects in accordance with statewide hazard management objectives, which has led to increased development along nourished beaches in coastal hazard areas (USDOC/NOAA, 2000). Biological impacts of beach nourishment activities will be discussed at length in this paper, but a few include diminished reproductive success, reduction in biomass of prey food items, and long-term changes to substrate composition at dredging sites (i.e. Jutte and Van Dolah, 1999; Peterson and Manning, 2001).

Another shortcoming associated with beach nourishment is the impact it may ultimately have on barrier beaches. A steeper beach profile is created when sand is stacked on the beach during the nourishment process. This condition can lead to greater wave energy on the beach and greater beachside erosion (Dolan *in* Kaufman and Pilkey, 1983). It can also preclude wave overwash, leading to further erosion on the soundside (Pilkey *et al.,* 1980). Under normal conditions, barrier islands move slowly landward with rising sea level (Pilkey *et al.,* 1998). Some scientists have predicted that efforts to keep these dynamic areas in a fixed location (i.e. beach nourishment) will ultimately result in their demise, which would have serious consequences for the fish and wildlife resources that depend on them (USFWS, 2000).

Despite its disadvantages, beach nourishment has become the preferred course of action to combat shoreline erosion in the United States, Australia, and Europe (NRC, 1995). Short-term, long-term, and cumulative environmental impacts may be the most problematic issues surrounding beach nourishment and they are discussed below to the extent that they are known. Given the fact that there remains a great deal of uncertainty surrounding some of the effects and the degree to which beach nourishment is being conducted along the East Coast, it might be advantageous for states and others to consider some of the research needs and recommendations offered at the conclusion of this paper.

Dredging and Emplacing Sand

During nourishment, most of the sand is "stacked" on the dry sand area of the beach (Houston, 1991), and to a lesser extent, in the intertidal zone. Beach nourishment projects can be augmented with dune construction and hard structures to provide a desired level of protection at the site (NRC, 1995). A beach nourishment episode can be defined as "an individual application of sand to a beach, which may be part of a larger beach nourishment project, consisting of several episodes over decades of time (Pilkey, 1999)." A beach nourishment program is a series of projects to re-nourish the beach at the same site over a period of time, often up to 50 years for federally funded projects. Repeated episodes are usually required to maintain artificial beaches and time between renourishment episodes depends on local conditions (NRC, 1995).

Sand that is placed on a nourished beach is reworked into the offshore zone by wave action until the equilibrium profile is reached. The equilibrium profile as applied to beach nourishment is defined as "a long term profile of ocean bed produced by a particular wave climate and type of coastal sediment (Zeidler, 1982)." This equilibrium profile may take several months or years to establish, depending on a number of factors, most notably wave activity. Following a major storm event, sand may appear to be lost permanently to the sea, but as long as it remains within the closure depth of profile, it is still considered part of the beach profile by project designers. The closure depth is "the base of the shoreface and represents the depth beyond which sand will generally not be lost in a seaward direction (Pilkey, 1992)." One of the functions this sand serves while in the offshore region is to help dissipate wave energy, which further protects the shore from erosion. Sand from nourished beaches has been shown to erode at a higher rate than natural beaches, which leads to increased demand for sand over the life of a beach nourishment project rather than a decrease (Trembanis *et al*., 1998). Selecting sediment that is of similar grain size to the nourished beach increases the likelihood that there will be less modification to the beach profile from wave activity. It is also desirable to select sediment that has no more than 10% silt/clay composition, which may help reduce the biological impacts to beach fauna (Walton and Purpura, 1977; Dean, 1983; NRC, 1995).

Sand for beach nourishment operations can be obtained from: 1) dry land-based sources; 2) estuaries, lagoons, or inlets on the backside of the beach; 3) sandy shoals in inlets and navigation channels; 4) nearshore ocean waters; or 5) offshore ocean waters. The latter two are the most common sources, as they are usually more cost-effective, and in the case of nearby channel dredging, can serve the dual purpose of maintaining the inlet for navigation and nourishing the beach. Finding compatible sand from upland sources may prove difficult, and estuarine sources are becoming increasingly off-limits because estuaries are ecologically important spawning and nursery areas. Mining sand beyond state waters (3 miles from shore in most states) will become more prevalent as state sources dwindle (NRC, 1995).

Beaches can also be nourished with sediment from sources outside of the United States, provided that the cost to transport it is less than domestic sources (NRC, 1995). In 1992, approximately 23,000 m^3 were brought in by barge from the Bahamas to Fisher Island, just south of Miami, Florida. Bahamian sand (known as oolitic aragonite sand) has not been used in Florida for beach nourishment purposes since then (Seeling, 2002).

Many types of dredges exist and the method used depends on a variety of conditions, such as water depth, weather, distance from shore, point of sand placement, etc. Most operations along the East Coast employ a cutter suction dredge or hopper dredge (NRC, 1995). A cutter suction dredge has a rotating cutter at the point of contact with the seabed, and a centrifugal pump, which extracts dense sands, gravel, clay, and soft rock through the intake pipe, turning the mixture into a watery slurry. The mixture is pumped over the stern of the vessel through a floating pipeline and then through an onshore pipeline to the deposition site. If the distance from vessel to beach disposal site is great, a portion of the pipeline may be submerged (USDOI/MMS, 1999).

A hopper dredge has a trailer suction pipe equipped with a draghead, which strips off layers of sediment from the seabed and suctions them through the pipe into the vessel's self-contained hopper by means of a hydraulic pump. The sediment settles in the hoppers and the excess water is discharged overboard through overflow troughs. If the hoppers are filled beyond their capacity, a turbidity plume is likely to result (USDOI/MMS 1999). When the hopper is filled to capacity, material is transported through a pipeline similar to a cutter suction configuration, or the contents are dumped near the beach through the bottom of the hull or through a split hull (where it is then pumped onto the shoreface). In the latter case, the hopper dredge is either self-propelled or is towed by tugboat to the site. Hopper dredges are better suited when weather is a factor, and cutter suction dredges are better at extracting compacted sediments (NRC, 1995). Once sand is placed on the beach, it can be spread about by moving the pipeline or by construction machinery, such as bulldozers, until the desired fill volume is achieved (USDOI/MMS, 1999).

The extracted sediment is typically placed along the beach in one of the following manners: 1) placing all of the sand as a dune behind the active beach; 2) using the nourished sand to build a wider and higher berm above the mean water level; 3) distributing the added sand over the entire beach profile; or 4) placing the sand offshore to form an artificial bar. Selecting one of these methods depends on several factors. For example, if the mine site is on land or from a nearby inlet that is being dredged and the sand is trucked to the beach, the sand is usually placed on the berm or dune because this is the most economical method. If the mine site is an offshore source, it may be more economical to place the sand along the entire beach profile, or to create a nearshore berm (either as a mound or a long linear ridge) that will reduce incoming wave energy and supply sand to the inshore and downstream beaches. If the sediment is pumped onto the beach through a hydraulic pipeline, it is typically discharged at a point high on the beach and later redistributed with bulldozers. Coarser sands will usually fall out of the dredged sediment slurry, but fine sediments will stay in suspension and move down the beach into the swash zone where turbidity plumes may occur (USACE, 2001a). There are four east coast states (Florida, North Carolina, Rhode Island, and South Carolina) that have explicit policies regarding where sand should be placed during beach nourishment projects (USDOC/NOAA, 2000).

Federally Funded Beach Nourishment Projects

Beach nourishment projects can be financed by a combination of federal, state, and local governments, and private funds. For large-scale projects that require substantial funding, states will often request that the federal government help carry out projects by helping pay for them. The Army Corps has primary authority to carry out federally authorized beach nourishment projects and can do so under the following program areas: 1) navigation (disposing of beach-quality sand during construction or maintenance of inlets, channels, and harbors); 2) flood damage reduction; 3) recreation; 4) hurricane and storm damage reduction; and 5) ecosystem restoration (see **Appendix A**, **The Federal Beach Nourishment Process**).

Ideally, projects can fulfill multiple purposes to achieve maximum economic and environmental benefits within a localized study area. The Army Corps will often initiate a multiple purpose study to determine if a single project or set of projects with multiple purposes can satisfy more than one type of water resources problem or opportunity. For example, dredged material from navigation projects can be used for beach nourishment to protect the shoreline from hurricane and storm damage. Although the Corps has used dredged material for many beach nourishment projects along the East Coast, some observers believe they have not done so often enough, i.e., only when it is the least costly disposal method. A revision of Corps policy to include the total benefits accrued and costs imposed by other projects (negative effects from navigation projects) might allow more navigation projects to make use of dredged sand for renourishing beaches. This approach might help keep sand within the longshore system (NRC, 1995).

State Beach Nourishment Policies

The National Oceanic and Atmospheric Administration's (NOAA) Office of Ocean & Coastal Resource Management published a document in 2000, entitled *State, Territory, and Commonwealth Beach Nourishment Programs: A National Overview.* In general, states that have greater erosion problems, and other east coast states with coastal barrier beaches, tend to have more comprehensive policies and funding mechanisms for beach nourishment programs. Except for Maine and Maryland, all east coast states have formal beach nourishment policies (USDOC/NOAA, 2000). For each states' policy regarding beach nourishment and projects that have taken place from 1995 to the present, see **Appendix B**, **State Beach Nourishment Policies**.

Dredged material used in beach nourishment projects must always be evaluated for content of contaminants based on local, state, and federal guidelines. In general, the dredged material should match the sediment of the eroding beach and have a low content of fine sediments, organic material, and pollutants (USACE, 2000). Some states have explicit sand compatibility requirements for beach nourishment using dredged material (Connecticut, Florida, New Jersey, North Carolina, Rhode Island), while other states simply recommend beneficial use of dredged material (New Hampshire, New York, Virginia). If there is no policy regarding sand compatibility, it may be up to the head of a particular state natural resource agency to make this determination (i.e. Virginia). While many states do not have laws that encourage beneficial use of dredged material for beach nourishment, it is often supported in policy guidance in state coastal management programs (i.e. Massachusetts).

Permit requirements vary from state to state, but in general, most east coast states review beach nourishment under general permit regulations, treating it as an alteration to the shoreline, dredged material disposal, or construction below the mean high tide line. New York and Delaware review permits as if beach nourishment was a shore protection structure, and New Jersey views beach nourishment as a non-structural measure. All east coast states except Connecticut and South Carolina regulate sand-mining activities within state waters; all east coast states have dredge and fill policies (USDOC/NOAA, 2000).

For non-federal beach nourishment projects in which states oversee the permitting process, states may require several permits or combine all requirements into one permit. Regardless of the number of permits required, there are typically several elements of environmental and land resources protection that are governed by various agencies within the state. In general, most states have provisions for protection of submerged lands, public access, the sand dune system, water quality, and aquatic, fish, and wildlife resources. Others may have special requirements, such as the need to protect sea turtle habitat or nearby wetlands.

Florida has a comprehensive license that combines all of their requirements into one permit [F.S. Section 161.041 (Joint Coastal Permit program)] that includes the following:

- Shoreline protection against activities that could hasten coastal erosion
- Habitat protection for marine turtles
- Water quality protection
- Aquatic resources protection (coral reefs, seagrasses, wetlands, etc.,)
- Fish and wildlife protection
- Protection of the public's interest in state-owned submerged lands, including mineral and biological resources
- Preservation of submerged lands in essentially natural conditions
- Protection of the riparian right of adjacent property owners

ENVIRONMENTAL IMPACTS

The Atlantic States Marine Fisheries Commission is concerned that some of the fish species they manage may be affected by beach nourishment activities. Species could be impacted in a number of different ways including direct mortality, sublethal impairment, and degraded habitat. Studies that have examined the effects of beach nourishment, including physical changes to the environment, as well as, impacts to organisms at various trophic levels at both the mine site and target beach, are discussed in the following sections. Non-beach nourishment studies that may be relevant, are also discussed below. While most studies have not focused on Commission managed species, the results may be of interest to fisheries managers, since they may be applicable to species managed by the ASMFC.

Biological effects of beach nourishment can occur from the individual organism level up through the entire ecosystem. Direct impacts are those consequences of a given action that occur at generally the same time as the action and in the immediate vicinity of the action. These effects are generally easier to observe and quantify than other types, but they are not necessarily the most serious and long-lasting impacts (USDOI/USFWS, 2000). Indirect effects are those changes that occur as a result of secondary responses, such as a shift in fish populations from an alteration of the benthic infauna (USDOI/MMS, 2001). Cumulative impacts are impacts on the environment that result from the incremental impact of the action when added to other past, present, and reasonably foreseeable future actions, regardless of who undertakes such actions (40 CFR 1508.7). Cumulative impacts can be the result of direct or indirect effects.

While a number of studies over the years have examined the environmental impacts of beach nourishment, many of them have not been peer-reviewed in scientific journals and results are often questionable (Nelson, 1993a, Lindeman *et al*., 2000). There are almost no studies that examine the ecological consequences of beach scraping or beach bulldozing (Wells *et al*., 1991), yet it is frequently used in some states to protect coastal structures (Lindquist and Manning, 2001). Despite a paucity of published monitoring studies, there are some noteworthy investigations that have identified some of the effects of beach nourishment; these will be discussed in this paper.

Since sand must first be extracted from a mine site, this is the first area that will be addressed for environmental impacts. It is possible that the sediment, water column, benthic fauna, fish, marine mammals, and sea turtles may be affected during mining. All of these topics are discussed to the extent that there is information available. Likewise, these resources may also be affected when sand is placed on the target beach, so they are discussed in the subsequent section. More is known about the effects at the target beach; thus more information is presented under this section.

It is possible that some of the effects at the mine site will be the same as those that occur at the target beach, and thus, do not need to be discussed in both sections. For example, elevated turbidity at both the mine site and target beach may have potential effects to fish species, such as gill abrasion, but may not be reiterated in both sections. Likewise, there are more extensive research needs listed under the target beach section, but it is reasonable to assume that some of them may apply to the mine site, as well.

Cumulative Impacts

In 1982, William Odum applied Alfred's Kahn's premise (1966) "the tyranny of small decisions" to environmental determinations, asserting that small, independent decisions are often achieved post hoc, resulting in detrimental outcomes in which the larger issue is never directly addressed. In 1997, the Council on Environmental Quality stated that, "Evidence is increasing that the most devastating environmental effects may result not from the direct effects of a particular action, but from the combination of individually minor effects of multiple actions over time." One project may be administratively acceptable and have subtle effects on habitats and organisms, but numerous projects over time may exert multiple assaults that result in "death by a thousand cuts (Lindeman, 1997b)." Special commissions have been convened and concluded that it will be impossible to achieve sustainable development without taking cumulative effects into account in environmental planning and management (World Commission on Environment and Development 1987; President' Council on Sustainable Development, 1996). Many scientists believe that most areas have already been modified or degraded by human activities to the point that any impact could be viewed as cumulative (Council on Env. Quality, 1997).

Cumulative effects may originate in a number of ways including: 1) Time crowded perturbations – repeated occurrence of one type of impact in the same area; 2) Space crowded perturbations – a concentration of a number of different impacts in the same area; 3) Synergisms – occurrence of more than one impact whose combined impact is greater than the sum of the individual parts; 4) Indirect impacts – those caused by, produced after, or away from the initial perturbation; and 5) Nibbling – a combination of all the above taking place slowly and incrementally or decrementally (USDOI/MMS, 1999).

Cumulative impact analyses must be conducted under the National Environmental Policy Act (NEPA), although often, only project-specific impacts are discussed (40 CFR § 1508.7). Some states, such as North Carolina, also have state environmental policy laws that can require cumulative impact analyses. Frequently, a single paragraph is devoted to describing cumulative impacts within an EIS, including assumptions that are not based on peer-reviewed literature (Env. Def., 2000). Long-term effects may never actually be evaluated, and eventually, assumptions become accepted as factual. Reports often omit detailed information about what variables are unknown and the actual lethal and sublethal effects on the populations (Lindeman, 1997b). A study of 89 environmental assessments (EAs) announced in 1992 found that only 35 (39%) mentioned cumulative effects, and almost half of those did not provide supporting evidence for their findings (Council on Env. Quality, 1997). While an EIS should thoroughly discuss cumulative impacts and an EA only has to note if cumulative impacts might occur, valid documentation should support conclusions in either case.

Long-term physical changes at the mine site are not well documented (NRC, 1995). This lack of information makes the task of identifying cumulative effects more difficult when only the immediate short-term changes are identified. Population responses to chronic turbidity can occur over decades, which can mask the effects of cumulative impacts that are collectively significant (Lindeman, 1997).

Beach nourishment is expected to increase in the coming years, compounding opportunities for recurring impacts. In southeast Florida, 100 dredging events are projected to occur between 1969 and 2050 using at least 100,000,000 yd^3 of sediment in an area that is 4 miles by 120 miles (Dade-Martin counties) (USACE, 1996; Lindeman in prep.). There are little data on the effects of turbidity under natural conditions, and the effects on organisms during repeated sedimentation (i.e. 2 to 4 hours, 4 to 6 times a day for 3 months) and turbid conditions (similar to a continuous three-month storm) are unknown (SAFMC, 1998). Add to this effect such conditions as overfishing and other types of environmental degradation, and it becomes clear that there are other factors besides the actual beach nourishment event that organisms must overcome to achieve full recovery. The need to quantify the direct and indirect cumulative effects on the environment will continue to be an important issue (Cocklin *et al*., 1992; Vestal and Reiser 1995; Lindeman and Snyder, 1999).

THE MINE SITE

Since about 1965, sand used for large beach nourishment projects has usually been mined from sediment deposits within state waters. Mine sites should be a minimum of 2 km from shore so that dredged sediment does not enter into the depth of closure. The most important factor when considering suitability of sand is grain size, which should closely match that of the native beach. Sediments that contain high levels of fine sand, silt, or clay may perform poorly, and may increase the turbidity level at the target beach area (NRC, 1995).

The term “borrow site” is generally used to note the site from which material is taken for deposition on a beach. The term implies that the material will be returned to the site, which never happens. The term “mine site” will be used throughout this paper in lieu of “borrow site,” which reflects a more accurate definition of the area where sediment is removed. The mine site usually fills in to some degree, although filling may take years and be incomplete (often leaving a pit). The material filling the pit may be similar to the mined material or quite different in grain size.

Sediment

Dredging involves the complete removal of sediment, which leads to direct mortality to the benthic infauna that live in the substrate. If wave patterns and sediment transport mechanisms are altered near the mine site following dredging, physical changes to the seafloor geomorphology can take place (e.g., substrate type and composition, surface texture, water circulation, and nutrient distribution). Such changes may reduce the ability of benthic flora and fauna to adapt to the existing conditions. For example, an increase in fine sediment may exclude some organisms and recruit higher numbers of other organisms (Naqvi and Pullen, 1982), such as replacement of crustaceans by polychaete worms (Johnson, 1982). It is also possible that the resultant mine pit can cause an increase in the depth of the water and reduce the amount of solar energy that reaches the seabed, which has the potential to cause a decrease in primary productivity (USDOI/FWS, 2000). Mined areas can also refill with decomposed organic matter that is silty and anaerobic, hydrogen sulfide levels may increase, and eventually, the area may become anoxic. Such areas may never recover from these dredging events. Selecting mine sites that are subjected to higher wave energy can help alleviate some of these potential problems (Murawski, 1969; Saloman *et al.,* 1982; Pullen and Naqvi, 1983).

Some of the physical changes that have been observed at the mine pit following dredging include: 1) lower sand content; 2) higher silt/clay content; 3) poorer sorting (greater variation in grain size of sediment); and 4) accumulation of fine sediment (Watts, 1963; Culter and Mahadevan, 1982; Van Dolah *et al.,* 1994). Areas where high sedimentation patterns persist may be unsuitable mine sites in the future, and altered reference areas can reduce their value as control sites in future studies. Mine sites that refill with beach compatible sediments are ideal so that numerous borrow sites are not necessary for proposed 50-year projects (Van Dolah *et al*., 1998).

Other potential physical changes that can occur from mining include the removal of offshore sand bars and shoals that absorb incoming waves, and creation of holes that may increase wave energy and/or change refraction patterns in the offshore region (Kaufman and Pilkey, 1983). If the mine site lies within the depth of closure, there is the possibility that incoming wave energy will increase between the mine pit and the shoreline, hastening erosion rates on the nourished beach (NRC, 1995). Peterson *et al*. (2000b) has suggested that this increased wave energy may have a lasting impact on resident beach organisms. Dredging in nearshore or offshore areas may also impede sediment transport in the longshore direction (NRC, 1995), and has been known to cause silting along adjacent reefs when buffer zones proved ineffective (Grober, 1992). Dredges, discharge pipelines, mooring chains, and other equipment associated with sand mining have also damaged hard bottom areas (Blair *et al*., 1990).

One of the conditions that should be monitored following dredging is the rate at which the mine pit refills. Studies of physical recovery rates report variable results. Van Dolah *et al*. (1998) evaluated five sand borrow sites dredged in South Carolina and reported estimated recovery rates ranging from 1.75 years at a relatively small site to 11.8 years at one of the larger sites. The average recovery among all five sites was 6.8 years. Researchers concluded that the rapid recovery of the site that recovered in 1.75 years was due to its smaller area, and its location, which received a greater amount of sediment influx than the other site. Areas that have high rates of sediment transport (sand, not fine-grained sediment), such as depositional shoals, are suggested to increase the likelihood of rapid refilling rates (Van Dolah *et al.*, 1998).

Studies should also monitor the composition of surficial sediments that refill the mine pit after dredging. The Folly Beach nourishment project (Van Dolah *et al.,* 1994) found that the silt-clay content exceeded 40% in one portion of a site mined within a high salinity inlet, and there was an increase in fine sediment at adjacent reference areas. Dredging sand for a renourishment project at Hilton Head Island, South Carolina (Jutte and Van Dolah, 1999) also led to changes in sediment at the mine site. Sand content at one mine site dropped from 90% shortly after dredging, to 75% one year later. The other mine site contained 84% sand immediately after dredging and 72% after one year. Prior to dredging, these areas were predominantly sand (at least 90%). Since it is desirable to have less than 10% silt/clay content, it is possible that these areas may not serve as potential mine sites for future beach nourishment projects. More monitoring studies should be conducted to determine if muddy sediments are capped or replaced with sandier sediments (Jutte and Van Dolah, 1999).

Recently, sand for a beach nourishment project was dredged from bathymetric peaks (rather than depressions or level sea bottom), which allowed for rapid recovery. Strong currents and sand movement contributed to quick refilling rates, replacement with similar sediment occurred, and water quality was unchanged (USACE, 2001a). Other recent developments include utilizing hopper dredges to extract thin layers of sediment (approximately 3 ft) over larger areas, rather than dredging to greater depths and smaller areas (Jutte *et al*., 1999a; Jutte *et al*., 2001). This operation created a series of ridges and furrows, with the ridges representing areas missed by the hopper dredge, due to the dredge's inability to completely remove all of the sediment. Two sites showed infilling rates of 34% / year and 21% / year, respectively, with researchers hypothesizing that the ridges provided an immediate source of sediment and recolonizing fauna after dredging. Dredging to shallow depths also likely led to less modification in wave energy and currents at the site, and infilling of less fine grained sediments (Van Dolah, 2002). This method is now advocated by state officials in South Carolina, whenever feasible.

Physical Habitat

In addition to the direct mortality suffered by organisms living in the extracted sediment, there is also the potential to affect species that rely on the physical habitat that the sediment provides. One such example is the habitat provided by relic shoals. The term "relic shoal" refers to a shoal that is not dynamic in nature, unlike many shoals that are constantly accreting and diminishing in response to tides and water currents. If relic shoals are removed they will likely not replenish themselves, and the structures will be permanently lost. For fish that rely on relic shoals to optimize feeding along an otherwise featureless substrate, relic shoals provide important physical habitat (Caruso, 2002; Tinsman, 2002). Relic shoals may also be used as navigation points by some fish species (Goodger, 1999). Striped bass, bluefish, scup, summer flounder, and coastal sharks are among the fish species known to use these structures (Caruso, 2002; Tinsman, 2002).

Both Massachusetts and Delaware have identified important relic shoals in their coastal areas where dredging for beach nourishment has either been proposed, or has actually taken place. There is concern among coastal managers, and commercial and recreational fishermen, that to lose this habitat would lead to a decline in local fisheries, and possibly, a loss of local productivity (Caruso, 2002; Tinsman, 2002). Delaware has successfully petitioned the U.S. Army Corps to mine an alternative site for the next Rehoboth/Dewey Beach renourishment episode, to avoid taking sand from the Hen and Chicken shoals, which provides habitat to many species (Tinsman, 2002).

Other states are likely to have similar physical features that can be potentially impacted during dredging operations. Research by Luczkovich *et al*. (1999) has shown that red drum, spotted seatrout, and weakfish spawn in the flood tide deltas at Ocracoke Inlet (North Carolina), and spotted seatrout and weakfish spawn at the flood tide delta in Hatteras Inlet. At present, there are no plans to dredge these areas for beach nourishment. State and federal agencies should identify physical structures that serve as important habitat for migrating and resident fishes in areas where mining is proposed or currently taking place.

Benthos

Along the southeast coast, typical benthic inhabitants in the seabed consist of a diverse array of amphipods, crustaceans, cumaceans, echinoderms, gastropods, isopods, polychaetes, and pelecypods (Dexter, 1972; Oliver *et al*., 1977; Rhoads and Young, 1979; Culter and Mahadevan, 1982; Johnson, 1982). Benthic communities can vary greatly in their distribution and biotic composition. They are rarely in equilibrium and physical variations make it difficult for researchers to distinguish between natural and man-induced disturbances (Grober, 1992).

Despite difficulties in discerning natural and unnatural variations, benthic organisms are studied most often because of several factors: 1) they serve as a vital food source for surf finfish, shrimp, crabs, shorebirds, and epibenthic invertebrates, and thus, may serve as indicators of habitat for these predator species; 2) sampling efforts are easier than with more mobile species; and 3) they reside within a confined area for most of their life, so researchers are better able to draw conclusions about the long-term average conditions of the area (Hackney *et al*., 1996). Thus, the benthic community is critical to the health of higher trophic levels and can serve as an important indicator of the effects of dredging (Gulland, 1970).

Very few organisms and little organic matter are left intact when surface sediments are removed during mining (Saloman, 1974; Oliver *et al.,* 1977; Culter and Mahadevan, 1982). If mining is not uniform throughout the site, sediments may slump into dredged furrows, and sensitive species will likely suffer high mortality (slumping of sediments may also have favorable results, as previously discussed in Sediment section). Organisms, such as fish larvae and mobile invertebrates, may become entrained in equipment during dredging operations and die (Saloman, 1974; Culter and Mahadevan*,* 1982; Johnson, 1982). Studies along the east, gulf, and west coasts document a similar decrease of 84%-90% in the number of organisms following a dredging event (Johnson 1982; Oliver *et al.,* 1977; Deis *et al.,* 1992).

Diversity also drops precipitously, and colonization by opportunistic organisms that are better suited to the new environment takes place rapidly (Rhoads *et al.,* 1979; Oliver *et al.,* 1977; Goldberg, 1988a; Deis *et al.,* 1992). Recovery of organisms in soft-sediments typically occurs through larval transport and post-settlement life-stages (juveniles and adults) and varies with the season, habitat, and the species' life history characteristics (e.g. Zajac and Whitlach, 1982; Thrush *et al*., 1996; Shull 1997). Some research suggests that the polychaetes and oligochaetes that colonize mine sites are short-lived, exhibit high fecundity, and have high larval availability (Rhoads and Young, 1979; Zajac and Whitlach, 1991).

Many studies have concluded that the mine site is fully recovered within one year post-dredging, maintaining that taxonomic diversity and density are often restored, as is the organisms' ability to adapt to their new environment (Welker 1974; McCauley *et al.,* 1977; Oliver *et al.,* 1977; Johnson, 1982; Pullen and Naqvi, 1983; Goldberg, 1988a; Deis *et al.,* 1992; Schaffner *et al.,* 1996). Saloman *et al*. (1982) determined that faunal abundance had recovered within three months following dredging, and species diversity, faunal similarity, and faunal stability had returned to pre-dredge conditions after nine months. Other researchers have reported quick recovery with no drastic changes in species diversity or relative abundance of major taxa (Hayden and Dolan, 1974; Gorzelany and Nelson, 1987; Baca and Lankford, 1988; Van Dolah *et al*. 1992, Jutte and Van Dolah, 2001). Data from studies conducted by Martin Posey between 1995-1999 suggest that recovery at the borrow site is rapid, and observed differences are likely the effects of interannual variability (Posey, 2001).

Some studies show densities by opportunistic species actually increase (Van Dolah *et al*., 1994), and one case found that abundance was eight times greater within nine months after dredging (Deis *et al.,* 1992). Schaffner *et al.,* (1996) found a significant increases in polychaetes following dredging, which was considered beneficial to spot because they consume large quantities, if available (Pihl *et al.,* 1992).

Other studies (Culter and Mahadevan*,* 1982; Johnson 1982; Deis *et al.,* 1990) have found that full recovery takes more time (likely beyond one year) for organic matter to accumulate on the substrate and for aerobic conditions to return to normal. Some researchers maintain that this time allows less mobile crustaceans, mollusks, carnivores, and predators to re-establish their presence and replace the pioneer organisms that first colonize the site after dredging (Rhoads *et al.,* 1979; Oliver *et al.,* 1977; Zajac and Whitlach, 1991). This may be especially true for deeper-burrowing infauna (such as maldanid polychaetes), which can take up to three years to achieve pre-dredge abundance (Wilber and Stern, 1992). One study reported quick recovery of faunal abundance and number of species at one site, but species composition shifted from an amphipod-dominated assemblage to a polychaete/mollusk-dominated assemblage (Van Dolah *et al*., 1994).

Some studies have found that deposit feeders and mid-depth burrowers are typically more abundant in reference areas than mine sites (Turbeville and Marsh, 1982; Deis, 1990; Coastal Planning and Engineering, 1991), and it is postulated that in the absence of these organisms, the mine site is still recovering and should not be considered fully recovered. Other studies that monitored beyond one year found that the community was still recovering and had not yet reached pre-nourishment conditions, noting that benthic species composition was still changing because sediment composition had not returned to pre-dredging conditions (Johnson and Nelson, 1985; Bowen and Marsh, 1988; Goldberg 1990; Van Dolah *et al.,* 1992). Taylor Biological Company (1978) estimated a 10-year benthic recovery time for a mine site in Florida, as a result of accumulated fine-grained sediment. A recent study conducted by the U.S. Army Corps (2001a) found that while abundance, biomass, and taxa richness recovered quickly after the first dredging operation, biomass and taxa richness did not recover as quickly following a second dredging operation, two years later. Furthermore, species and biomass composition were affected over a longer period, with biomass composition taking 1.5 to 2.5 years to recover. Another study found that species abundance of dominant taxa, higher taxonomic composition, and diversity indices had been altered, 14-17 months after dredging, which may have been explained, in part, by a 200-fold increase in the density of a particular gastropod (Jutte and Van Dolah, 1999).

The rate of benthic recovery and degree of diversity following a dredging event depend on a number of factors, including: 1) duration and timing of dredging; 2) the type of dredging equipment used to extract the sediment; 3) sediment composition of the mine site; 4) amount of sand removed from the site; 5) the fauna present in the mine pit and surrounding area prior to dredging and their ability to adapt to change; 6) characteristics of the new sediment interface; 7) life history characteristics of fauna that recolonize; 8) water quality at the site; 9) hydrodynamics of the mine pit and surrounding area; and 10) degree of sedimentation that occurs following dredging (Johnson, 1982; Gorzelany, 1983; Pullen and Naqvi, 1983; Van Dolah *et al*., 1992; Blake *et al*., 1996; Oakwood Env. Ltd., 1998; Newell *et al*., 1998). In general, it appears that areas where biological impacts are greatest and most prolonged, are areas where bottom sediment composition has been altered (NRC, 1995; Van Dolah, 2002).

Some of the differences in reported success rates may be attributed to the fact that benthic recolonization studies often look at the abundance and proportion of individuals in the sample, but often fail to measure trophic levels, life history of individual species, and species function within the benthic community (Rhoads and Young, 1979; Rhoads and Boyer, 1982; Desrosiers *et al.*, 1990; Zajac and Whitlach, 1991). Even if the diversity remains unchanged, the arrangement of individuals within the community may be different, and thus, alter the function of the ecosystem (Hurlbert, 1971; Washington, 1984). The post-dredging community may function very differently than the pre-dredging ecosystem and a comparison of community structure and function must be determined to measure full recovery. A thorough knowledge of the contributions that individual species make to the entire ecosystem is essential before an area can be declared fully recovered (Grober, 1992; NRC, 1995). A key research question that should be answered when determining benthic recovery is, "Do the new benthic communities fill the same trophic function and provide the same energy transfer to higher trophic levels, as did the original communities (USDOI/MMS, 2001)?"

Gorzelany and Nelson (1987) have suggested that seasonal variability in species distribution and abundance may minimize or mask the effects of nourishment in the intertidal and nearshore zones; therefore, baseline data should be gathered over several years so that seasonal trends can be distinguished from the effects of beach nourishment. If the mine site does not undergo continued dredging, unusually high sedimentation rates, or other disturbances, the area should recolonize to its original levels of biomass and abundance within 1-5 years (Van Dolah *et al*., 1992; Blake *et al*., 1996; Newell *et al*., 1998). It is possible that the original species composition may not be the same, however (USDOI/MMS, 1999). Because the benthic community provides a significant source of food, studies must ascertain whether the new benthic community has less, more, or equal value as a food source (Peterson, 2002).

While most areas that have been mined for beach nourishment have occurred in state waters, there is a growing need to move beyond state waters in search of sand. The MMS has conducted several large-scale studies to ascertain possible environmental effects from mining in federal waters. One of their recent studies off the coast of Delaware and Maryland (USDOI/MMS, 2000) concluded that adverse effects were possible, but likely to not be substantial, and steps could be taken to minimize or eliminate the impacts. The MMS suggested leaving small "untouched" islands within the dredged area to allow the benthic community an opportunity to recolonize (USDOI/MMS, 2000). Using this technique could result in similar results observed by Jutte *et al*. (2001), in which dredging to relatively shallow depths with hopper dredges left ridges that served as a source of benthic recolonization.

Ridges and Swales

Along the continental shelf of the east coast of the United States, there are topographic features known as ridges and swales, which can serve as a convenient source of sediment for beach nourishment. First described by Uchupi (1968), numerous theories regarding their origin have been proposed (i.e. Swift *et al*., 1973; Boczar-Karakiewicz and Bona, 1986;), but there is no consensus regarding the processes that work to keep them intact (USDOI/MMS, 2001). They are most prevalent on the East Coast in the Mid-Atlantic Bight region, and most ridges in depths less than 20 meters remain intact and may even be enlarged by current hydrodynamics (Snedden and Dalrymple, 1999).

At present, there appears to be no scientific evidence in the literature that supports the ecological relationship of ridges and swales and their associated biological communities (USDOI/MMS, 2001); however, studies conducted by VIMS (2001) confirmed the hypothesis that these areas are very diverse and active physical systems. Furthermore, they found that different habitats within these features support a vast array of benthic communities and fish populations. Microhabitats within the ridge and swales are also assumed to exist (USDOI/MMS, 2001). Several authors (Hammer, 1993; Oakwood Environmental, 1998; Louis Berger Group, 1999) have proposed that ridges and swales provide fish habitat during growth and development and during migration. Striped bass, spiny dogfish, and other commercially and recreationally valuable species have been reported to use these features (Peterson, 2002).

It is possible that the benthic community and sedimentology can vary longitudinally along the ridges and swales, and if so, sampling designs may need to be stratified to the degree that these variations are taken into account. Some studies have reported variable rates of migration and infill of ridges and swales, but current technology does not allow for confident prediction of assessing the physical impacts (USDOI/MMS, 2001). Monitoring studies need to determine how quickly these features return to normal after mining, and if the heterogeneity in the benthic community will be maintained. If the area dredged is spatially limited habitat, studies must also ascertain if displacement occurs and to what degree this affects demersal fishes (Peterson, 2002).

Turbidity

Siltation and sedimentation are defined as “the accumulation of suspended inorganic particles in the water column and subsequent deposition of fine particulates (Angino and O’Brien, 1967).” The Nephelometric Turbidity Unit (NTU) is the legal standard for measuring turbidity, which is defined as a decrease in water clarity due to fine silt and clay particles in suspension (Bartsch, 1960; Brehmer, 1965). Large-sized sand grains settle out more quickly than fine silt/clay sediment, which can remain in suspension much longer (Marszalek, 1981). Wilber and Clarke (2001) have said that the resuspension of bottom sediments during dredging events is different in scope, timing, duration, and intensity than the resuspension that occurs during storms, freshets, or tidal flows.

Changes in water quality from dredging can depend on a number of factors including the type of dredging system employed, characteristics of the sediment, and site-specific conditions (Herbich, 1992). For example, small "benthic plumes" are created along the seabed when either cutterhead or draghead dredges are used, and larger surface plumes when the sediment-enriched water spills over hoppers with hopper dredges. Elevated turbidity may also depend on whether or not the sediment is sorted during dredging. Screens are often placed at the point of discharge from the hopper dredge, which can lead to significant overspill of sediment creating turbidity plumes. Dredging without the use of a screening device will likely diminish the size and duration of turbidity plumes (USDOI/MMS, 2001).

Studies of turbidity associated with beach nourishment dredging are limited; most are conducted at the target beach or are generic turbidity studies. This could be due to the fact that, in general, elevated turbidity is usually limited to the period of dredging activity. Once this ceases, water quality if often restored. Studies conducted by Van Dolah *et al*. (1992, 1994) found that dredging appeared to have little impact on bottom turbidities at various mine sites. One site (1992) experienced high turbidity levels during sampling, but these levels were also observed prior to dredging. This was attributed to the close proximity to nearby Port Royal Sound, which transported heavy loads of silt to the area. This study underscores the need to locate mine sites that are sufficiently distant from areas that receive a high rate of fine-grained sediment influx.

During dredging operations, it is possible that suspended sediment levels will become elevated, and silt and clay particles will increase at the expense of suspended organic material, which results in less available planktonic food sources. A lack of suspendable organic matter that is typically present in the water column can be a limiting factor affecting the survival of existing organisms and recolonizing larvae at the mine site (Zajac and Whitlach, 1991; Berge and Valderhaug, 1983; Goldberg, 1988a). Some early studies that examined the response of infauna to turbidity and sedimentation have noted the following: 1) suffocation of benthic animals from heavy silt loads; 2) difficulty in locating and capturing food by filter-feeders as a result of increased non-nutritive particles in suspension; 3) reduced microalgal production for the duration of active mining; 4) changes in water chemistry; and 5) decreased light penetration. (Brehmer, 1965; Courtenay *et al.,* 1974; Marszalek in Goldberg, 1988a; Johnson, 1982; Naqvi and Pullen, 1983). Sediment will eventually settle out along the sea floor, which can lead to unsuitable fish spawning and egg hatching areas, as well as, death to microscopic plants (Brehmer, 1965). Deposit feeders may also be negatively affected by the increase in inedible particles along the seafloor.

Fisheries

Obtaining accurate data on fish populations in response to beach nourishment dredging can be difficult, due to their transient nature. In fact, it is their ability to move about freely that has led some researchers to hypothesize that fish will simply leave the area because of the noise and vibration (Van Dolah *et al*., 1992; Hackney *et. al*., 1996). Environmental impact assessments for OCS mining have predicted that effects from dredging will be minimal or non-existent based on the assumption that resident fish are wide-foraging or migratory and spent only a portion of their life cycle at the mine site (Hammer *et al.,* 1993; Louis Berger Group, 1999). Hobbs (in prep.) proposes that the habitat impacted by dredging will have minimal effects on transitory fish, given the small percentage of the overall geographic range that the dredge site represents. Contrasting opinion suggests that fish (and other secondary production) may be dependent on the areal extent of required habitat(s), and that every unit loss of habitat function results in a decrease in production (Peterson *et al*., 2001). Grober (1992) has suggested that some of the studies she reviewed had short post-sampling times, which did not allow researchers to determine if fish abundance remained high after benthic organisms were consumed, so results may be tenuous.

Some studies have found the impacts to fish populations to be benign, while other studies have documented increased diversity at the mine site. The Folly Beach, South Carolina nourishment project found that despite an initial reduction in the number of fish and crustacean species immediately following dredging, pre-dredge conditions were restored within one year. Changes in species composition were attributed to normal seasonal and yearly variability, not from the effects of dredging (Van Dolah *et al*., 1994). The Asbury Park/Manasquan Beach, New Jersey study (USACE, 2001a) found that taxonomic composition of finfish assemblages following dredging was similar to that described by Grosslein and Azarovitz (1982), and that abundance was unaffected. This study also concluded that the feeding habits of winter flounder and summer flounder did not change appreciably during post-dredging time periods.

Studies that have documented an increase in fish abundance have attributed the increase to the release of nutrients and infauna that occur when sediment is removed from the mine site (Saloman, 1974; Applied Biology, 1979; Courtenay *et al.,* 1980; Turbeville and Marsh, 1982; Nelson and Collins, 1987; Coastal Science Associates, Inc., 1990). One study found an increase in larval fish abundance at one mine site, which led researchers to believe that elevated turbidity had a positive effect on larval fish recruitment (Van Dolah *et al*. (1992).

Van Dolah *et al*. (1992) estimated the mortality of postlarval shrimp from entrainment to be no more than 1,883 shrimp per day during dredging. Given that one female white shrimp produces 500,000 to 1 million eggs per spawn (Anderson *et al*., 1949) and natural post-larval penaeid shrimp is estimated at greater than 60% (Minello *et al*., 1989), the number entrained was considered inconsequential. This study also evaluated impacts to recreationally important fish based on a potential change in prey species, and estimated that only two fish species might be impacted by sediment removal. Because whiting and catfish feed mainly on non-motile or slowly moving bottom species, there was a possibility that they could be affected, but no impact was observed (Van Dolah *et al*., 1992).

Potential impacts during mining include the removal of habitat, including hardbottom habitat, or underwater sand berms or mounds that offer refuge for some species. Fish habitat can also be smothered by sediment, but since turbidity at the mine site often subsides shortly after dredging ceases, it may not pose a serious threat unless the sediment contains high concentrations of silt and clay (USDOI/USFWS, 2000). Some species that may be present in the nearshore or offshore vicinity during spawning season may be unable to leave the area because their larvae are estuarine dependent. Other fish species may be permanent residents and unable to find other habitat.

Fish that prey on exclusively non-motile organisms and fish that are less motile, themselves, are anticipated to suffer the greatest effects from dredging. The degree to which fish that prey on benthic invertebrates are affected depends on the recovery rate of the benthic communities. If full recovery of benthic communities is measured in terms of years (not months) as some researchers have asserted, then it is reasonable to assume that recovery of predator species will require a similar or greater amount of time (Peterson *et al*., 2001).

Since very few studies on the effects of fish at the mine site have been conducted, more research is essential. Seasonality of fish species should be determined, especially the location and period of spawning activity. The degree to which fish are impacted by changes in habitat needs to be assessed. Species that are truly dependent on the affected habitat and those that are unable to avoid entrainment should be identified. Additionally, conceptual food web models should be developed so that researchers can gain a better understanding of the impacts that may occur throughout the food chain.

Marine Mammals and Sea Turtles

Potential impacts to marine mammals include loss of prey, interference with filter feeding mechanisms as a result of turbidity, habitat degradation, noise disruption, and possible collision with dredging equipment. In areas that are primary feeding grounds or important developmental habitat, the effects are likely to be greater. The potential effects to sea turtles are similar to those for marine mammals, including disrupted feeding ability and loss of prey, interference with underwater resting areas, noise disruption, and possible collisions with equipment (USDOI/MMS, 1999). Direct impact with dredging vessels is a significant concern, given the estimated 400 sea turtles that die per year in coastal areas as a result of collisions with boats (NRC, 1990b). Recently, a hopper dredge took five sea turtles during a beach nourishment project at Bogue Banks, North Carolina during November 2001-March 2002 (M.W. Street, N.C. Division of Marine Fisheries, pers. comm., April 2002).

Using minimal lighting on dredging barges, if dredging at night, may help reduce migration interference and collisions with hatchlings, both when they exit the beach and during their swim offshore. Predation can also be reduced if lighting is minimized, since predatory fish are often attracted to well-lit barges (USDOI/USFWS, 2000).

THE TARGET BEACH

The dune, the active beach, and the offshore zone are dynamic high-energy areas, subject to the forces of wind and waves. Sand normally moves offshore in the winter and returns on-shore in the spring and summer. During beach nourishment, sand can be placed in any one, or all of these areas, and will redistribute to a more stable profile (NRC, 1995). The division between the nearshore and offshore region occurs where waves first come into contact with, or scour, the bottom sediment. Thus, the nearshore zone is landward of the point where waves are breaking (Leatherman, 1988).

Biological abundance is seasonal, with the maximum achieved in the summer and the minimum in the winter, throughout the surf zone in the southeast (Spring, 1981; Matta, 1977). Species composition varies within different areas of the beach, with less species diversity occurring in the upper beach zone. The following types of organisms are typically found along sandy beaches in their respective zones: 1) upper beach – burrowing organisms such as talitrid amphipods (sand fleas), ocypodid crabs, and isopods; and transient animals, such as scavenger beetles; 2) midlittoral zone – polychaetes, isopods, and haustoriid amphipods; and interstitial organisms that feed on bacteria and unicellular algae among the sand grains; 3) swash zone – polychaete worms, coquina clams, and mole crabs; and 4) surf zone – shellfish, forage fish, and predatory birds; offshore migrating predators are most common in this zone (Trevallion *et al*., 1970; Thompson, 1973; Reilly, 1979; Reilly and Bellis 1978, 1981; Naqvi and Pullen, 1983)

Areas of the ocean floor comprised of hard rock and free of unconsolidated sediment are referred to as "hard bottoms." Hard bottoms support a diverse assemblage of corals, anemones, and sponges, which provide food and shelter for many other organisms, including many important species of finfishes. These organisms are sensitive to surficial sediment patterns, which determine the composition and spatial distribution of the benthic communities (Riggs *et. al*., 1998). Hard bottom habitats are found along the entire Atlantic coast (USDOI/MMS, 1990), but are most abundant along the coasts of Florida and South Carolina. They also contain greater species diversity and biomass than sand bottom habitats (Nelson, W.G., 1990; Goldberg, 1989; Van Dolah and Knott, 1984; Sedberry *et al.,* 1984).

Sediment

Following sand placement, there are notable physical changes to a nourished beach. For example, sand is more compacted along a nourished beach, sometimes three to four times higher, which has been shown to increase over time for some beaches (Ryder, 1991). The use of heavy machinery to redistribute the sediment can crunch and impede the movement of fauna along the beach (Rice, 2001). Formation of a scarp, or a small bluff at the shoreline, is sometimes a signature of a nourished beach, which can hinder or completely eliminate movement of organisms between the swash zone and the upper beach (Reilly and Bellis, 1978; Parr *et al.,* 1978; Nelson *et al*., 1987).

Other physical changes from sand deposition include increased shear resistance (sand permeability), altered dry density, change in moisture content, different grain size and shape, silt/clay composition changes, and altered placement of sand grains throughout the nourished area (Parr *et al.,* 1978; Reilly and Bellis, 1978, 1983; Fletemeyer, 1980; Nelson and Dickerson, 1988; Ryder, 1991). Alterations to the sediment can also lead to changes in the hydrodynamic patterns in the intertidal zone. Infilling of sediment high in clay/silt may cause turbidity levels to temporarily increase. Adjacent beaches that are down-drift from the nourished beach may accumulate sand that moves alongshore, which can be beneficial as long as the sand is compatible (NRC, 1995). Sediment that has a high shell content is likely to pose long-term problems because shell remains on the beach essentially forever, unlike silts and clays that are eventually winnowed away by erosion. Dune plants, which help maintain the shoreline by stabilizing the dunes, can also be destroyed during beach nourishment (Peterson *et al*., 2001).

Beach Bulldozing

Physical changes can also take place from beach bulldozing. Beach bulldozing has the potential to alter sedimentology, compaction, and the nature of the sands along the primary dune (Wells and McNinch, 1991). Wind is one of the major forces that form dunes, which sorts sediment according to grain size. Lindquist and Manning (2001) found that bulldozed dunes contain sediment that is more poorly sorted and has a higher percentage of coarse sands and gravel-sized particles. Stacking sand along the high beach during bulldozing can steepen the beach profile. Kaufman and Pilkey (1983) have stated that steepening the beach profile can increase wave energy on the beach. Higher wave energy has the potential to create a more stressed environment, which can reduce the diversity and abundance of infaunal assemblages (McLachlen, 1983). It is possible that the topography and sedimentology can be impacted over the long-term as more beaches are subjected to this process, but little research has been conducted on the effects of beach bulldozing.

Benthos

High-energy beaches along the U.S. Atlantic coast are dominated by two types of infaunal assemblages: small interstitial organisms and large mobile organisms. Temperate beaches are typically characterized by amphipods and isopods in the upper beach; coquina clams, mole crabs, and several species of polychaetes in the swash zone; and molluscs, polychaetes, amphipods, isopods, and other crustaceans in the shallow subtidal zone (Croker, 1976; Dexter, 1967; Dorjes, 1972; Reilly and Bellis, 1978, 1983; Gorzelany, 1983; Knott *et al*., 1983; Charvat *et al*., 1990). Interstitial organisms are usually more abundant while larger organisms constitute a greater proportion of the biomass (USACE, 2001a). The distribution of beach infauna is dependent on several physical factors, including wave energy, tidal range, sediment texture, and morphological features of the beach, such as cusps and horns (Dexter, 1969; Leber 1982b; McLachlan and Hesp, 1984; McLachlan, 1990). Intertidal infauna are usually highest in both abundance and biomass in the summer, and lowest during mid-winter (Reilly and Bellis, 1983: Salomon and Naughton, 1984; Van Dolah *et al*., 1994).

Using sediment that closely matches the target beach is considered vital to minimizing adverse effects to beach fauna (Hayden and Dolan, 1974; Gorzelany and Nelson, 1987; Baca and Lankford, 1988). Recovery time for organisms will usually take longer if silts or clays are present; which have the ability to affect small organisms, such as flatworms, that reside in the interstitial spaces between sand grains (Rakocinski *et al*., 1996). One study attributed rapid benthic recovery to the similarity of fill material to existing sediments, as well as placing the fill high on the beach, well above mean sea level (Van Dolah *et al*., 1992). Placing sediment high on the beach allows gradual sand redistribution, which gives more motile organisms time to move away from the area or burrow up through the overburden. Factors known to affect burrowing capabilities of intertidal and/or subtidal organisms following nourishment include depth of sand overburden, sediment composition and temperature (Maurer *et al.,* 1978, 1981a, b, 1982, 1986; NRC, 1995), as well as grain size characteristics (Nelson, W.G., 1985). Some studies indicate that changes to the geomorphology and sediment characteristics may have a greater influence on the recovery rate of invertebrates than direct burial or mortality (USDOI/FWS, 2000).

Impacts to benthic organisms at the target beach are generally considered to be less than those that affect benthic organisms at the mine site. This is likely due to the fact that organisms living in the high-energy beach environment, especially the intertidal area, may be better adapted to disturbances (Van Dolah *et al*., 1994; Levison and Van Dolah, 1996). Unless the resident organisms migrate before sand placement occurs, are large and mobile enough to leave the area, or burrow through the sand, they will be suffocated and die upon burial (NRC, 1995; USACE, 2001a).

Recovery of beach fauna may occur through several mechanisms such as: 1) entrainment through the dredge pipeline 2) vertical migration of existing beach fauna through the sediment overburden placed on the beach; and 3) recruitment of pelagic larvae, juveniles, and adult organisms from adjacent areas (Oliver, *et al*., 1977; Naqvi and Pullen, 1982; Grober, 1992; Van Dolah *et al*., 1992.

May (1973) found that most macroscopic organisms were killed after being transported through a dredge pipeline. Parr *et al*. (1978) did not find any living macroinfauna in the newly nourished sediment they examined. Lynch (1994) found that the only species to essentially survive during transport through the dredge pipeline was a mollusc *Mulinia lateralis*. He concluded that the high-pressure pipe likely kills most soft-bodied infaunal organisms and animals that survive entrainment do not play a minor role in recolonization.

Lynch also conducted vertical migration experiments to determine their tolerance to sand overburdens, and found that several species were capable of burrowing through sediments between 60 and 90 cm. He concluded that vertical migration was likely a substantial source of recovery along the nourished beach. To enhance the chance of survival, he recommended that the sediment closely match the native beach and that sediment be applied slowly in a sheeting spray of sand and water. This may allow organisms to keep up with the sediment overburdens as they are applied. Earlier studies by Maurer *et al*. (1978) found that some species in the nearshore subtidal area could withstand sediment overburdens of up to 40 cm, and that sediment composition and temperature influenced their survivability. More studies are needed to determine mortality for sediment overburden depths greater than 1 meter, as many nourishment projects exceed this depth (NRC, 1995).

The polychaete *Scolelepis squamata* has been shown to be an effective colonizer following nourishment, and Reilly and Bellis (1978, 1983) found that it was the only living organism during nourishment operations. Baca and Lankford (1988), Peterson (2001) and Van Dolah *et al*. (1994) also found *S. squamata* to be a prolific colonizer, with the latter study noting their appearance one day after nourishment and abundance increasing over a three-month sampling period (as discussed in Lynch, 1994).

Literature reviews of beach nourishment impacts to beach infauna conducted by Nelson (1985, 1993) and Hackney *et al*., (1996) report short-term declines in infaunal abundance, biomass, and taxa richness following beach nourishment, with recovery occurring between 2 to 7 months. More recent studies conducted since then, have also observed quick recovery times, as well (Van Dolah *et al*., 1994; Jutte *et al*., 1999a; 1999b, USACE, 2001a). One study reported that infauna had recolonized within two weeks (Schoeman *et al*., 2000). Another recent study found that abundance dropped quickly following sand placement (USACE, 2001a), but recovery occurred quickly because the affected species exhibited high reproductive rates and wide dispersal capabilities. This study also attributed quick recovery to ceasing nourishment activities in early fall, which allowed infauna to continue colonizing until populations begin seasonally dropping, usually between November and January. Those areas where filling did not end until the low point in the seasonal cycle of infaunal abundance took the longest to recover.

Emerita talpoida, Donax spp., and *Ocypode* spp.

Several studies have evaluated the impacts to *Emerita talpoida* (mole crab) and *Donax* spp. (i.e. coquina clams, bean clams), and to a lesser degree, O*cypode* spp., at the target beach. They are good indicators of the relative health of beach communities and lend themselves well to study (Leber, 1982b; DeLancey, 1989). A number of studies pertaining to these species are referenced in this section. It should be noted that not all nourished beaches along the East Coast contain significant populations of *Emerita*, *Donax*, and *Ocypode*, therefore, results of these studies may not be applicable. For example, *Emerita* may be absent or sparsely populated along low-energy beaches, and severely eroded beaches with a narrow high beach do not support *Ocypode* populations.

Donax spp. and *Emerita talpoida* are common residents in the lower beach (Efford, 1966; W.G. Nelson, 1985). Both *Donax* and *Emerita* reach peak larval abundance in the summer (Diaz, 1980) and are presumed to migrate offshore with the movement of sand during the winter months (Edwards and Irving, 1943). Both *Emerita* and *Donax* are a primary prey base for surf zone fish, crabs, and shorebirds, and the population density of some predators may actually be dependent on the availability these species (Pearse *et al.,* 1942; Leber, 1982b; Naqvi and Pullen, 1983; Brown *et al*., 1990). Researchers have concluded that several factors appear to influence the effects on *Emerita* and *Donax*: 1) the size and type of sediment used (coarser grains are preferred to allow better burrowing, low content of fines to minimize effects on feeding efficiency, more gradual beach slope); 2) compatibility of fill (should closely match natural beach, low/no organic and shell content, and free of clay, hydrogen sulfide); 3) hydrodynamic patterns (can impair filter feeding mechanisms, reduce efficiency of coquina clams to forage in the surf wash, and decrease ability of clams and crabs to burrow effectively in the swash zone, which could lead to being washed out to sea and facing increased predation); 4) seasonal timing of nourishment (should end before species migration to the target beach); 5) the time between renourishment episodes (shorter intervals may have greater long-term impacts); 6) geographic range of the project (larger areas may hinder recovery); and 7) location of sand placement (intertidal beach vs. outer sand bar) (Reilly and Bellis, 1983; Bowman and Dolan, 1985; Dolan *et al*., 1992; Turner, 1990; Hackney *et al*., 1996; Donoghue, 1999; Peterson *et al*., 2000b; Lindquist and Manning, 2001).

Charles Peterson and colleagues have conducted a number of studies over the years, and he presented recent findings at the 2001 Coastal Ecosystems and Federal Activities Technical Training Symposium (Peterson and Manning, 2001). Some of the studies revealed the following:

- An increase in fine sediments, an increase in sorting, and enhanced turbidity in the surf zone were observed during active sediment pumping on the beach – no detectable recovery was detected between projects that were one year apart
- Abundance of *Emerita talpoida* and *Donax variabilis* decreased by 86-99%, at a time when they should have been at seasonal peak abundance
- Greater than 50% reduction in the biomass dominant, *Donax* spp., abundance occurred integrated over the whole summer of peak production; similar reductions were observed in the most abundant amphipods, *Parahaustorius longimerus* and *Amphiporeia virginiana*; *Emerita talpoida* almost disappeared altogether for one full year following nourishment
- On the nourished beach, *Donax variabilis* and *Emerita talpoida* exhibited considerably smaller body size, and during the two years of study, they never exhibited convergence with sizes on the control beaches

Peterson determined that there was a "reduction of habitat value of the intertidal beach for most surf fishes and shorebirds through reduced prey abundance and body size, a compound impact on production and trophic transfer." He concluded that ending beach nourishment activities before the warm season (April or May in North Carolina) would likely reduce the impacts to the offshore *Donax* and *Emerita* populations, since they would be sufficiently distant from the target beach during sand placement. Ceasing operations in the spring may also allow the sediments to become more stable before populations return, which provides more favorable conditions for release of larvae in the intertidal zone (Peterson *et al*., 2000b). Lindquist and Manning (2001) have suggested that it is possible that repeated renourishments could continue to reduce the proportion of large adults in the population, which could have far-reaching consequences.

Reilly and Bellis (1983) conducted earlier experiments on the effects to *Donax* and *Emerita.* They found that *Donax* were killed not only along the nourished beach, but also at their offshore wintering grounds. As a result, no larval recruitment was observed until the following year; the only source of recruitment was from colonists that were bred that year and settled by littoral drift. *Emerita* also disappeared initially and recolonization did not occur by the normal spring migration of adults, but through pelagic larval recruitment. This loss resulted in an overall reduction in biomass, due to the absence of adults in the population. Researchers determined that a high content of fine sand that did not match the existing beach sand led to elevated turbidity and subsequent high mortality. Other studies have also reported delayed recovery when high silt/clay content is present in the fill material (Rakocinski *et al*., 1996).

Some studies have observed impacts to be less significant. Gorzelany (1983) and Gorzelany and Nelson (1987) concluded that *Donax* was not significantly affected because the adult population was offshore during the winter nourishment. Spring (1981) also found the overwintering population survived because it had moved far enough from the shoreline and was not affected by sand re-entering the surf zone at the target site. Van Dolah, *et al*. (1994) observed a reduction in *Donax,* but adults were present after nourishment was completed.

The uppermost beach is typically heavily populated by air-breathing crustaceans and O*cypode* spp. (i.e.ghost crabs), which contribute a significant amount of food to higher trophic levels (Wolcott, 1978; McLachlan and Jaramillo, 1995). Beaches that have been severely eroded to the point that they have little or no high beach during high tide, such as some beaches in South Carolina, may be depauperate of faunal organisms, and even be devoid of ghost crabs (in such instances, beach nourishment may actually restore lost habitat). Beach nourishment studies of *Ocypode* spp., have revealed high direct mortality levels (i.e. 50%) from beach nourishment activities; however, it is unclear what physical changes contributed to their mortality (Reilly and Bellis, 1983; Peterson 2000b).

Beach Bulldozing

One beach bulldozing study reported rapid recovery (less than 60 days) of the beach infauna, including species abundance and diversity of the overall faunal complex, and abundance of dominant taxa. In addition, the sediment components, including sand, silt, clay, calcium carbonate, and organic matter content, at the bulldozed beach and reference area were essentially the same (Levisen and Van Dolah, 1996). This study supports earlier findings that documented quick recovery of the invertebrate fauna and no long-term changes to species composition from beach scraping (Lankford and Baca, 1987; Lankford *et al*., 1988; Baca et al., 1990; CSA, 1991). Peterson *et al*., (2000b) documented a 100% increase in abundance of coquina clams following bulldozing activities. Lindquist and Manning (2001) did not detect any negative impacts to the amphipod *Amphiporeia virginiana*, the polychaete *Scolelepis squamata*, coquina clam abundance, as well as, surf fishes and shorebirds.

The Lindquist and Manning (2001) study did document negative impacts to some species, most notably mole crabs and ghost crabs; the ghost crab population was significantly reduced for 6-8 months following beach bulldozing. Peterson *et al*., (2000b) also found that densities of mole crabs in the intertidal zone and ghost crabs in the upper beach zone were reduced by 35-37% and 55-65%, respectively, three months after bulldozing. The cause for the decrease in mole crab and ghost crab abundance could not be determined, given that beach slope, grain size, and wave and tidal energy appeared to be similar on both the treated and untreated beaches; however, the bulldozed dune was unable to hold a burrow, and the natural berm face contained more fine sediments, less shell, and more vegetation that helped hold the shape of excavations. More studies are needed to determine what physical differences accounted for the reduction in ghost crab abundance in these studies**.**

Both the Lindquist and Manning, and the Peterson *et al*., studies, were unable to identify the specific physical attributes of the nourished sediment that caused reductions in observed species;

however, they did speculate what some of the future impacts could be if these variables could not be identified and abated. For example, larger shell fragments will not erode off the beach and may remain on the nourished beach for a long time (Peterson *et al*., 2000b). Lindquist and Manning (2001) have speculated that ghost crabs may avoid a newly bulldozed beach in the spring even if activities have ceased prior to their annual return to the beach, which could result in slower recovery for the populations. If bulldozing is repeated annually, and ghost crab populations do not return to the bulldozed beach until the following season, there could be long-term consequences. As with beach nourishment, it is recommended that beach bulldozing cease before the spring migration to the beach. Planting dune grass may also help reduce impacts because the grass's roots hold bulldozed sand in place and may allow the crabs to burrow more effectively (Peterson *et al.,* 2000b).

Turbidity

Turbidity at the target beach can result from resuspension of sediment at the discharge pipe, and from sediment winnowing from the nourished beach into the surf zone, which can be carried in the long shore direction or seaward with waves and currents (Nichols *et al.,* 1978; Schubel *et al.,* 1978; Parkinson *et. al*., 1991; Van Dolah *et al*., 1992, 1994). Turbidity can also occur between the mine site and target beach when sand may be lost during hopper loading; leaks may occur in transport pipes; during sediment movement between sites; and from routine drainage of water containing high quantities of fine sediment (Britt and Assoc., 1979; Marszalek 1981; Courtenay *et al.,* 1974). Sediments can be re-suspended by waves and currents between the mine site and the target beach for years after dredging (Lindeman in prep). If mud balls, silts, and clays are present in mined sediment, they too, can be a persistent source of turbidity long after project completion. The severity of resuspension appears to be related to several factors: 1) wave energy (more turbid during storms); 2) amount of sand placed on the beach (more sand may increase turbidity); 3) the quality of the sand (higher content of silt/clay caused elevated levels); and 4) the mode of placement (i.e., hydraulic pipeline or barge pump-out) (Goldberg, 1989, USACE, 2001a).

Turbidity in the area of the outfall will usually disappear within several hours after nourishment operations cease (Van Dolah *et al*., 1992). Schubel *et al*. (1978) found that 97-99% of slurry discharged from pipelines settled to the bottom within several tens of meters from the discharge point. Nichols *et al*. (1978) observed that sediment plumes were limited to the area of the discharge, and that after terminating activities, the plumes disappeared within 2 hours. Studies conducted off the coast of New Jersey revealed short-term turbidity at the fill site was essentially limited to a narrow swath (less than 500 m) of beachfront. Dispersed sediment was most prominent in the swash zone in the area of the operation, with concentrations dropping off in the surf zone and nearshore bottom waters. Except for the swash zone, the concentration of sediment was considered comparable to conditions that might occur when sediment becomes resuspended during storms (USACE, 2001a). Van Dolah *et al*. (1994) reached a similar conclusion; despite a maximum of 200 NTU confined to a narrow area, background turbidities were close to 100 NTUs during storms and normal fluctuations often elevated turbidity.

Some turbidity studies have revealed that certain species may be positively affected by an increase in suspended sediment. For juvenile Chinook salmon, bluegill, and rainbow trout, the reaction distances to planktonic prey was reduced as turbidity increased (Confer *et al*., 1978; Vinyard and O'Brien, 1976; Gregory and Northcote, 1999). Larval Pacific herring have demonstrated increased feeding rates under turbid conditions, which provided greater visual contrast of prey items (Boehlert and Morgan, 1985). Juvenile Chinook salmon have been shown to benefit from a reduced risk of predation while foraging under turbid conditions (Gregory and Northcote, 1999).

Just as there are species that appear to benefit from increased turbidity, there are also organisms that become stressed under these conditions. Increased turbidity can kill suspension-feeding benthic organisms (Reilly and Bellis, 1983) and reduce foraging ability of animals that rely on sight to capture their prey (Benfield and Minello, 1996). Turner (1990) found that mole crabs suffered impaired feeding ability as a result of turbidity. Wave tank experiments conducted by Lindquist and Manning (2001) showed that turbidity caused a reduction in growth for filter feeding coquina clams. The Florida pompano also showed a decline in feeding on coquina clams and mole crabs, by 40.5% and 30%, respectively.

It is possible that sessile species that occupy hard bottom reef habitats can be smothered by silt. Fish gills can become clogged, planktonic larvae of both vertebrates and invertebrates in the surf zone may be adversely impacted, filter-feeding mechanisms may become impaired, and photosynthetic activity may decrease (Courtenay *et al.,* 1974, 1980; Hay and Sutherland, 1988; Goldberg, 1989; NRC, 1995). Fish subjected to high sedimentation and turbidity have died from anoxia, especially juveniles and small fish (Courtenay *et al.,* 1974; O'Connor *et al.,* 1976). Elevated sediment concentrations can also lead to egg abrasion and reduced ventilation rates in molluscs (Moore, 1978; Newcombe and MacDonald, 1991; Wilber and Clarke, 2001).

Turbid conditions can also decrease light penetration, which may reduce primary productivity. When algal production decreases, motile species associated with attached macroalgae may have less available substrate (W.G.Nelson, 1989a). Increased turbidity and sedimentation reduce growth and increase calcification rates in coral reefs (Aller and Dodge, 1974; Dodge and Vaisnys, 1977). These effects can lead to changes in primary and secondary production, which, in turn, may cause substantial changes at higher levels of the food web (Nelson, 1989a).

Some studies have found turbidity to be a persistent problem, reducing visibility seven years after project completion (Hume and Pullen, 1988; Goldberg, 1989). Reilly and Bellis (1978) reported unusually high turbidity following nourishment in North Carolina, which was possibly linked to a high content of clay balls in the fill sediment. Coral heads off the shore of Miami Beach were still dying 14 years after project completion (Bush *et al*., 1996), and another south Florida study recorded high turbidity and burial of nearshore rocks seven years later (Goldberg, 1985).

Increased turbidity can have a number of physiological effects on marine life. Some of these effects are directly related to beach nourishment activities, while others originate from turbidity from other sources or during laboratory experiments. This is an important distinction, as non-beach nourishment related turbidity studies may or may not be applicable to species at the target beach. The nearshore area is often subject to turbid conditions and many species in the surf zone may be well adapted to withstand such circumstances. Additionally, many coastal areas are subjected to storms that elevate turbidity in the surf zone and subject the species to these conditions over larger areas and multiple day periods. Areas that do not have naturally high turbidity, or beaches that are not typically subjected to storm-related turbidity, may experience greater impacts from beach nourishment-related turbidity, especially if a higher silt/clay content is present in the beach fill (Van Dolah, 2002). More research is necessary to determine if these studies are applicable.

Sea Turtles

Along south Atlantic beaches, sea turtles nest from spring through late summer. They emerge from the water at night, lay their eggs in burrows above the high tide line, and return to the water. Researchers have found that successful nesting is dependent on a dry beach with a narrow temperature range, and loosely compacted sediment that allows for easy excavation (Raymond, 1984; Nelson, 1988; Nelson and Dickerson, 1988). Beach nourishment can benefit endangered and threatened sea turtles by restoring habitat along eroded beaches. Some studies have found no significant difference between nourished and non-nourished beaches in the number of eggs per nest, as well as, hatching and emergence success (D.A Nelson *et al*., 1987; Ryder, 1991). Other projects have shown increased numbers of nests, hatchlings, and survival rate of young turtles (Raymond, 1984; LeBuff and Haverfield, 1990; D.A. Nelson, 1991).

Beach nourishment can also pose a serious threat to sea turtles if proper conditions are not met. Physical changes along nourished beaches include formation of steep berms, or scarps, (D.A. Nelson *et al*., 1987) which can prevent females from reaching preferred nesting sites along the beach (referred to as false crawls). As a result, eggs may be laid closer to the water where they are more likely to be swept away by incoming tides (Bagley *et al*., 1994; Steinitz *et al*., 1998). Nourished beaches are often harder (increased shear resistance) than natural beaches, causing females to abandon attempts at digging nests to lay their eggs (Nelson and Dickerson, 1989; Steinitz *et al*., 1998). According to Steinitz *et al*. (1998) a nourished beach does not become suitable again for turtle nesting in the middle beach zone until two to three years after project completion, which allows sufficient time for the surface to become more penetrable (at depths of around 20cm). Other studies have documented longer times, up to seven years, for the beach sand to return to its normal density (Moulding and Nelson, 1988).

The success of incubating eggs can be reduced when the sand grain size, density, shear resistance, color, gas diffusion rates, organic composition, and moisture content of the nourished sand is different from the natural beach sand (Nelson and Dickerson, 1988; D.A. Nelson, 1991; Ackerman, 1991, Ackerman *et al*., 1991, 1992; Ehrhart, 1995; Rice, 2001). Nourished beaches often retain more water than natural beaches, which can impede gas exchange in the nest (Mrosovsky, 1995; Ackerman, 1996). Sand temperature changes can alter the incubation time, which can lead to increased predation and alter the sex ratio of hatchlings (Schulman *et al*., 1994). Altered beach conditions may also hamper embryonic development (Ackerman *et al*.,

1992) and reduced behavioral competence of hatchlings, including changes in locomotion (Miller *et al*., 1987).

Egg-bearing females may be deterred from suitable nesting sites by the presence of equipment used during operations (pipelines, bulldozers, and lights), structures (seawalls and pilings), and even noise and human activity (NRC, 1995). One study documented a 41% reduction in nesting where pilings were present (Bouchard *et al*., 1998). Artificial beachfront lighting has caused turtles to become disoriented (lose their bearings) or become misorientated (incorrect orientation) (Philbosian, 1976; Mann, 1977). Impacts to sea turtles from beach nourishment can be reduced by ending activities before spring nesting, using as little light as possible during project construction, and "harrowing" or tilling the sand to reduce the hardness of the nourished beach.

Shorebirds

A large number of avian species can be found feeding, wintering, and/or breeding along soundside beaches, dunes, oceanside beaches, coastal islands, and inshore and offshore waters. For example, large numbers of male gannets feed exclusively on schooling marine/estuarine fish species during the winter months off North Carolina. Many other waterfowl do the same, in addition to spending a great deal of time resting and feeding on benthic invertebrates. Many of these birds depend on the winter months to store energy reserves for the coming breeding season. The beach can provide undisturbed habitat for nesting and brood-rearing, and the intertidal zone supplies abundant food sources (Peterson *et al*., 2001). While a number of avian species have lost important beach habitat as a result of coastal development (USACE, 1998), beach nourishment can restore habitat in some areas for nesting birds. Some of these birds may be federally-listed or state-listed as threatened or endangered.

Birds that use the target beach for nesting and breeding are more likely to be affected by beach nourishment than those species that use the area for feeding and resting during migration (USDOI/MMS, 1999). Birds may be displaced by dredges, pipelines, and other equipment along the beach, or may avoid foraging along the shore if they are aurally affected (Peterson *et al*., 2001). Sand that is placed on the beach has the potential to crush eggs, hatchlings, and adult birds (USDOI/MMS, 1999). If the sediment is too coarse or high in shell content it can inhibit the birds' ability to extract food particles in the sand. Fine sediment that reduces water clarity can also decrease feeding efficiency of birds (Peterson *et al*., 2001).

Fisheries

The beach serves as important habitat for some fish species, with the surf zone supporting abundant fish resources comprised mainly of small species or juveniles (Modde and Ross, 1981; Brown and McLachlan, 1990). Data are lacking, but the surf zone and nearshore regions are suggested to be important migratory areas used by larval/juvenile fish moving in and out of inlets and estuarine nurseries, and also by adult fish migrating parallel to the coast (Hackney *et al*., 1996). Populations are generally higher and more diverse in the summer and early fall and it is not uncommon to find as many as 95 species within a given area of the surf zone (Naughton and Saloman, 1978; Saloman and Naughton, 1979; Modde and Ross, 1981). In their review, Hackney *et al*. (1996) found that the diets of surf fish may change with their developmental stage (Ross, 1983) and prey availability (Johnson, 1994); they suggested that fish that exhibit opportunistic behavior and live in a dynamic environment such as the surf zone, may be able to adapt to events like beach nourishment.

The nearshore region serves as vital habitat for many recreational and commercial species that are managed by the Atlantic States Marine Fisheries Commission. Atlantic croaker, bluefish, red drum, Spanish mackerel, spot, and summer flounder top the list for nearshore recreational fish catches for the states North Carolina, South Carolina, Georgia, and Florida. Other ASMFC species that are caught to a lesser extent are Atlantic menhaden, spiny dogfish, spotted seatrout, striped bass, and weakfish. There is also considerable commercial fishing activity in this area, with bluefish, spot, spotted seatrout, striped bass, and weakfish dominating the landings in some states. Atlantic croaker, red drum, American shad, Spanish mackerel, and summer flounder are also landed to a lesser degree. For species-specific habitat designations for all 22 species managed by ASMFC, see **Appendix C Fish Habitat**.

In 1996, Hackney *et al.,* conducted an extensive literature review and found that a thorough knowledge of fish biology was lacking and that studies on the effects of beach nourishment on fish in the South Atlantic Bight were mostly derived from anecdotal information. More recent reviews have confirmed that existing information on the overall effects of beach nourishment to surf fish and associated habitats is inadequate (Peterson *et al.,* 2000b; Lindquist and Manning, 2001).

Despite the paucity of documented effects on fish, Nelson (1985) has noted some potential effects, including: 1) altered distribution during nourishment; 2) potential for gill clogging; 3) temporary removal of benthic prey; 4) burial of structures that serve as foraging and shelter sites; and 5) potential burial of demersal fish (W.G Nelson, 1985). Surf zone fish have also proven vulnerable to the effects of turbidity from major storm events, with large fish kills sometimes occurring (Robins, 1957). Van Guelpen and Davis (1979) observed winter flounder leaving shallow coastal waters to avoid turbulence during storms. Since adult winter flounder are sight feeders, it is likely that increased turbidity affects their success rate for capturing prey.

As discussed in a previous section, there are negative impacts to invertebrates that serve as prey for fish. It is postulated that predator fish are affected by a diminished food supply and fish larval recruitment drops; this hypothesis has been difficult to test so far (Donoghue, 1999; Peterson *et al*., 2000b; Lindquist and Manning, 2001). More trophodynamic studies are needed to determine links between non-fish and fish communities and to assess the impacts that are transferred through the food chain (Hackney *et al*., 1996).

In July 2001, the Army Corps released the results of the most costly monitoring project conducted by the agency to date ($8.6 million). For eight years, a Biological Monitoring Program was conducted at the Asbury Park to Manasquan Inlet Beach Erosion Control Project in New Jersey and findings include: 1) no long-term impacts to surf zone finfish distribution and abundance patterns were observed; 2) there was no sustained biological indicator, i.e., fish abundance or distribution pattern that distinguished nourished from non-nourished beach habitat; and 3) bluefish were essentially absent during nourishment, while benthic feeders (silversides and kingfish) were potentially attracted to the nourishment area, either related to resuspended benthic material (silversides) or the general nourished condition (kingfish). Feeding habits of benthic-feeding surf zone fish were also examined, including northern kingfish, rough silverside, and Atlantic silverside. They found that the percentage of fish with filled stomachs did not differ, nor did the relative composition of prey items. Finally, the study also investigated the effects to surf zone and nearshore ichthyoplankton. Studies to date for Atlantic coast beaches are essentially non-existent. Comparisons of reference and control beaches revealed no obvious differences in surf zone ichthyoplankton abundance, size and species composition.

While the time and money spent to complete the New Jersey study is quite impressive, the limitations were also evident, given that this caveat was issued along with the results: "because inter-annual variation of surf zone fish community dynamics is considerable, it is unlikely that anything other than catastrophic environmental impacts on surf zone fish populations would be evident (USACE, 2001a)." Some notable researchers have expressed dissatisfaction with the methods used to evaluate the effects of beach nourishment by the Army Corps and are reluctant to accept their findings. For further discussion regarding this issue, refer to page 46 under the **General Recommendations** section.

Two non-beach nourishment studies are worth noting, which may be applicable to studying the impacts to fish at both the target beach and the mine site. Newcombe and Jensen (1996) analyzed numerous documented reports of fish responses to suspended sediment in streams and estuaries. They produced equations that correlated biological response to duration of exposure and suspended sediment concentration. Different taxonomic groups, various life stages, and particle sizes of suspended sediments were taken into account. Four major classes of effects included: 1) no effect; 2) behavioral effects; 3) sublethal effects (may include reduced feeding success); and 4) lethal effects (includes direct mortality) or paralethal effects (may include reduced growth, reduced fish density, habitat damage, delayed hatching, and reduced population size). They created "look-up tables," which can be used in the field to predict biological responses to suspended sediments. This study supported the hypothesis that susceptible individuals are affected by sediment doses lower than those at which population responses can be detected. The study also determined that some species and life stages were particularly sensitive to suspended sediments. One of the limitations of this study was that early life stages were often grouped (i.e. eggs with larvae, young with old juveniles), which prevented researchers from determining exact thresholds for each developmental stage.

Wilber and Clarke (2001) also synthesized the results of many studies and correlated them with the effects of turbid conditions in estuarine waters during dredging activities. They emphasized the dearth of information on biological responses of fish and shellfish within the range of concentration and exposure duration that can be expected during dredging. As noted above, one of the limitations identified with some current sampling programs, is the inability to detect less than dramatic changes in fishery resources. Sampling the benthic community to infer impacts to fishery resources is one way to draw conclusions, (USACE, 2001a), but without measuring the range of direct effects to fishes, especially behavioral and sublethal effects, it is possible that some changes will go undetected.

It is possible that the results of these studies can be used to predict impacts that might occur during beach nourishment activities if estuarine waters are affected. Research needs were identified in these studies (see **Research Needs** section), which are applicable to other areas, such as marine waters. It would be advantageous to expand these "look-up tables" so that the range of effects in non-estuarine waters can be determined.

There may also be a need to examine the effects on horseshoe crab populations along beaches that have been nourished. Beaches provide essential spawning habitat for horseshoe crab adults, and nearshore, shallow water, intertidal, and subtidal flats are considered essential habitat for the development of juvenile horseshoe crabs. While beach nourishment may create additional suitable habitat for horseshoe crab spawning, it may adversely impact this activity. Researchers should determine if changes in sediment characteristics of beach fill affect horseshoe crab population, especially in the active foreshore region. For example, a high content of fine-grained sediments can lead to different moisture-retention characteristics. If this sediment settles as layers, the surface may become more wave resistant and burrowing organisms can be affected (Jackson, in prep.). Researchers should determine if spawning success declines, if "homing" ability is reduced (different chemical cues), and whether or not eggs are damaged as a result of beach nourishment.

Physical Habitat

Similar to the mine site, there are physical structures in the vicinity of the target beach that may be impacted by beach nourishment. While the impacts that occur at the mine site typically involve the complete removal of physical structures, negative impacts to physical structures at the target beach are often the result of burial or heavy siltation. One example is the physical structures created by colonial sabellariid polychaete worms. These organisms build mound-like and tubular aggregations in the nearshore surf zone, and sometimes form distinct reefs, extending for thousands of kilometers along some shores in Brazil and India (see Caline *et al*., in Kirtley, 1992). Sabellariid worms are common in Delaware Bay below the mean low water line, forming considerable structures. Following beach nourishment, the reefs are less prevalent due to smothering by sand and silt. Since fish use these reef structures for feeding and escaping predation, a reduction in reef area is likely to have an impact on the fish that use this habitat (Tinsman, 2002).

Another habitat that is of significant importance is hard bottom habitat. Hard bottom habitat is prevalent immediately offshore in southeast Florida, which provides settlement areas for larval fish and nursery areas for juvenile fish (Vare, 1991; Lindeman, 1997a). In fact, all habitats impacted by projects in southeast Florida have been identified as habitat areas of particular concern by the South Atlantic Fishery Management Council. There is great diversity, with at least 325 invertebrate and algal species, and at least 192 recorded fish species associated with nearshore hard bottom habitat (Lindeman and Snyder, 1999, Env. Def., 2000). Surveys conducted by Lindeman and Snyder (1999) found that over 80% of the fish occupying this habitat were from early life stages (newly settled, early juvenile, and juvenile) and an estimated 34 fish species used it as a nursery area.

While the importance of hard bottom habitat is well established, there is conflicting information and differing viewpoints on the effects of beach nourishment on species that rely on these areas. The final EIS for the Carlin project (Palm Beach Co. Dep. Env. Res. Mgmt. 1994; USACE, 1996) determined that among other things, the short-term displacement and temporary loss of food sources for fish would be minimal and temporary, and that the fishery value of impacted species was low. Lindeman and Snyder's (1999) findings for this project were contrary. They determined that direct burial reduced the abundance of fish species and individuals, and concluded that displacement was permanent (15 months). "Because of behavioral and morphological constraints on flight responses, high mortalities are probably unavoidable for many cryptic species, newly settled life stages, or other site-associated taxa subjected to direct habitat burial." Many of these hard bottom habitats are often separated by sand plains that do not support the diversity and abundance of early life stages of fish found on hard bottoms, and it is not reasonable to expect fish to have high rates of survival in these other areas.

Ross and Lancaster (1996) have also reported strong site fidelity for juvenile fish in the surf zone. Loss of habitat structures in coral reefs has been shown to reduce growth rates and increase predation of fish (Hixon, 1991). Despite the fact that fish populations were seasonally low at the time of burial for the Carlin project (March-April), abundance was still reduced because burial occurred just prior to the time that early life stages are typically peaking (spring and summer). If recruitment windows are lost for one or more years, long-term effects can be expected in the future.

Any changes that add to or remove surface sediment can affect the availability of hard bottom habitats, their benthic communities, and the structure of those communities (Riggs *et al*., 1996, 1998; USDOI/FWS, 2000). In South Carolina, the effects of increased siltation and smothering from sand movement are considered to have a greater impact on hard bottom habitat than other nearshore habitat (Van Dolah *et al*., 1994). Some areas have already been lost to the effects of beach nourishment, such as hard bottom habitat off the coast of Wrightsville Beach, NC, which was buried under two to six inches of sand when sand eroded from the nourished beach. These once productive fishing grounds no longer support the fish they once did, leading researchers to conclude that, "The business of beach nourishment and hard bottoms represents a very serious conflict, and a problem that's going to get much bigger (Riggs, 1994)."

Some states have attempted to offset the effects of beach nourishment to hard bottom habitats by constructing artificial reefs. Unlike many artificial reefs that are primarily designed to enhance sportfishing, mitigation artificial reefs are designed to replicate the impacted habitat. Mitigation reefs are typically constructed of limestone and offer a stable substrate on which algae can colonize and fish species assemblages can seek refuge. Reefs have been constructed in depths ranging from 8-15 feet of water at sites in Pinellas, Manatee, Sarasota, and Charlotte counties in Florida, and have proven successful in providing additional fish habitat (Mille in prep).

New technologies are continually evolving and reef designers will continue to improve methods for construction of like-for-like replacement of hard bottom habitat. While artificial reefs may offer relief to areas affected by beach nourishment, impacts that require mitigation should be prevented, if at all possible.

RESEARCH NEEDS

Monitoring is "the systematic collection of physical, environmental, or economic time-series data or a combination of these data on a beach nourishment project in order to make decisions regarding the need for or operation of the project or to evaluate the project's performance" (NRC, 1995). Beach nourishment projects have the potential to impact water quality, alter bottom topography, change sediment characteristics, and impact living organisms, to name a few. While there are currently no standard sampling programs used in monitoring the environmental impacts of beach nourishment projects (USACE, 2001a), there are guidelines (Cochran, 1963; Morrisey *et al.,* 1992; Nelson, 1993b) and specific applications for environmental impact studies are available (Saila *et al.,* 1976; Cohen, 1988; Underwood 1992). Grober (1992) suggests that in order to determine the full effects of beach nourishment, three areas should be monitored for short and long-term impacts: 1) mine site, 2) target beach, and 3) adjacent communities.

The Committee on Beach Nourishment and Protection was convened by the National Research Council to evaluate various aspects of beach nourishment and results were published in 1995 in a book entitled *Beach Nourishment and Protection*. Despite their conclusion that beach nourishment was a viable alternative for protecting the shore and providing recreation, they identified a number of important research needs. The general consensus was that, "Most beach nourishment programs are inadequately monitored following construction." They considered most biological resources assessments to be incomplete, especially at the mine site. Monitoring is especially necessary in areas that have never been sampled and information gaps are especially notable for indirect effects. They recommend that sponsors develop monitoring programs that are appropriate to the scale of the nourishment program and use the data appropriately to make project-related decisions (NRC, 1995). Researchers believe that statistically valid field monitoring of project impacts is rarely performed for beach nourishment activities (Lindeman, 2001).

The following are research needs that have been specifically identified by scientists and researchers in the course of their work, according to the subject that needs further study. The Commission recognizes that some of these recommendations may not currently be feasible, given the present level of funding and interest in some areas of research. Nonetheless, they have been identified by the scientific community and are listed herein. It is up to the individual states to determine their priorities and fiscal abilities and then respond accordingly.

Mine site

To learn more about the general effects to the benthic community and associated effects to consumers, the following research needs have been identified:

- Document changes in sediment characteristics and recovery of both sediment composition, grain size, and overall refilling rates
- Conduct more turbidity studies during dredging
- Determine if individuals displaced from a habitat by disturbance are able to successfully replace the lost energy and/or prey base elsewhere
- Ascertain the reproductive seasons of benthic organisms so that dredging can be timed to minimize impacts
- Ascertain whether the proposed mine site constitutes only a small fraction of available similar habitat and benthic prey resources within the wintering or other seasonal range of the affected predators, or if it is a significant fraction of the available habitat
- Determine whether there is site fidelity among migratory marine/estuarine vertebrates from year-to-year
- Investigate the extent to which affected species are directly killed and/or driven away by disturbance (either visually, aurally, or other senses) from impacted habitats
- Determine whether the number of killed/disturbed species and individuals is a significant proportion of the population
- Implement long-term studies to verify that post-dredging communities recover to pre-dredging conditions
- Identify which fish are subject to dredge entrainment and which are capable of avoidance
- Identify species that are preferred by predators
- Find out if nutrition, growth, and reproductive success of predators is linked to the type and amount of available prey. If so, determine the decline in production per unit area altered or lost
- Identify physical structures that serve as important habitat for migrating and resident fishes in areas where mining is proposed or currently taking place
- Determine the physical, biological, and biophysical processes of ridges and swales in the OCS region

Target Beach

To learn more about the general effects of turbidity, the following research needs have been identified:

- Determine turbidity and suspended sediment levels that are typically observed at the target beach, including during storm events, and document whether either turbidities or total

suspended solids (TSS) are elevated during nourishment operations compared to natural elevations. If so, determine the areal extent of these plumes.
- Identify consequences of elevated turbidity and sediment overburdens (especially for sediment over 1 meter in depth). Effects from reduced light penetration should be evaluated separately from physical/chemical effects, if possible, especially if experiments are in vitro, and the turbidity source may cause a chemical reaction.
- Define turbidity criteria (i.e. NTU) in terms of light requirement or silt tolerances of the various organisms in the project area
- Ascertain which life stages/species are most susceptible to turbidity impacts, and identify effects ranging from reduced feeding efficiency to death (this may be more practical for sessile fauna that are typically not subjected to high natural turbidities).
- Determine the likelihood that organisms of interest will encounter suspended sediment plumes
- Prolong the study time to learn more about the long-term effects of turbidity at the target beach, especially where wind- or wave- induced resuspension of sediments occurs
- Determine the fate of sediment that is washed away

To learn more about the effects on surf zone fish, the following research needs have been identified:

- Determine what fraction the fill area represents of the total available foraging / resting / breeding habitat of affected taxa
- Conduct fishery-independent surveys of surf zone fishes to determine the seasonality of each species, their relative abundance, and size structure
- Ascertain the significance of the fill area to predators (site fidelity)
- Compare species diversity before and after beach nourishment, and ascertain the abundance of species that are preyed upon by shorebirds and surf fishes
- Develop conceptual food web models and determine their validity
- Ascertain sediment concentration levels that cause behavioral changes and those that are sublethal (Most data that exist include only concentrations that induce mortality). Key species and life stages that are present during nourishment should be evaluated.
- Conduct more short-term sampling on smaller scales of ichthyoplankton in the surf zone and nearshore area. Conduct diel sampling to fully cover day/night and tidal cycle, and subsample larvae to look for signs of physiological damage or stress
- Determine the function of sand ridges and shoals as potential “essential habitat” by migrating or resident fish. There is also a need to determine if certain procedures for dredging these shoals and ridges would minimize ecological impacts

To learn more about the effects on sea turtles, the following research needs have been identified:

- Determine the effects of exposed pilings and other equipment on nesting females
- Ascertain the range of tolerance to different sediment by sea turtles and their eggs
- Continue experimentation with decompaction techniques, such as harrowing

Several general research needs have also been identified:

- Quantify the physical effects of beach bulldozing
- Determine the effects on polychaetes on the beach, which serve as an important food source for fish and crustaceans
- Study the effects on meiofaunal flatworms (turbellarians), which occupy the interstitial spaces between sand grains
- Determine the effects on shorebirds, including the fraction of the total available foraging / resting / breeding habitat that the area proposed for fill constitutes, and if they are limited by food supply in their growth and production

Adjacent Communities

Because there is essentially no current research into the effects on adjacent communities, the research needs are broad:

- Ascertain the extent to which filling of nearshore habitats cascades into adjacent areas and ecosystems

When monitoring studies expand their area to include nearby communities, it is likely that research needs will be more specific. The scientific community awaits more inclusive studies that will take all of these research needs into consideration.

GENERAL RECOMMENDATIONS

In addition to specific research needs, there are also a number of general recommendations. Some of the following recommendations may also be regarded as research needs, but they are listed in this section because they tend to be more general.

- The scoping process should include the effects of the life cycle of all segments of each project, not just the effects of the individual project segments
- Expand public involvement programs supported by the project sponsor, which should continue for the life of the project
- States should make collection of baseline environmental data a priority, with identification of unknown variables
- Use sand that is closely matched in grain size and chemical attributes to the natural beach to minimize environmental impacts
- Standardize studies so that similar methodology is used, to allow for better comparison among studies, projects, and specific recommendations
- Expand monitoring studies to include the entire littoral geographic region and adjacent littoral regions, rather than just the portion that the project occupies (may require legislation

that does not base project limits on political boundaries; will also require more funding to account for a larger monitoring area)

- Increase coordination among state agencies involved in beach manipulation activities
- Grant authority to state fisheries-management agencies to coordinate conservation plans and conduct properly designed studies that examine threats
- Adopt an ecosystem approach to reduce the fragmented approach towards assessing the impacts of beach nourishment
- Improve coordination by district Army Corps offices with state CZM programs and management policies of other federal agencies, to avoid projects that are contrary to the laws and regulations of coastal states and to the adopted policies of sister agencies
- Devise state permitting systems that track cumulative effects by individual permits in a given area, which should help managers identify other projects that may have a compounding effect
- Educate the public regarding how development in one area may effect an entire region
- Adopt state policies regarding beneficial use of dredged material for states that undertake frequent dredging of navigation channels
- Beach management agencies should utilize a variety of management techniques, such as land use controls, construction setbacks, and retreat policies in areas where it is feasible to implement them
- Determine which months are biologically inactive for prospective sites and conduct operations during this time (this may reduce direct mortality and also allow ample time for emplaced sand to be re-worked over the beach profile, which may allow a return to acceptable conditions for colonization)
- Identify physical features that offer significant habitat value to migrating or resident fish species that could be impacted during dredging or nourishing the target beach
- Experiment with mining sediment to shallower depths, wherever possible, which may allow for quicker benthic recolonization due to untouched sediment ridges left behind
- Avoid covering the vegetation at the base of the dune during beach filling, in areas where sea turtles are known to nest
- Fund more experimental research to help build mechanistic understanding of impacts
- Where possible, states should closely examine sand transfer and bypass methods, which are constructed in shallow water on the accretionary side of inlet jetties
- Develop interagency comprehensive coastal management plans with programmatic environmental impact statements (PEIS) for coastal activities whenever appropriate. Such designs could better identify the individual, cumulative, and secondary impacts from beach nourishment that occur over a larger area.

Turbidity

McCarthy *et al*. (1974) suggest that turbidity criteria be defined in terms of light requirement or silt tolerances of organisms. It is not uncommon for state turbidity standards to be exceeded when beach dredge-and-fill projects are underway (Reilly and Bellis, 1978; USDOI/USFWS, 2000). Ideally, these standards should be based on thresholds that cannot be exceeded in order to maintain the health of organisms and habitat in the vicinity of the project area. However, it is possible that these standards may not be conservative enough and state agencies may want to re-examine their turbidity standards. A study conducted by Telesnicki and Goldberg (1995) found that in vitro responses of two hard coral species from Florida showed increased respiration from elevated turbidity levels at 18 NTU. This value is below the Florida standard for coastal water turbidity (29 NTU) during construction. Researchers suggested that maintaining the current water quality standards in Florida could lead to short-term stress and long-term decline in some coral species.

When reviewing water quality standards, it may be useful for states to consider that some coastal areas have naturally high turbidity and may require different standards than areas that have less turbid conditions. It would also be appropriate to set these standards based on the organisms present in the coastal areas, with some areas requiring more stringent standards.

Research Design and the United States Army Corps of Engineers

The Army Corps has conducted numerous beach nourishment projects over the years, relying on their manual entitled *General Procedures for Conducting Offshore Sand Inventory Assessment Studies* to direct such studies. There are scientists that contend this manual is outdated and inadequate to fully assess the biological impacts and changes in seabed topography. Most studies include estimates of the volume of sediment removed from the site, but few have undergone rigorous studies that monitor the bottom bathymetry and sediment composition following dredging (NRC, 1995). One scientist has stated that because the Corps' monitoring designs use only empirical modeling, they are so defective that many important questions cannot be answered and conclusions of "no impact" cannot be accepted (Peterson, 2001). Other prominent scientists agree. A group of 70 researchers has urged the Corps to take action to improve their environmental monitoring of dredge and fill projects. Claims of no long-term impacts from dredging and filling of coastal habitats have been deemed "potentially false and, at best, premature (Lindeman *et al*., 2000)."

Critics would like to see more research that includes process-oriented science that incorporates experiments and modeling; current Corps monitoring studies have been deemed inefficient, imprecise, and inadequate (Peterson and Manning, 2001). For example, multiple sedimentological variables, seasonal timing of projects, spatial scale, temporal frequency, and history of previous modifications at the nourished beach and control sites may confound the ability of current methodology to detect significant changes (Peterson and Manning, 2001). There is also concern that personnel reviewing the results many not be properly trained to perform rigorous analysis of the data (Peterson, 2001).

CONCLUSION

With an estimated $17.7 billion spent by beach tourists in the state of Florida alone (FSBPA, 2001), and with many of the tourists along the Atlantic Coast visiting the beaches, it is clear there is going to be ongoing pressure to continue beach nourishment. What may not be clear, is whether or not the important environmental questions related to beach nourishment have been answered.

The impacts to many significant species, including those managed by the ASMFC, have yet to be defined. In order to determine what these effects may be, extensive changes to current modeling designs are required, in addition to, more experimental research (Peterson, 2002). Once these changes have been instituted, ongoing monitoring must be conducted until recovery is achieved. Adverse effects should be minimized whenever possible, (both in terms of scale and duration) through appropriate engineering and design (Van Dolah, 2002).

There is also a pressing need to quantify the relationship between fish species and their habitat, especially for early-life stages, which are more vulnerable to environmental degradation. There is currently a lack of information regarding distribution, abundance, and composition of early life stages for surf zone fish. Diaz *et al*. (in prep.) found a strong relationship between the abundance of juvenile fish and benthic habitat that contained seemingly small physical structures. Fish not only showed a strong affinity for more spatially complex habitat during the day, but at night, this pattern was reversed, as fish retreated to bare sandy habitats. Researchers should determine which habitat is considered essential for fish species of importance so that proper steps can be taken to minimize or avoid impacts.

Researchers have become increasingly concerned with the frequency that beaches are renourished. One study (Leonard *et al*., 1990) found that 88% of Atlantic coast artificial beaches had to be renourished within five years of initial nourishment. Areas that are slow to return to pre-nourishment conditions may never fully recover before the beach is renourished again. Long-term monitoring that continues until the site is fully recovered is critical to prevent repeated events from creating cumulative impacts on the environment.

Some states have already begun looking beyond the territorial waters for sources of sand, in the Exclusive Economic Zone (EEZ), to ensure that their sediment needs will be met for years to come. Between 1995 and 2001, only ten projects used OCS sand in their beach nourishment projects (USDOI/MMS, 2002). Mining for beach nourishment in the EEZ is likely to increase in the near future, which underscores the need to ensure that monitoring methods are adequate before large-scale mining begins.

While it is not likely that sand supplies will fall short in the next few years, state and local coastal planners may want to reconsider their coastal planning policies. Included in this examination is developing options to abandon existing structures. At present, federal funding is not available to help state and local governments engage in abandonment operations. Guidance is available for studies of restoring aquatic ecosystems (NRC, 1992) and restoring marine habitat (NRC, 1994), and states should consider planning now. They may also want to reconsider any further planning and development along stretches of coastline that are sure to require constant renourishing throughout the next decade.

Research needs and recommendations have been offered by the scientific community. These changes will require large contributions of funds to implement, and given the enormous revenue generated from beach tourism, it may be appropriate to allocate additional revenue from beach-related tourism towards these programs. States and the federal agencies should take a close look at these suggestions and determine if they are applicable to their environmental monitoring needs. Gaining a comprehensive understanding of how the various fish and benthic communities fit into the larger ecosystem will be necessary for researchers to fully assess how anthropogenic activities affect beach and nearshore ocean ecosystems, fishes, and fisheries. Only then will state and federal agencies be able to state with confidence that their monitoring programs are rigorous and adequate to measure beach nourishment impacts on the environment.

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Appendix A The Federal Beach Nourishment Process

Reconnaissance Study

In the event that a local community/and or local government lacks necessary financial resources, technical expertise, or jurisdiction to undertake a water resources project alone, they may request federal assistance for a project. The local or state government requests the U.S. Army Corps of Engineers (Corps) to initiate a reconnaissance study. If Congress authorizes the study, a project manager is selected from a Corps district office to coordinate the project through the study, design, and construction phases. The Reconnaissance Study is 100% federally funded and typically takes 12-18 months to complete. The objectives of the Reconnaissance Study are to: (1) determine if the water resources(s) problems warrant federal participation in feasibility studies; (2) define the federal interest; (3) complete a 905(b) Analysis; (4) prepare a Projects Management Plan; (5) assess the level of interest and support from non-federal entities; and (6) negotiate and execute a Feasibility Cost Sharing Agreement. The 905(b) Analysis is the Reconnaissance Report, which is submitted at the conclusion of the Reconnaissance Study, and contains among other requirements, the views of other agencies regarding the proposed project.

Feasibility Study

If the Reconnaissance Study finds that both a need and federal interest exists, then Congress can authorize a Feasibility Study. This Feasibility Study is cost-shared 50% by the federal government and 50% by non-federal interests, and may take 18-36 months to complete. During this phase, consultations take place between the applicant, Corps district staff, and federal, state, and local agencies. Together, they plan alternatives to the water resources problem, evaluate the costs and benefits of the alternatives, and discuss procedures for reducing impacts. The interested public may also take part in these discussions. Key elements included in the Feasibility Study are project design and engineering sand sources, environmental analysis, and determination of a "National Economic Development (NED) plan." The Principles and Guidelines, published in 1983 by the U.S. Water Resources Council, are used by water resources agencies during this planning phase (USACE, 2001b).

The Planning Process

The Corps relies on the economic and environmental Principles and Guidelines (P&G) to guide them through the planning process of all their civil works projects. At the heart of the P&G is the Federal Objective. It states that "water and related land resources planning is to contribute to national economic development (NED) consistent with protecting the Nation's environment, in accordance with national environmental statutes, applicable executive orders, and other federal planning requirements." Direct net benefits identified in the NED are viewed as favorable not only to the planning area, but the overall Nation. Examples of benefits include a reduction in damages to structures and contents, loss of land, and reduced emergency costs. For all beach nourishment projects, the alternative plan that reasonably maximizes net economic benefits consistent with protecting the nation's environment, the NED plan, will be selected.

Planning a water resources project requires that state and local needs be addressed and that their participation occurs throughout the process. All planning studies conducted by the Corps follow a six-step process defined in the P&G:

Step 1 – Identifying problems and opportunities
Step 2 – Inventorying and forecasting conditions
Step 3 – Formulating alternative plans
Step 4 – Evaluating alternative plans
Step 5 – Comparing alternative plans
Step 6 – Selecting a plan

Identifying Problems and Opportunities

During the first step, partnerships between project sponsors and other stakeholders are established. Project sponsors may include a state, a political subpart of a state or group of states, a Native American Nation, quasi-public organizations chartered under state laws (i.e. a port authority, flood control district, water management district or conservation district), an interstate agency and, in some cases, a non-profit organization. Project sponsors and non-federal participants help identify water resources problems, opportunities for solving them, the study planning objectives, and the constraints that limit the planning process.

All federal agencies involved in water resources projects are required to initiate the scoping process, as required by the National Environmental Policy Act of 1969 (NEPA). The NEPA scoping process seeks to determine the range of issues to be addressed and identifies the significant issues related to a proposed action. Federal, state, and local agencies that develop and enforce environmental standards should participate in the scoping process. Included in this group are state fish and wildlife agencies that help identify fish and wildlife concerns, give opinions regarding the significance of these resources, list anticipated impacts, and specify resources to be evaluated in the study. Public involvement is also integral to the scoping process, and meetings are typically convened early in the process to attract parties interested in participating. Scoping is often combined during this first step of planning to help identify important issues that may be addressed later in the planning process. The Corps will prepare a draft statement regarding the impacts of the project in accordance with NEPA, and all interested parties are expected to comment.

Inventorying and Forecasting Conditions

The next step requires participants to make qualitative and quantitative descriptions of critical resources (physical, demographic, economic, social, etc.,) that might be affected by the proposed project. It is at this stage that potential sources of sand are investigated. Both existing and forecasted future without-project conditions should be documented so that accurate impact assessments can be made.

The United States Geological Survey (USGS) is the lead United States' agency for conducting surveys, investigations, and research of the earth's resources. In addition to locating potential sand sources, the USGS also analyzes the physical, chemical, and biological processes in the surrounding area in an effort to determine the environmental consequences of developing these resources. The USGS often coordinates its activities with the interest, needs, and activities of the Army Corps and the Department of the Interior's (DOI) Minerals Management Service (MMS) (USGS, 2002). The MMS is responsible for overseeing development of the submerged lands of the outer continental shelf (OCS) seaward of state territorial waters. The MMS has been granted the authority to negotiate, on a non-competitive basis, the rights to OCS sand, gravel, or shell resources for shore protection and beach restoration funded, in whole or part, or authorized by the federal government. Non-federal interests are exempted from assessment of fees for the use of these OCS resources, for projects authorized or funded by the federal government.

Formulating, Evaluating, and Comparing Alternative Plans

The next step is to identify possible management measures, giving equal consideration to structural and non-structural alternatives. In formulating alternative plans, four criteria must be considered as described in the P&G: completeness, efficiency, effectiveness, and acceptability. Acceptability is the extent to which the alternative plans comply with applicable laws, regulations, and public policies. Except for ecosystem restoration, each alternative plan must account for adverse effects through mitigation of those effects.

Once alternative plans have been fully formulated, these plans must be evaluated both economically and environmentally. The alternative plan that maximizes net economic benefits consistent with protecting the study area and the Nation's environment, referred to as the NED plan, is usually selected. There are exceptions to this rule, such as when a non-Federal sponsor cannot support the NED (i.e.: economic reasons), in which case, a Locally Preferred Plan may be selected. The period of evaluation is also determined at this point, such as a 50-year beach nourishment project.

Section 102 of NEPA requires that any federal action that may significantly affect the quality of the human environment include the following: 1) the environmental impacts of the proposed action; 2) any adverse environmental effects which cannot be avoided should the proposal be implemented; 3) alternatives to the proposed action; 4) the relationship between local short-term uses of man's environment and the maintenance and enhancement of long-term productivity; and 5) any irreversible and irretrievable commitment of resources which would be involved in the proposed action should it be implemented. Alternative plans must also be evaluated for their environmental impacts.

An Environmental Assessment (EA) / Finding of No Significant Impact (FONSI) is issued if the project will not have a significant impact on the environment. A full Environmental Impact

Statement (EIS) is required if the project is expected to have a significant impact on the environment. For beach nourishment projects, non-structural alternatives must be evaluated in the NEPA study, as well as, relocation, retreat, land-use planning, and structural changes to reduce storm hazards. Secondary or indirect impacts must be analyzed, such as an increase in development along renourished beaches. Cumulative impacts must also be evaluated, which includes identifying relevant past, present, and future actions.

Fish and Wildlife Resources

Federal agencies are required to consult with the National Marine Fisheries Service (NMFS) regarding any activity, or proposed activity, authorized, funded, or undertaken by the agency that may adversely affect EFH (16 CFR 305(b)(2)). Adverse effects may include direct or indirect physical, chemical, or biological alterations of the waters or substrate and loss of, or injury to, benthic organisms, prey species and their habitat, and other ecosystem components, if such modifications reduce the quality of and/or quantity of EFH. Adverse effects to EFH may result from actions occurring within EFH or outside of EFH and may include site-specific or habitat-wide impacts, including individual, cumulative, or synergistic consequences of actions (67 FR 2343-2383 (17 January 2002)(600.810(a)). Federal agencies are not required to initiate consultation for actions that were completed prior to the approval of EFH designations by NMFS (16 CFR 305(b)(2)). For more information on EFH, see **Appendix C**.

The Federal agency notification to NMFS that an action may have potential adverse effects on EFH can be in the form of a Public Notice (PN), Draft Environmental Assessment (EA), or Draft Environmental Impact Statement (EIS). The EFH Assessment is the assessment by the federal agency of the effects of the proposed project and must contain the following: i) A description of the proposed action; ii) An analysis of the potential adverse effects of the action on EFH and the managed species; iii) The federal agency's views regarding the effects of the action on EFH; and iv) Proposed mitigation, if applicable (67 FR 600.920 (e)(3)(i-iiii). It is important to note that it is up to the federal agency to notify NMFS that an action may adversely affect EFH, and whether or not to initiate a consultation.

Upon receiving the completed EFH assessments, NMFS and the Councils are directed to provide comments and EFH Conservation Recommendations on actions that may adversely affect EFH. Such recommendations may include measures to avoid, minimize, mitigate, or otherwise offset adverse effects on EFH resulting from actions or proposed actions authorized, funded, or undertaken by that agency (16 CFR 305(b)(3-4)). These recommendations are advisory in nature. Finally, the federal agency is required to respond to recommendations made by NMFS and the Councils within 30 days. In the case where their actions are inconsistent with the Conservation Recommendations, the federal agency must also respond to NMFS and the Councils at least 10 days prior to final approval of action (305(b)(4)(B)). The response must include a description of measures proposed by the agency for avoiding, mitigating, or offsetting the impact of the activity on EFH. If the response is inconsistent with the Conservation Recommendations, the Corps must explain the reasons for not following the recommendations, including the scientific justification for any disagreements with NMFS over the anticipated effects of the proposed action and the measures needed to avoid, minimize, mitigate, or offset such effects (67 FR 600.920 (k)).

EFH Consultations

Consultations between the federal agency and NMFS for actions that may adversely impact EFH may be conducted using one of five different approaches, depending on the severity of impact: General Concurrence, programmatic consultation, abbreviated consultation, expanded consultation, or existing environmental review procedures (67 FR 600.920 (f-j)). A General Concurrence can be used for activities that are similar which are likely to result in no more than minimal adverse effects individually and cumulatively. When EFH conservation recommendations can be developed such that they address all reasonably foreseeable adverse impacts within a specific program area, a programmatic consultation may be appropriate. For those project areas that have great geographic variability and differences in aquatic resources, programmatic consultations may not be appropriate (Reubsamen, 2001; Greene, 2002). An abbreviated consultation is used when impacts to EFH are expected to be less than substantial, and often, minor design or operational changes can be made to the project to avoid such impacts. An expanded consultation provides the greatest opportunity for NMFS and the Corps to work together, and is used when the action is likely to have substantial adverse effects on EFH. A general concurrence does not require further consultation by NMFS because they have already determined from previous analyses, that the type of action will have minimal adverse effects individually and cumulatively (USDOC/NOAA, 1999; 67 FR 600.920).

To provide the greatest level of efficiency during the consultation process, EFH consultations are often incorporated into other environmental reviews required under other federal statutes such as the National Environmental Policy Act, Clean Water Act, Endangered Species Act (ESA), the Fish and Wildlife Coordination Act, and Federal Power Act. Often, Corps consultations will be subject to more than one of these statutes (i.e., ESA section 7 consultation and NEPA) (600.920 (f)).

Under Section 7 of the Endangered Species Act, consultations must also be initiated between the Corps and FWS/NMFS to insure that a proposed action will not jeopardize listed species or adversely modify its habitat. If it is determined that the proposed activity will jeopardize a federally listed species or adversely modify its habitat, FWS/NMFS must propose measures (contained in the biological opinion) to protect and conserve the species and its habitat.

Water Quality

Water quality is governed under Sections 401 and 404 of the Clean Water Act. The Corps has authority to discharge dredged or fill material into the water of the U.S. in accordance with guidelines under section 404. These guidelines developed by the EPA and the Corps, provide evaluation procedures for determining if the plan is in compliance with the Clean Water Act. Also required during the planning process is the State Water Quality Certification under Section

401. Under Section 401, discharges are evaluated using Section 404 guidelines, public notices are issued, and certification is obtained from the State or interstate water pollution control agency when the proposed action is determined to be in compliance with established effluent limitations and water quality standards. If the State is in charge of the 404 regulatory program, the 404 permit will serve as the certification of compliance. The degree to which the project is in compliance with state water quality certification will be identified in the EA/FONSI. A section 404 exemption may be obtained if the effects of the discharge are identified in the EIS.

Selection of a Final Plan

After the alternative plans have been evaluated both economically and environmentally, they are then compared, and a final plan is selected. A Feasibility Report and the final EIS (if applicable) are sent to federal agencies and governors of affected states for comment, and public comments are also considered. They have 30 days to respond. The EIS is also filed with the EPA. If Congress appropriates federal funds for the project (usually, but not always, under the Water Resources Development Act), a PCA Cooperation Agreement is signed, which binds non-federal sponsors and the Corps to implement, operate, and maintain the project in accordance with conditions instituted by Congress and the administration (including cost-share scheme). Based on the results of the Feasibility Study, the Corps may request Congress to authorize funds for the project, usually up to 50 years, but authorization of a project does not guarantee that funds will be appropriated. The Corps district office follows the project through the engineering and design phase, and private contractors perform construction with oversight by the Corps. Most projects are operated and maintained by the non-federal sponsors, and the Corps periodically inspects these projects for compliance.

The Water Resources Development Act

Beach nourishment projects are usually approved under the Water Resources Development Act, which is typically reauthorized every two years. The U.S. Army Corps of Engineers is authorized to carry out Civil Works water resources projects in seven areas:

- Navigation
- Flood damage reduction
- Recreation
- Hurricane and storm damage reduction
- Ecosystem restoration
- Hydroelectric power
- Water supply

Of these seven project areas, all except hydroelectric power and water supply can be used to fund disposal of clean sand on coastal beaches. Sometimes the project satisfies one purpose, such as protecting shoreline structures from hurricane and storm damage. Other projects satisfy more than one water resources problem by combining purposes for a single project. For example, during the construction or maintenance of inlets, channels, and harbors, navigation projects may dispose of beach-quality sand on nearby beaches when it is the least costly method for disposal. In cases where beneficial use of the dredged material is not the least costly method, authorization can be obtained if: 1) the state requests such action; 2) it is in the public interest; and 3) the added costs are justified by the hurricane and storm damage benefits.

Funding

The following is the cost share scheme for the five project areas that can be used for beach nourishment:

Purpose	Non-Federal Share
• Navigation – harbors	20%: depth < 20ft. 35%: depth 21-45 ft. 60%: depth > 45 ft.
• Navigation – inland	50%
• Flood Damage Reduction	35%
• Recreation	50%
• Hurricane and Storm Damage Reduction	35%
• Ecosystem Restoration	35%

The following are some recent federally funded 50-year projects along the East Coast that provide for periodic renourishment over the life of the project:

- Brevard County, FL (Shoreline protection) – Total cost: $76,620,000, Average Annual Cost for 50 years: $2,341,000 **WRDA 1996**
- Rehoboth Beach and Dewey Beach, DE (Storm damage reduction and shoreline protection) – Total cost: $9,423,000, Average Annual Cost for 50 years: $282,000 **WRDA 1996**
- Raritan Bay and Sandy Hook Bay, Port Monmouth, NJ (Hurricane and Storm Damage Reduction) – Total cost: $32,064,000, Average Annual Cost for 50 years: $173,000 **WRDA 2000**
- Dare County Beaches, NC (Hurricane and Storm Damage Reduction) – Total cost: $71,674,000, Average Annual Cost for 50 years: $34,990,000 **WRDA 2000**

Appendix B State Beach Nourishment Programs

In March 2000, the National Oceanic and Atmospheric Administration's (NOAA) Office of Ocean & Coastal Resource Management published a document entitled *State, Territory, and Commonwealth Beach Nourishment Programs: A National Overview* (USDOC/NOAA, 2000). This document summarized states' beach nourishment programs, including beach nourishment policies and projects funded from 1995-98. In July 2001, the ASMFC Habitat Program sent a survey to members of the Management and Science Committee and the Habitat Committee, requesting updated information on their state's beach nourishment programs. The NOAA document was referenced in the survey, and Management and Science Committee members were requested to verify that their state beach nourishment policy information was correct and up-to-date. They were also asked to update any beach nourishment projects that have been funded since 1998.

This appendix contains the results of the beach nourishment survey. All of the 15 East Coast states, except Pennsylvania, conduct beach nourishment along the Atlantic seaboard. Accordingly, Pennsylvania is not included in this appendix. For all of the other states, the information contained in the State Beach Nourishment Policy and Related Policies sections are taken verbatim from the NOAA document, unless there have been changes to that state's policies since the NOAA document was published. States that have had policy changes since publication, were amended using results from the survey. The Summary of Projects Funded section contains specific information about beach nourishment projects in the state from 1995-2001. For those states that did not respond to the survey or were unable to provide the information requested, the NOAA document was the sole source used to complete that state's section and there is less project specific information provided. This will be noted at the beginning of each state's section.

For each beach nourishment project, information is provided in the following format:

Name of Project and date initiated

A. The amount of sand dredged
B. The area of beach nourished
C. The source of sand (dredging site)
D. The method used for moving the sand (i.e. hopper dredge, hydraulic pipeline, etc.,)
E. The source of funding, with specific state and local entities identified
F. The agency or contractor that actually performed the beach nourishment operations

Note: The results from this survey are used simply to provide a general overview of the level of beach nourishment activity in each state, how operations are conducted, and the degree of involvement of different levels of government and private entities. For more detailed information about a particular project, contact the appropriate state or U.S. Army Corps of Engineers district office.

For many states, beach nourishment is an ongoing process that will continue for years to come. The ASMFC will periodically update the information on beach nourishment projects in each state and amend this appendix accordingly.

CONNECTICUT

Note: Survey results were not available for this state and the following information is taken verbatim from the NOAA document entitled, *State, Territory, and Commonwealth Beach Nourishment Programs: A National Overview*.

1.0 State Nourishment Policy

1.1 State has some policies regarding beach nourishment

1.2 Policy Citation and Description
Conn. Gen. Stat §22a-90 to 22a-112. Connecticut Coastal Management Act (CCMA). Conn. Gen. Stat §22a-92(b)(2)(F). Coastal Hazard Areas: Development to minimize hazards to life and property and promote nonstructural solutions to flood and erosion except where structural alternatives are necessary to protect existing inhabited structures, infrastructure and water-dependent uses.

Conn. Gen. Stat §22a-92(b)(2)(J). Coastal Hazard Areas: Maintain natural relationship between eroding and depositional coastal landforms; minimize adverse impacts of erosion and sedimentation on coastal land uses through nonstructural mitigation; structural solutions are permissible when necessary and unavoidable for protection of infrastructure, water-dependent uses, existing inhabited structures, and where not feasible, less environmentally damaging alternative and where all reasonable mitigation measures and techniques minimize adverse environmental impacts.

Conn. Gen. Stat §22a-92(c)(1)(B). Tidal Wetlands: Disallows any filling of tidal wetlands and nearshore, offshore and intertidal waters for the purposes of creating new lands from existing wetlands or coastal waters unless adverse impacts on coastal resources are minimal.

2.0 Related Policies

2.1 Near Shore Sand Mining Regulations
Not applicable.

2.2 Dredge and Fill Regulations
Conn. Gen. Stat 22a-92(b)(1)(D), 22a-92(c)(1)(D), 22a-359(a) as referenced by 22a-92(a)(2). CCMA. Coastal Structures and Filling: requires that all structures in tidal wetlands and coastal waters are designed, constructed and maintained to minimize adverse impacts on coastal resources, circulation and sediment patterns, flooding and erosion, and to reduce to the maximum extent practicable the use of fill; filling of tidal wetlands and nearshore for the purpose of creating new land is disallowed; and, the commissioner of environmental protection shall regulate dredging and the placement of fill.

Conn. Gen. Stat §22a-359 to 22a363f. Structures, Dredging and Filling: regulates dredging and erection of structures and the placement of fill in the tidal and coastal waters to prevent or alleviate shore erosion, preserve wildlife habitat, development of adjoining uplands, etc. Requires state permit for placement of structures, fill or dredging below High Tide Line (HTL) consistent with CCMA policies. Incorporates regulation of commercial excavation of in-water sand and gravel, which requires $2.00/cubic yard royalty payment. Activities that may be consistent include: a) Filling along beach/dune for beach nourishment depending on quality of sand, minimizing water quality impacts, fill beach slope to maintain same natural beach slope, and limit destruction to dune vegetation/shore bird nesting/breeding habitat; b) Disposal of appropriate dredged material for beach nourishment or dune management.

Conn. Gen. Stat 22a-92(c)(1)(C), 22a-92(c)(1)(D), 22a-92(c)(1)(E), 22a-383 as referenced by 22a-92(a)(2). All of these citations are part of Connecticut's Coastal Management Program Policies on Dredging and Navigation.

2.3 Sand Scraping/Dune Reshaping Regulations
Yes, but only as part of beach/dune nourishment/filling.

2.4 Dune Creation/Restoration Regulations
Conn. Gen. Stat §22a-92(b)(2)(C). Beaches and Dunes: Encourages the restoration and enhancement of disturbed or modified beach systems.

2.5 Public Access Regulations
Connecticut Coastal Management Program. Part IV. Coastal Policies and Use Guidelines. Coastal Recreation and Access. Public access is encouraged and required as a condition in permitting new beach stabilization structures.

<u>3.0 Summary of Projects Funded (1995-1998)</u>

1) Savin Rock – West Haven Beach Nourishment/Revegetation/Rock Armoring

A. 71,500 cubic yards
B. ¼ mile (also used 700 tons of armoring stones)
C. Not available
D. Not available
E. $2.29 million (State 2/3, Local 1/3); cost of dune revegetation - $55,000
F. Not available

*Source: Tina Bernd-Cohen

DELAWARE

1.0 State Beach Nourishment Policy

1.1 The state has some policies regarding beach nourishment.

1.2 Policy Citation and Description
Regulations Governing Beach Protection and Use of Beaches. Part 4. Activities Requiring a Permit or Letter of Approval from the Division. 4.03: Construction of Beach Erosion Control/Shore Protection Structures/Facilities Seaward of the Building Line. A permit is required for beach nourishment projects. 4.07: Mitigating Measures. Allows beach nourishment to be used as a form of mitigation.

Division of Soil and Water Conservation: Shoreline and Waterway Management Section. Responsible for beach preservation projects, such as major beach nourishment along oceanfront communities. Key programs include:
1) Dune Maintenance Program – conducts dune construction and maintenance on all public beach lands including repairing coastal storm damage to dunes, planting dune grass, erecting dune fence, and constructing and maintaining pedestrian and vehicular dune crossings; and 2) Technical Engineering Program – monitors the condition of the state's beaches through surveys designed to measure actual sand losses. This work element has supplied critical data needed to determine beach nourishment needs and has been a basis for federal assistance for sand replacement in declared disasters in Delaware.

The Division also coordinates with the U.S. Army Corps of Engineers on all federal shoreline protection studies and projects and oversees the operation of the Sand Bypass Facility at Indian River Inlet. The facility is designed to maintain the coastline on the north side of the inlet and protect the coastal highway and bridge approach at that location. It operates by excavating (dredging) sand accumulated on the beach south of the inlet jetty and pumping it to the north side beach to replace that which is lost annually due to normal erosion processes and storm occurrences.

2.0 Related Policies

2.1 Near Shore Sand Mining Regulations
Del. Code Ann. Tit. 23, §1707. Establishes guidelines for sand removal; with the exception of gravel.

Del. Code Ann. Tit. 7, §6805. A permit is required to alter, dig, mine, move, remove or deposit any substantial amount of beach or other materials, or remove a significant amount of vegetation on any beach seaward of the Building Line which may affect enhancement, preservation or protection of beaches.

2.2 Dredge and Fill Regulations

Del. Code Ann. Tit. 23, §1706. No sand shall be dug, mined, removed or carries away from any public or private beach extending from mean high watermark to the Ocean Highway between Rehoboth and the Maryland state line.

2.3 Sand Scraping/Dune Reshaping
Del. Code Ann. Tit. 7, §6803. Allows construction, reconstruction and maintenance of dunes when necessary in order to prevent and repair damages from erosion of public beaches.

2.4 Dune Creation/Restoration
Del. Code Ann. Tit. 7, §6803. Allows construction, reconstruction and maintenance of dunes when necessary in order to prevent and repair damages from erosion of public beaches.

2.5 Public Access Regulations
Del. Code Ann. Tit. 7, §4701(c). Publicly owned beaches and shorelines shall be managed and maintained to assure adequate and continued public access to these areas within the carrying capacity of the resource.

3.0 Summary of Projects Funded (1995 – 2001)

1) Little Creek Wildlife Area (1995, 1999)

A. 50,000 cy (1995)
   53,000 cy (1999)
B. 4,500 lf (southern end of Ted Harvey Tract)
C. Offshore
D. Hydraulic pipeline dredge
E. 100% State
F. DNREC, Division of Soil and Water Conservation

2) Kitts Hummock (1996)

A. 32,850 cy
B. 1,500 lf (south end)
C. Offshore
D. Hydraulic pipeline dredge
E. 100% State
F. DNREC, Division of Soil and Water Conservation

3) Broadkill Beach (1996, 2000)

A. 25,000 cy (1996)
   36,200 cy (2000)
B. 1,200 lf (south central)
   1,600 lf (north central)
C. Offshore

D. Hydraulic pipeline dredge
E. 100% State
F. DNREC, Division of Soil and Water Conservation

4) Bowers Beach (1998)
A. 86,250 cy
B. 2,800 lf (entire community)
C. Offshore
D. Hydraulic pipeline dredge
E. 100% State
F. DNREC, Division of Soil and Water Conservation

5) Lewes Beach (1998)
A. 30,900 cy
B. 1,000 lf (adjacent to Roosevelt Inlet)
C. Roosevelt Inlet
D. Hydraulic pipeline dredge
E. 100% Federal
F. Corps of Engineers

6) Rehoboth Beach (1998)
A. 274,300 cy
B. 3,500 lf (Laurel Street to Lake Avenue)
C. Offshore (Hen & Chicken Shoal)
D. Hydraulic pipeline dredge
E. 100% State
F. DNREC, Div. of Soil and Water Conservation (Great Lakes Dredge & Dock Co.)

7) South Bowers Beach (1998, 2000)
A. 10,300 cy (1998)
   2,500 cy (2000)
B. 800 lf (south end)
C. Murderkill River entrance channel
D. Hydraulic pipeline dredge
E. 100% Federal
F. Corps of Engineers

8) Pickering Beach (2001)
A. 27,150 cy
B. 2,400 linear feet (entire community)
C. Offshore
D. Hydraulic pipeline dredge

E. 100% State
F. DNREC, Division of Soil and Water Conservation

9) Dewey Beach (1998)
A. 453,500 cy
B. 6,000 lf (entire community)
C. Offshore (Hen & Chickens Shoal)
D. Hydraulic pipeline dredge
E. 85% State/15% FEMA
F. DNREC, Div. of Soil and Water Conservation (Great Lakes Dredge & Dock Co.)

10) North Shores (1998)
A. 188,100 cy
B. 2,400 lf (entire community)
C. Offshore (Hen & Chickens Shoal)
D. Hydraulic pipeline dredge
E. 100% North Shores Board of Governors
F. Great Lakes Dredge & Dock Co.

11) Bethany Beach (1998)
A. 321,700 cy
B. 5,140 lf (entire community)
C. Offshore (Borrow Area 'E')
D. Hydraulic pipeline dredge
E. 67% State/20% FEMA/13% Town of Bethany Beach
F. DNREC, Div. of Soil and Water Conservation (Great Lakes Dredge & Dock Co.)

12) South Bethany (1998)
A. 168,900 cy
B. 4,300 lf
C. Offshore (Borrow Area 'E')
D. Hydraulic pipeline dredge
E. 71% State/27% FEMA/2% Town of South Bethany
F. DNREC, Div. of Soil and Water Conservation (Great Lakes Dredge & Dock Co.)

13) Sea Colony (1998)
A. 128,000 cy
B. 2,380 lf (entire community)
C. Offshore (Borrow Area 'E')
D. Hydraulic pipeline dredge
E. 100% Sea Colony Recreation Association
F. Great Lakes Dredge & Dock Co.

14) Fenwick Island (1998)

A. 56,100 cy
B. 1,000 lf (northern part of community)
C. Offshore
D. Hopper dredge
E. 73% State/27% FEMA
F. DNREC, Div. of Soil and Water Conservation (Great Lakes Dredge & Dock Co.)

FLORIDA

1.0 State Nourishment Policy

1.1 The state has extensive policies on beach restoration and nourishment.

1.2 Policy Citation and Description
Fla. Stat. Ch. 161.041. Permits required. A coastal construction permit is required for any physical activity undertaken specifically for shore protection purposes or artificial nourishments.

Fla. Stat. Ch. 161.082. Review of innovative technologies for beach nourishment. The department is directed to periodically review innovative technologies for beach nourishment and, on a limited basis authorize, through the permitting process, experimental projects that are alternatives to traditional dredge and fill projects to determine the most effective and less costly techniques for beach nourishment.

Fla. Stat. Ch. 161.088. Declaration of public policy respecting beach erosion control and beach restoration and nourishment projects. Beach restoration and nourishment projects are declared to be in the public interest if they are in an area designated as critically eroded shoreline, have a clearly identifiable beach management benefit consistent with the state's beach management plan and are designed to reduce potential upland damage or mitigate adverse impacts caused by improved, modified, or altered inlets, coastal armoring, or existing upland development.

Fla. Stat. Ch. 161.101. State and local participation in authorized projects and studies relating to beach management and erosion control.

Fla. Stat. Ch. 161.091. Beach management; funding repair; and maintenance strategy. Ecosystem Management and Restoration Trust Fund is used to carry out the proper state responsibilities in a long-range statewide beach management plan for erosion control; beach preservation, restoration, and nourishment; and storm and hurricane protection. The department strategy includes: (a) Maximizing the infusion of beach-quality sand into the system; (b) Extending the life of beach nourishment projects and reducing the frequency of nourishment; and (c) Promoting inlet sand bypassing to replicate the natural flow of sand interrupted by inlets and ports.

Fla. Stat. Ch. 161.111. If a shore erosion emergency is declared by the Governor, the state, acting through the department, may spend whatever state funds are available to alleviate shore erosion.

Fla. Stat. Ch. 161.141. Property rights of state and private upland owners in beach restoration project areas. If an authorized beach restoration, beach nourishment, and erosion control project cannot reasonably be accomplished without taking of private property, the taking must be made by the requesting authority by eminent domain proceedings.

Fla. Stat. Ch. 161.142. Declaration of public policy relating to improved navigation inlets. While there is a need for maintaining navigation inlets, inlets alter the natural drift of beach-quality sand resources, which often results in these sand resources being deposited around shallow outer-bar areas instead of providing natural nourishment to the downdrift beaches. Therefore: (a) All construction and maintenance dredging of beach-quality sand should be placed on the downdrift beaches; or, if placed elsewhere, an equivalent quality and quantity of sand from an alternate location should be placed on the downdrift beaches; (b) On an average annual basis, a quantity of sand should be placed on the downdrift beaches equal to the natural net annual longshore sediment transport.

Fla. Stat. Ch. 161.161. Procedure for approval of projects, which includes the development and maintenance of a comprehensive long-term management plan for the restoration and maintenance of the state's critically eroded beaches.

Fla. Stat. Ch. 161.163. Designation of coastal areas which are utilized, or are likely to be utilized, by sea turtles for nesting, and guidelines for local government regulations that control beachfront lighting to protect hatching sea turtles.

2.0 Related Policies

2.1 Near Shore Sand Mining Regulations

Fla. Stat. Ch. 161.041. Permits required. Biological and environmental monitoring conditions included in the permit shall be based upon clearly defined scientific principles.

2.2 Dredge and Fill Regulations

Dredging and filling activities are regulated under Fla. Admin. Code. R. 62.312-0.80

2.3 Sand Scraping/Dune Reshaping Regulations

Fla. Admin. Code Ann. R. 62B-33.003. No person shall conduct any excavation seaward of the coastal construction control line or 50-foot setback except as provided in the Act and this Chapter. No person shall remove any beach material, or otherwise alter existing ground elevations, drive any vehicle on, over, or across any sand dune or the vegetation growing thereon, seaward of the coastal construction control line or 50-foot setback except as provided in the Act or this Chapter, or as otherwise provided by law.

2.4 Dune Creation/Restoration Regulations

Fla. Stat. Ch. 161.041. Permits required. A coastal construction permit is required for any physical activity undertaken specifically for shore protection purposes or artificial nourishments.

Public Access Regulations

Fla. Stat. Ch. 161.55. Public Access. Development or construction can not interfere with public access unless a comparable alternative accessway is provided.

3.0 Summary of East Coast Projects Funded (1995-2002)

The following is a list of beach nourishment projects along the Atlantic coast of Florida (including sand bypassing), and miles of beach nourished:

Project Name	Length (miles)	Activity
South Amelia Island Beach Restoration	3.3	Nourished - 2001
Duval Co. Beach Erosion Control	10.1	Nourished - 1996
Brevard Co. Beach Restoration – North	9.7	Restored - 2000
Patrick AFB Restoration	3.0	Restored - 2000
Brevard Co. Beach Restoration – South	2.6	Restored - 2001
Sebastian Inlet Bypassing	1.9	Bypassing - 1997, 1999, 2001
Ft. Pierce Inlet Management	1.0	Bypassing - 1995, 1998, 2001
Ft. Pierce Shore Protection Project	1.4	Nourished - 1999
Martin Co. 4-Mile Beach	4.2	Restored - 1996, Nourished - 2002
St. Lucie Inlet Management	1.0	Bypassing - 1997
Jupiter Island Beach Restoration Project	6.1	Nourished - 2002
Jupiter/Carlin Beach Restoration	1.0	Restored - 1995, Nourished - 2002
Juno Beach Restoration	2.5	Restored - 2001
Lake Worth Inlet Management	0.6	Annual bypassing
Mid Town Beach Restoration	1.2	Restored - 1995
Ocean Ridge Beach Nourishment	1.6	Nourished - 1997
Delray Beach Nourishment	2.8	1.7 m nourished in 2002
Boca Raton North	1.5	Nourished - 1998
Boca Raton South	1.0	Nourished – 1996, 2002
Deerfield Beach /Hillsboro Beach	1.2	Nourished - 1998
Broward Co. Beach Erosion Control Segment II	5.4	In design for nourishment
Broward Co. Beach Erosion Control Segment III	6.9	In design for nourishment
Miami Beach Restoration	13.4	1997-99, spot nourishments
Village of Key Biscayne Beach Restoration	2.4	Restored - 2002
Smathers Beach	0.6	Restored - 2001
TOTAL	86.4	

GEORGIA

1.0 State Nourishment Policy

1.1 Yes, Georgia has policies regarding beach nourishment.

1.2 Policy Citation and Description
The Georgia Shore Protection Act. Ga. Code Ann. §12-5-230. The Georgia Shore Protection Act outlines the permitting process and requirements for beach nourishment activities and the mechanism for funding such projects. A permit is required for all shoreline engineering activities, which include beach restoration or renourishment and artificial dune construction. All littoral property owners must consent in writing to the Beach Nourishment Project. The state holds all artificially accreted lands in trust for the benefit of the public.

A permit will be issued only if the activity will not impair the values and functions of the sand-sharing system including the coastal sand dunes, beaches, sandbars, and shoals, and if the activity is not contrary to the public interest. Public interest considerations include:
(1) Whether or not unreasonable harmful obstruction to or alteration of the natural flow of navigational water within the affected area will arise as a result of the proposal; (2) Whether or not the granting of a permit and the completion of the applicant's proposal will unreasonably interfere with reasonable access by and recreational use and enjoyment of public properties impacted by the project; and (3) Whether or not the granting of a permit and the completion of the applicant's proposal will unreasonably interfere with the conservation of fish, shrimp, oysters, crabs, clams or other marine life, wildlife, or other resources, including but not limited to water and oxygen supply.

2.0 Related Policies

2.1 Near Shore Sand Mining Regulations
Georgia's Surface Mining Act regulates all surface mining in Georgia, including the Coastal Zone. Dredging or ocean mining of materials is not directly regulated by state authority, except that sand and gravel operations are subject to the Shore Protection Act.

2.2 Dredge and Fill Regulations
Dredge and fill activities are regulated under the Coastal Marshlands Protection Act, Ga. Code Ann. §12-5-286. Erecting structures, dredging, or filling marsh areas requires a Marsh Permit and where the activity is carried out on state-owned tidal water bottoms, a Revocable License from the Coastal Resources Division may also be required.

2.3 Sand Scraping/Dune Reshaping
Under the Shore Protection Act, a permit is required for any activity that alters the natural topography of the sand dunes, beaches, and bars.

2.4 Dune Creation/Restoration
Under the Shore Protection Act, a permit is required for artificial dune construction.

2.5 Public Access Regulations
There are no state-level public access regulations, however, the Coastal Resources Division provides technical assistance to develop model ordinances for coastal access that can be used by local governments when developing local zoning ordinances.

<u>3.0 Summary of Projects Funded (1995-2001)</u>

1) Tybee Island (1995)

A. 342,000 cubic yards
B. 1.5 miles
C. 1.5 miles offshore and SE of Tybee
D. pipeline dredge with booster pump
E. $10.2 million total - $1 million – local govt., $2.8 million – state general fund, unspecified amount – city planning and engineering
F. Army Corps of Engineers – agency, Contractor - unknown

2) Sea Island (1997)

A. 500,000 cubic yards
B. 1 mile
C. Subtidal shoal on north end of island
D. Pipeline
E. Private funding
F. Sea Island Company – agency, Contractor – unknown

MAINE

1.0 State Nourishment Policy

1.1 The state does not have a policy for beach nourishment.

1.2 Policy Citation and Description
Not applicable.

2.0 Related Policies

2.1 Near Shore Sand Mining Regulations
Me. Rev. Stat. Ann. Tit. 38, §480. Maine Natural Resources Protection Act (NRPA). Any dredging, bulldozing, removing or displacing of soil, sand, vegetation or other materials within the coastal sand dune system and coastal wetlands require a NRPA permit.

2.2 Dredge and Fill Regulations
Me. Rev. State. Ann. Tit. 38, §480. Maine Natural Resources Protection Act (NRPA). Any dredging, bulldozing, removing or displacing of soil, sand, vegetation or other materials within the coastal sand dune system and coastal wetlands require a NRPA permit. Filling, including adding sand or other material to a sand dune requires a NRPA permit.

Guides for Municipal Shoreland Zoning Ordinances. Section 11. Land Use Standards. Erosion and Sedimentation Control (E). All filling, dredging and other earth-moving activities should be done in a way that prevents erosion.

2.3 Sand Scraping/Dune Reshaping Regulations
Guides for Municipal Shoreland Zoning Ordinances. Section 11. Land Use Standards. Erosion and Sedimentation Control (E). All grading and other earth-moving activities should be done in a way that prevents erosion.

Me. Rev. Stat. Ann. Tit. 38, §480. Maine Natural Resources Protection Act (NRPA). Any dredging, bulldozing, removing or displacing of soil, sand, vegetation or other materials within the coastal sand dune system and coastal wetlands require a NRPA permit. Filling, including adding sand or other material to a sand dune requires a NRPA permit. Coastal Sand Dune Rules do apply also.

2.4 Dune Creation/Restoration Regulations
NRPA Permit by Rule Standards Ch. 305:16. Dune restoration/construction and beach nourishment projects must use sand with texture and color characteristics consistent with natural sand texture and color and minimize damage to existing dune vegetation and follow configuration and alignment of adjacent dunes as closely as possible.

Me. Rev. Stat. Ann. Tit. 38, §480. Maine Natural Resources Protection Act (NRPA).

Any dredging, bulldozing, removing or displacing of soil, sand, vegetation or other materials within the coastal sand dune system and coastal wetlands require a NRPA permit. Filling, including adding sand or other material to a sand dune requires a NRPA permit.

Sand Dune Law 38: Regulates dune restoration. State and local dune restoration projects have occurred.

2.5 Public Access Regulations
Not applicable.

3.0 Summary of Projects Funded (1995-2001)

The state of Maine has not directly funded beach nourishment projects, nor have there been any extensive sand volumes added to beaches by private individuals. There have been numerous times beaches have been nourished (and funded) by federal projects. Disposal on beaches is a "beneficial use" and not the main reason the Corps has dredged sandy channels in Maine. They dredge in Maine to clear navigation channels of sediment, not to nourish beaches. If the dredged material is sandy, the state usually insists on beach or nearshore disposal to help nourish adjacent beaches.

1) Camp Ellis (1996) – Navigation
A. Not available
B. Not available
C. Not available
D. Suction cutter dredge/hydraulic pipeline
E. $1,180,000 – 100% Federal
F. Private contractor – unknown

2) Wells Beach and Drakes Island Beach (2001) - Navigation
A. 180,000 cubic yards
B. Not available
C. Wells Harbor
D. Suction cutter dredge/hydraulic pipeline
E. $2.6 million ($2,115,000 – Federal; $485,000 Local)
F. private contractor - unknown

MARYLAND

1.0 State Beach Nourishment Policy

The state does not have a beach nourishment policy.

1.2 Policy Citation and Description
Not applicable.

2.0 Related Policies

2.1 Near Shore Sand Mining Regulations
Md. Code Ann., Nat. Res. §7-6A07. Requires a permit for near shore sand mining.

2.2 Dredge and Fill Regulations
Md. Code Ann., Nat. Res. §9-202. Requires a license to dredge or fill on state wetlands.

Md. Code Ann. Env. §5-1104.2. Defines beneficial use of dredge material and guides placement in open water.

2.3 Sand Scraping/Dune Reshaping Regulations
Md. Code Ann., Nat. Res. §8-1105.1. Allows sand scraping/dune reshaping if for storm control, beach erosion and sediment control or maintenance projects to benefit the Beach Erosion Control District.

2.4 Dune Creation/Restoration Regulations
Not applicable.

2.5 Public Access Regulations
Not applicable

3.0 Summary of Projects Funded

Ocean City Beach Replenishment and Hurricane Protection Project (1988-2001)

A. Phase I – 2.5 million cubic yards (1988)

Phase II – 6.5 million cubic yards (1990-1994)

1998 Periodic Nourishment – 1.25 million cubic yards

B. Project includes Inlet to MD/Delaware line – 9 miles
C. Shoals 1-3 miles offshore
D. Method varies depending on contractor, amount to be dredged and location of placement sites for each particular project. Usually the contractors use hopper dredges, however, twice a cutter head dredge was used.

E. Local share: State of Maryland (50%), Town of Ocean City (25%) and Worcester County (25%)
   Phase I - 100% local money
   Phase II - 65% Federal/35% local
   Maintenance: 100% local
   Periodic nourishment - 53% Federal/47% local
   Phase II: U.S. Army Corps of Engineers 65%, State 17.5%, Worcester County and Town of Ocean City 8.75% each. 6.0 million cubic yards of sand
F. Phase I - Contracted by State of Maryland, Contractor – American Dredging / Great Lakes Dredge and Dock
   Phase II - Contracted by Corps, Contractor - Great Lakes -1990-1991,
   T.L. James – 1992, Great Lakes – 1994
   1998 Periodic Nourishment contracted by Corps - Great Lakes
   All maintenance work contracted by State Of Maryland

Assateague Island National Seashore and **Assateague State Park** are being restored in 2001-2002. Costs are shared by state ($1.2 million) and the U.S. Army Corps of Engineers ($13 million).

MASSACHUSETTS

Note: Survey results were not available for this state and the following information is taken verbatim from the NOAA document entitled, *State, Territory, and Commonwealth Beach Nourishment Programs: A National Overview*.

1.0 State Nourishment Policy

1.1 The state has some policies regarding beach nourishment.

1.2 Policy Citation and Description
MA Coastal Zone Management Program Policies. Coastal Hazard Policy #1. Preserve, protect, restore, and enhance the beneficial functions of storm damage prevention and flood control provided by natural coastal landforms, such as dunes, beaches, barrier beaches, coastal banks, land subject to coastal storm flowage, salt marshes, and land under the ocean.

2.0 Related Policies

2.1 Near Shore Sand Mining
MA Coastal Zone Management Program Policies. Ocean Resources Policy #3. Accommodate offshore sand and gravel mining needs in areas and in ways that will not adversely affect shoreline areas due to alteration of wave direction and dynamics, marine resources and navigation. Mining of sand and gravel, when and where permitted, will primarily be for the purpose of beach nourishment.

2.2 Dredge and Fill Regulations
MA Coastal Management Program Policies. Port Policy #1. Ensure that dredging and disposal of dredged material minimize adverse effects on water quality, physical processes, marine productivity and public health.

MA Coastal Management Program Policies. Ocean Resources Policy #3. Accommodate offshore sand and gravel mining needs in areas and in ways that will not adversely affect shoreline areas due to alteration of wave direction and dynamics, marine resources and navigation. Mining of sand and gravel, when and where permitted, will primarily be for the purpose of beach nourishment.

Mass. Gen. L. ch. 91, §1-63. Public Waterfront Act. Mass. Regs. Code tit., 310, §9. Waterways Regulations. Applies to projects conducted below the mean high tide line.

Mass. Gen. L. ch 131, §40. Wetlands Protection Act. Mass. Regs. Code title, 310, §10. Wetlands Regulations. Proposed projects must meet the performance standards of the wetlands protection act.

Mass. Gen. L. ch. 132A, §12, 13, 16-18. Ocean Sanctuaries Act. Mass. Regs. Code tit., 302, §5. Ocean Sanctuaries Regulations. Proposed projects within the five designated ocean sanctuaries are subject to these regulations.

Mass. Gen. L. ch. 21A, §2. Areas of Critical Environmental Concern. Mass. Regs. Code tit., 301, §12. Proposed projects with designated Areas of Critical Environmental Concern are subject to these regulations.

Mass. Gen. L. ch 21. Mass. Regs. Code tit., 314, §9. Water Quality Certification Program. Proposed projects involving dredging of fill below the mean high water line are subject to these regulations.

2.3 Sand Scraping/Dune Reshaping Regulations
The Massachusetts Coastal Zone Management Program policies do not directly address this issue in detail. However, this activity has been found to be inconsistent with the performance standards for coastal dunes under the Wetlands Protection Act by the Massachusetts Department of Environmental Protection, Mass. Gen. L. ch. 131, §40. And Mass. Regs. Code tit., 310, §10.28.

2.4 Dune Creation/Restoration Regulations
Mass. Gen. L. ch. 131, §40. Wetlands Protection Act. Mass. Regs. Code tit., 310,§10. Wetlands Regulations. Proposed projects must meet the performance standard of the Wetlands Protection Act.

2.5 Public Access Regulations
Mass. Gen. L. ch. 91, §1-63. Public Waterfront Act. Mass. Regs. Code tit., 310, §9. Waterways Regulations. Applies to projects conducted below the mean high tide line.

3.0 Summary of Project Funded (1995-98)

1) Quincy Shore Beach (Wollaston Beach), 1996. Cost: $663,000 (State/Local)

2) Long Beach, Barnstable, 1986, 90,000 cu yards. 1999, 60,000 cu yards. Funding: Private

3) Dead Neck Island, Barnstable, 1986, 115,000 cu yards. 1998, 100,000 cu yards. Funding: Private

4) Great Island, Barnstable, 1986, 80,000 cu yards. Funding: Private

*There are an additional 25 dredging projects a year in Massachusetts where clean, compatible dredged material is used for beach nourishment.

NEW HAMPSHIRE

1.0 State Nourishment Policy

1.1 The state has some policies regarding beach nourishment. Shoreline erosion is a problem of limited scope since the state only has 10.2 miles of beachfront.

1.2 Policy Citation and Description
New Hampshire Coastal Program Policies – July 1988. Coastal Dependent Uses #14. Preserve and protect coastal and tidal waters and fish and wildlife resources from adverse effects of dredging and dredged disposal, while ensuring the availability of navigable waters to coastal-dependent uses. Encourage beach renourishment and wildlife habitat restoration as a means of dredge disposal whenever compatible.

N.H. Rev. Stat. Ann. §482-A. I. Fill and Dredge in Wetlands Act. This statute regulates activities that excavate, remove, fill, dredge or construct any structures in or on any bank, flat, marsh, or swamp in and adjacent to any waters of the state without a permit from the department.

2.0 Related Policies

2.1 Near Shore Sand Mining Regulations
New Hampshire Coastal Program Policies – July 1988. Protection of Coastal Resources #3. Regulate the mining of sand and gravel resources in offshore and onshore locations so as to ensure protection of submerged lands, and marine and estuarine live. Ensure adherence to minimum standards for restoring natural resources impacted from onshore sand and gravel operations.

2.2 Dredge and Fill Regulations
N.H. Rev. Stat. Ann. §482-A. I. Fill and Dredge in Wetlands Act. This statute regulates activities that excavate, remove, fill, dredge or construct any structures in or on any bank, flat, marsh, or swamp in and adjacent to any waters of the state without a permit from the department.

New Hampshire Coastal Program Policies – July 1988. Coastal Dependent Uses #14. Preserve and protect coastal and tidal waters and fish and wildlife resources from adverse effects of dredging and dredged disposal, while ensuring the availability of navigable waters to coastal-dependent uses. Encourage beach renourishment and wildlife habitat restoration as a means of dredge disposal whenever compatible.

2.3 Sand Scraping/Dune Reshaping Regulations
N.H. Rev. Stat. Ann. §482-A. VII. Fill and Dredge in Wetlands Act. No person shall destroy, raze, reduce, alter, build upon or remove any sand or vegetation from any sand dune in this state without a permit from the department.

2.4 Dune Creation/Restoration Regulations

N.H. Rev. Stat. Ann. §482-A. VII. Fill and Dredge in Wetlands Act. No person shall destroy, raze, reduce, alter, build upon or remove any sand or vegetation from any sand dune in this state without a permit from the department.

2.5 Public Access Regulations
New Hampshire Coastal Program Policies – July 1988. Recreation and Public Access #7. Provide a wide range of outdoor recreational opportunities including public access in the seacoast through the maintenance and improvement of the existing public facilities and the acquisition and development of new recreational areas and public access.

3.0 Summary of Projects Funded (1995 – 2001)

1) Hampton Harbor (1998)
A. 5,000 cubic yards
B. Hampton Beach
C. Hampton Harbor
D. Hydraulic pump
E. Capital budget
F. Private contractor - unknown

2) Hampton Harbor (1998)
A. 14,500 cubic yards
B. Half-tide jetty
C. Seabrook Harbor
D. Hydraulic pump
E. State budget
F. Private contractor - unknown

3) Seabrook Harbor Dredge (1999)
A. 37,650 cubic yards
B. Half-tide jetty
C. Seabrook Harbor
D. Hydraulic pump
E. State budget
F. Private contractor - unknown

4) Seabrook Harbor Dredge (2001)
A. 8,000 cubic yards
B. 2,000 cubic yards to Hampton State Beach
C. Seabrook Harbor
D. Clam shell
E. State budget
F. Private contractor - unknown

NEW JERSEY

Note: Survey results were not available for this state and the following information is taken verbatim from the NOAA document entitled, *State, Territory, and Commonwealth Beach Nourishment Programs: A National Overview*.

1.0 State Nourishment Policy

1.1 The state has some policies regarding beach nourishment.

1.2 Policy Citation and Description
N.J. Admin. Code tit. 12 §5-3. Water Resources Development Act. Established funding for beach nourishment projects.

Beaches and Harbors Bond Act: PL 1978. C 157 and PL 1983. C 356. Responsible for the Comprehensive Shore Protection master Plan and also for funding erosion control and beach nourishment projects stressing non-structural approaches to erosion.

N.J. Admin. Code tit. 7 §7E – 4.42. Acceptable Conditions for Uses. Uncontaminated dredged sediments with 75% sand or greater are generally encouraged for beach nourishment (on ocean or open bay shores).

N.J. Admin. Code tit. 7 §7E – 7.11. Standards Relevant to Beach Nourishment. Beach nourishment projects, such as non-structural shore protection measures are encouraged, provided that: 1) The particle size and type of fill material is compatible with the existing beach material to ensure that the new material will not be removed to a greater extent than the existing material would be by normal tidal fluctuations; 2) The elevation, width, slope and form of proposed beach nourishment projects are compatible with the characteristics of the existing beach; 3) The sediment deposition will not cause unacceptable shoaling in downdrift inlets and navigation channels; and 4) Public access to the nourished beach is provided in cases where public funds are used to complete the project.

2.0 Related Policies

2.1 Near Shore Sand Mining Regulations
N.J. Admin. Code tit. 7 §7E – 4.42. Acceptable Conditions for Uses. Sand and gravel extraction is discouraged. Priority will be given to sand extraction for beach nourishment, and extraction is conditionally acceptable.

2.2 Dredge and Fill Regulations
N.J. Admin. Code tit. 13 §9A-1 et. seq. Wetlands Act of 1970. A Department of Environmental Protection permit is required for dredging, filling, removing or otherwise altering or polluting coastal wetlands.

N.J. Admin. Code tit. 7 §7E-4.42. Acceptable Conditions for Uses. Coastal Zone Management rules for dredging and dredged material disposal.

N.J. Admin. Code tit. 12 §3-21, 3-22. Requires proper license to dig, dredge or remove any deposits of sand or other material from lands of the state under tidewaters. Gives the Board the authority to issue the license.

N.J. Admin. Code tit. 12 §6B-1 to 6B-8. Includes the state findings and declarations relative to dredging and dredged material disposal. Establishes the Dredging Project Facilitation Task Force, a priority list for dredging projects, and the Dredging/Dredged Material Management and Disposal Plan.

2.3 Sand Scraping/Dune Reshaping Regulations
N.J. Admin. Code tit. 7 §7E-7.11. Standards Relevant to Dune Management. Allows dune restoration, creation and maintenance projects as non-structural shore protection measures as long as they are carried out in accordance with Subchapter 3A, Standards for Beach and Dune Activities.

2.5 Public Access Regulations
N.J. Admin. Code tit. 7 §7E-7.11. Standards Relevant to Beach Nourishment. Public access to the nourished beach is provided in cases where public funds are used to complete the project.

3.0 Summary of Projects Funded (1995-98)

1) **Sandy Hook**, 1995 – Storm and Erosion – 16,368 ft. renourished. Cost: $19,673,000 (Federal)

2) **Sandy Hook**, 1996 – Storm and Erosion – 12,672 ft. renourished. Cost: $16,300,000 (Federal)

3) **Ocean City**, 1995 – 10,560 ft. renourished. Cost: $1,269,546 (State/Local)

4) **Ocean City**, 1995 – Storm and Erosion – 24,816 ft. renourished. Cost: $5,922,269 (Federal)

5) **Cape May**, 1995 – Storm and Erosion – 4,800 ft. renourished. Cost: $2,683,150 (Federal)

*Source: Duke University Program for the Study of Developed Shorelines
Explanation of the funding category: this does not mean that all the funds used for a particular project were obtained exclusively from that source, but that the source listed was the primary source. For example, most federally funded projects are given authorization by Congress but local governments may still pay for 25% of the cost.

NEW YORK

Note: Survey results were not available for this state and the following information is taken verbatim from the NOAA document entitled, *State, Territory, and Commonwealth Beach Nourishment Programs: A National Overview*.

1.0 State Nourishment Policy

1.1 The state has some policies regarding beach nourishment.

1.2 Policy Citation and Description

N.Y. Envir. Conserv. Law §34. N.Y. Exec. Law §42. N.Y. Comp. Codes R. & Regs. tlt. 6, §505. N.Y. Comp. Codes R. & Regs. tlt. 19. §600. Divides erosion protection into structural and non-structural methods with preference given to non-structural methods. Beach nourishment is considered a structural erosion protection measure and is subject to several state laws and their associated regulations.

State of New York Coastal Management Program Document / FEIS. Policy 13. Beach nourishment that occurs as a result of beneficial disposal of dredged material is not held to the 30 year standard (of reasonably controlling erosion); it is recognized that beach nourishment is not the primary purposed of action and that placement of sand on the beach has benefits to natural protective features thus advancing other policies.

2.0 Related Policies

2.1 Near Shore Sand Mining Regulations

State of New York Coastal Management Program Document / FEIS. Policy 15. Mining of borrow sites for beach nourishment must not adversely impact coastal processes and natural protective features so that erosion of flooding is exacerbated.

2.2 Dredge and Fill Regulations

N.Y. Envir. Conserv. Law §34. Coastal Erosion Hazard Areas Act N.Y. Comp. Codes R. & Regs. tit. 6,§505. Coastal Erosion Management Regulations. Activities allowed and permitted within natural protective features are dredging which is used for constructing or maintaining navigation channels, bypassing sand around natural and man-made obstructions, or artificial beach nourishment and deposition of clean sand or gravel within nearshore areas.

2.3 Sand Scraping/Dune Reshaping

Allowed, but DEC has placed requirements on beach dimensions – the beach must be 8 ft. high and 100 ft. wide before scraping is allowed. A permit is required.

State of New York Coastal Management Program Document / FEIS. Policy 17. Non-structural measures to minimize damage to natural resources and property from flooding and erosion shall be used whenever possible. This includes the reshaping of bluffs and dunes in order to strengthen coastal landforms.

2.4 Dune Creation/Restoration
State of New York Coastal Management Program Document / FEIS. Policy 17. Non-structural measures to minimize damage to natural resources and property from flooding and erosion shall be used whenever possible. This includes the strengthening of coastal landforms by planting appropriate and stabilizing vegetation on dunes.

2.5 Public Access Regulations
State of New York Coastal Management Program Document / FEIS. Policy 19. It is the policy of the State to: Protect, maintain, and increase the level and types of access to public water-related recreation resources and facilities.

State of New York Coastal Management Program Document / FEIS. Policy 20. It is the Policy of the State that: Access to the publicly-owned foreshore and to lands immediately adjacent to the foreshore or the water's edge that are publicly-owned, shall be provided and it shall be in a manner compatible with adjoining uses.

Together, these policies provide for maintenance of existing access, and development of new access (including transportation to a site, services, and parking) for publicly funded beach nourishment projects.

3.0 Summary of Projects Funded (1995-98)

1) **West Hampton Beach**, 1997 – Storm Damage Protection – 12,000 ft. nourished. Cost: $30,700,000 initially, plus $7 million every 3 years for 30 years of nourishment (Federal/State/Local)

2) **Great Gunn Beach (Great South Beach, Fire Island)**, 1995 – Navigation and Erosion Protection. Cost: $160,000 (Local)

3) **Smith Point County Park (Great South Beach, Fire Island)**, 1996 – Emergency Erosion Protection – 1,000 ft. nourished with 190,000 cu yards of material from an upland source. Cost: $2,400,000 (Local – Suffolk County)

4) **Water Island (Great South Beach, Fire Island)**, 1996 – Navigation and Erosion Protection – 1,000 ft. nourished. Cost: $470,000 (Local/Private)

5) **Hempstead Beach (Long Beach Island)**, 1996 – Navigation Disposal – 3,000 ft. nourished. Cost: $3,060,750 (Federal/State/Local)

6) **Rockaway Beach**, 1996 – Navigation Disposal – 4,000 ft. nourished. Cost: $2,400,000 (Federal/State/Local)

7) **Rockaway Beach**, 1996 – Storm Damage Protection – 6.2 mi. nourished. Cost: $22,500,000 (Federal/State/Local)

8) **Coney Island**, 1995 – Storm Protection Project – 18,340 ft. nourished. Cost: $9,270,000 (Federal/State/Local)

9) **Gilgo Beach**, 1996 – Navigation and Erosion Protection. Cost: $3,000,000 (Federal/State)

10) **Shinnecock Inlet**, 1997 – Navigation and Erosion Protection – 3,000 ft. nourished. Cost: $1,850,000 (State/Local – Suffolk County)

11) **Shinnecock Inlet**, 1998 – Navigation and erosion Protection – 3,500 ft. nourished with 405,000 cu yards of sand. Cost: $2,950,000 (69% Federal/31% State)

12) **Dune Road, Shinnecock Inlet**, 1995 – Emergency Erosion Protection – 1,435 and 1,359 cu yards on dune. Cost: $25,000 (State)

13) **Dune Road, Shinnecock Inlet**, 1996 – Emergency Erosion Protection – 1,000 ft. of dune nourished. Cost: $1,200,000 (State)

14) **Quogue**, 1996 – Emergency Erosion Protection – 91 ft. of dune nourished. Cost: $6,000 (Private)

15) **Moriches Inlet**, 1998 – Navigation and Erosion – 2,200 ft. of nearshore placement. Cost: $679,000 (69% Federal/31% State)

16) **Fire Island Pines**, 1996 – Erosion Protection – 7,000 ft. nourished with 500,000 cu yards. Cost: $3,000,000 (Private Erosion Control District Project)

17) **Jones Inlet Dredging**, 1996 – Erosion Protection – 458,000 cu yards placed on Long Island Beach. Cost: $2,913,800 (100% Federal)

*Source: Fred Anders, NY DOS

NORTH CAROLINA

1.0 State Nourishment Policy

1.1 The state has policies regarding beach nourishment. General Statute 113-229 (h1) provides that:

> "All construction and maintenance dredgings of beach quality sand may be placed on the downdrift beaches, or. if placed elsewhere, an equivalent quality and quantity of sand from another location shall be placed on the downdrift beaches."

This state law does not apply to the federal government.

1.2 Policy Citation and Description (Rules of the Coastal Resources Commission)
N.C. Admin. Code tit., 15A, r. 7M.1100. General Policy Guidelines for the Coastal Area. Policy on Beneficial Use and Availability of Materials Resulting from the Excavation or Maintenance of Navigation Channels. Certain dredged material disposal practices may result in removal of material important to the sediment budget of ocean and inlet beaches. This may, particularly over time, adversely impact important natural beach functions especially during storm events and may increase long term erosion rates. Ongoing channel maintenance requirements throughout the coastal area also lead to the need to construct new or expanded disposal sites as existing sites fill up. This is a financially and environmentally costly undertaking. In addition, new sites for disposal are increasingly harder to find because of competition from development interests for suitable sites. Therefore, it is the policy of the State of North Carolina that material resulting from the excavation or maintenance of navigation channels be used in a beneficial way wherever practicable:

(a) Clean, beach quality material dredged from navigation channels within the active nearshore, beach or inlet shoal systems must not be removed permanently from the active nearshore, beach or inlet shoal system unless no practicable alternative exists. Preferably, this dredged material will be disposed of on the ocean beach or shallow active nearshore areas where environmentally acceptable and compatible with other uses of the beach.
(b) Research on the beneficial use of dredged material, particularly poorly sorted or fine grained materials, and on innovative ways to dispose of this material so that it is more readily accessible for beneficial use is encouraged.
(c) Material in disposal sites not privately owned shall be available to anyone proposing a beneficial use not inconsistent with paragraph (a) of this Rule.
(d) Restoration of estuarine waters and public trust areas adversely impacted by existing disposal sites or practices is in the public interest and shall be encouraged at every opportunity.

N.C. Admin. Code tit. 15A, r. 7M.0201-0202. General Policy Guidelines for the Coastal Area. Shoreline Erosion Policies. (c) The replenishment of sand on ocean beaches can provide storm protection and a viable alternative to allowing the ocean shoreline to migrate landward threatening to degrade public beaches and cause the loss of public facilities and private property. Experience in North Carolina and other states have shown that beach restoration projects can present a feasible alternative to the loss or massive relocation of oceanfront development. In light of this experience, beach restoration and sand nourishment and disposal projects may be allowed when:

(1) Erosion threatens to degrade public beaches and to damage public and private properties.
(2) Beach restoration, nourishment or sand disposal projects are determined to be socially and economically feasible and cause no significant adverse environmental impacts.
(3) The project is determined to be consistent with state policies for shoreline erosion response and state use standards for Ocean Hazards, and Public Trust Waters, Areas of Environmental Concern and the relevant rules and guidelines of state and federal review agencies.

When these conditions can be met, the Coastal Resources Commission supports, within overall budgetary constraints, state financial participation in Beach Erosion Control and Hurricane Wave Protection projects that are cost-shared with the federal government and affected local governments pursuant to the federal Water Resources Development Act of 1986 and the North Carolina Water Resources Development Program (G.S. 143-215.70-73).

2.0 Related Policies

2.1 Near Shore Sand Mining Regulations

N.C. Admin. Code tit. 15A, r. 7H.0106, 7H.0208. Submerged lands mining rules and use standards for estuarine and public trust waters.

2.2 Dredge and Fill Regulations

N.C. Admin. Code tit. 15A, r. 7H.1500. Coastal Management. A General permit allows excavation within existing canals, channels, basins and ditches in estuarine and public trust waters for the purposed of maintaining previous water depths.

N.C. Admin. Code tit. 15A, r.7K.0401. Coastal Management. The USACE is exempt from permit requirements regarding maintenance of federal navigation channels. This includes dredging and disposal of dredged materials in Areas of Environmental Concern (AEC's). Projects must receive consistency approval from the North Carolina Division of Coastal Management.

2.3 Sand Scraping/Dune Reshaping Regulations

N.C. Admin. Code tit. 15A, r. 7H.1800. N.C. Coastal Management. A General permit allows beach limited bulldozing needed to reconstruct or repair frontal and/or primary dune systems. Research shows negligible beneficial effects for land owners and negative effects on ghost crabs.

2.4 Dune Creation/Restoration Regulations

N.C. Admin. Code tit. 15A, r. 7M.0202. General Policy Guidelines for the Coastal Area. Dune creation is allowed as a temporary measure to counteract erosion, but only to the extent necessary to protect property for a short period of time until threatened structures may be relocated or until the effects of a short-term erosion event are reversed.

2.5 Public Access Regulations
N.C. Admin. Code tit. 15A, r. 7M.0202 (d). Shoreline Erosion Policies. The following are required with state involvement (funding or sponsorship) in beach restoration or sand nourishment projects: (a) the entire restored portion of the beach shall be in permanent public ownership; and (b) it shall be a local government responsibility to provide adequate parking, public access and services for public recreational use of the restored beach.

2.0 Summary of Projects Funded (1995-98)

1) **Pea Island**, 1995 – Navigation – 2,000 ft. renourished. Cost: $1,725,242 (Federal)

2) **Ocracoke Island**, 1995 – Navigation. Cost: $149,489 (Federal)

3) **Topsail Island**, 1995 – Navigation – 389 ft. renourished. Cost: $277,749 (Federal)

4) **Topsail Island**, 1997 – Navigation

5) **Carolina Beach**, 1995 – Storm and Erosion – 11,600 ft. renourished. Cost: $3,281,211 (Federal). This beach is renourished every 3-4 years, as is Wrightsville beach

6) **Bald Head Island**, 1996 – 13,000 ft. renourished. Cost: $2,860,000 (Local/Private)

7) **Kure Beach**, 1997 – Storm and Erosion, Initial Construction – 18,000 ft. renourished. Beach will be renourished every 3-4 years.

Ocean Beach Management Projects in coastal North Carolina (all values = miles)[1]

Ocean beach management projects in coastal North Carolina (As of March 2002, all data in miles)

		Federal COE status			Local
Location	Type[2]	Exist	Authorized	Requested	project
Kitty Hawk North	SDR		4.5	2.2	
Dare County – Nags Head/Bodie Isl	SDR		10.5		
Pea Island NWR3 (Oregon Inlet)	DD	3.4			
Rodanthe[3]	DD	0.9			
Avon[3]	DD	3.1			
Hatteras[3]	DD	5.9			
Ocracoke[3]	DD	0.4			
Ocracoke[3]	DD	0.1			
Hatteras Island - NC 12	SDR			53.0	
Ocracoke Island - NC 12	SDR			17.0	
Core Banks	DD	2.0			
Fort Macon (Atlantic Bch/PKS)	DD	7.3			

Pine Knoll Shores [3]	DD				2.0
Emerald Isle [3]	DD				1.0
Bogue Banks[3]	SDR			17.0	
Bogue Banks	State permit				16.8
Onslow Beach	DD	1.6			
Onslow Bch (Camp Lejeune, COBRA)	SDR		1.0		
North Topsail Beach (COBRA area ?)	SDR			4.0	
North Topsail Beach [3]	DD	1.5			
Surf City	SDR			5.5	
Surf City [3]	DD	1.6			
Topsail Beach	SDR	3.0		5.5	
Topsail Beach [3]	DD	1.0			
Topsail Beach [3]	DD	0.6			
Figure 8 Island (North)	State permit				1.8
Figure 8 Island[3]	DD	0.6			
Figure 8 Island (South - Shell Island)	State permit				2.8
Shell Island[3]	DD	0.4			
Wrightsville Beach	SDR	3.0			
Masonboro Isl (Masonboro Inlet)	DD	1.2			
Masonboro Isl (Carolina Bch Inlet)	DD	1.3			
Carolina Beach	DD	0.8			
Carolina Beach	SDR	3.0			
Kure Beach	SDR	3.8			
Bald Head Island[3]	DD	3.0			
Bald Head Island	State permit	4.7			
Long Beach Sea Turtle Restor.	CAP Project	2.3			
Oak Island[3]	SDR	10.3			
Oak Island	DD	9.6			
Long Beach[3]	DD	0.3			
Holden Beach[3]	DD	0.2			
Holden Beach[3]	DD	2.0			
Holden Beach[3]	State permit	5.7			
Holden Beach	SDR		5.7		
Ocean Isle [3]	DD	0.6			
Ocean Isle	SDR	5.3			
Ocean Isle	State permit	0.8			
Sunset Beach[4]	SDR		2.7		
TOTAL		91.3	24.4	104.2	24.4

CUMULATIVE AFFECTED LENGTH -- ABOUT 176 MILES (55% OF OCEAN COASTLINE)

1 Information from draft Coastal Ocean CHPP, FWS, COE (March 2002)

2 SDR=Storm Damage Reduction, DD=Dredge Disposal

3Overlapping projects, not duplicated in cumulative affected length

4 Old project - requires re-evaluation

PENNSYLVANIA

1.0 State Nourishment Policy

1.1 The commonwealth does have enforceable and encouragement policies regarding beach nourishment.

1.2 Policy Citation and Description
PA Coastal Zone Management Program. Procedures for Managing the Effects of Erosion. Techniques, such as beach nourishment and sand pumping, are non-structural alternatives that attempt to produce a satisfactory response in erosion reduction. Both procedures involve high annual costs, destroy the natural regimen and may have a severe impact on aquatic life. Such techniques are discouraged. However, in cases where structural alternatives are too costly in protecting a public facility or lands of high value, these non-structural techniques may have to be considered.

Policy 1.2 Bluff Setback and Erosion Control/Structures in part, is designed to protect the bluffs from lake caused erosion. It is through this enforceable policy (via permit conditions) that CZM requires that groin structures be limited in length, height, and prefilled on the updrift side to prevent starvation and erosion of downdrift beaches/shorelines. Impacts to the natural regime and aquatic habitat may be considered during project review.

2.0 Related Policies

2.1 Near Shore Sand Mining Regulations
Commonwealth of Pennsylvania Coastal Zone Management Program. Guidance Document – March 31, 1999. Policy 2.1 Dredging and Spoil Disposal/Regulation. Ensures that the recovery of commercially valuable sand and gravel in the coastal zones will be regulated.

Policy 2.0 Dredging and Spoil Disposal in part, is designed to regulate dredging and the disposal of dredged material. Through permit conditions, suitable material dredged from Lake Erie stream mouths and updrift sides of marinas are allowed and encouraged to be placed on downdrift beaches/shoreline areas to prevent starvation and erosion of these downdrift areas. Impacts to the natural regime and aquatic habitat may be considered during project review.

In addition, the Dam Safety and Encroachment Act 32 P.S. §693.1, the Clean Streams Law, 3 P.S. §691.1, and the Fish and Boat Act, 30 P.S. §200, protect the Commonwealth's submerged lands, water quality, and the commercial use of sand and gravel mined from Commonwealth's waters.

2.2 Dredge and Fill Regulations
Commonwealth of Pennsylvania Coastal Zone Management Program. Guidance Document – March 31, 1999. Policy 2.1 Dredging and Spoil Disposal/Regulation. Ensures that

dredging and spoil disposal in the coastal zones will be regulated. Permits are required for activities in navigable water between the high and low water marks. Submerged lands licenses are required below low water marks. Permit conditions require that for dredging stream mouths, appropriate materials must be placed along the shoreline to maintain littoral processes. Groin construction permits require pre-filling of the updrift side, top prevent starvation and erosion of downdrift beaches.

2.3 Sand Scraping/Dune Reshaping Regulations
Not applicable.

2.4 Dune Creation/Restoration Regulations
Not applicable.

2.5 Public Access Regulations
Public access is addressed in the Chapter 105 regulations as an evaluation criterion for encroachment permits. The Commonwealth also relies on the Public Trust Doctrine and the Environmental Rights Amendment in the PA Constitution to support the publics right to the waters of the Commonwealth for the purposed of, but not limited to, navigation and fishing.

In several instances, local zoning ordinances require public access to the shoreline for new construction or substantial improvement. Permits for groins are conditioned to maintain lateral access.

3.0 Summary of Projects Funded

The only beach nourishment programs undertaken by the Commonwealth occur at Presque Isle State Park – Lake Erie and none in or near habitat frequented by fishes covered by ASMFC fisheries management plans. By virtue of the nature of the lower Delaware River and upper Delaware Estuary, beach areas do not exist. Thus, no beach nourishment projects that actually pertain to the need of the ASMFC Habitat Program survey.

RHODE ISLAND

1.0 State Nourishment Policy

1.1 The state has some policies regarding beach nourishment. State waters are classified into 6 categories based on current use of water and adjacent land. Types of activities permitted on shoreline feature depends on the designation the Coastal Resources Management Council (CRMC) has given the water body adjacent to the site. See section 1.3 for an explanation of the water types.

1.3 Policy Citation and Description
State Water Classification/Activities Permitted
(1) *Beaches* and *Dunes* and *Undeveloped Barrier Beaches* adjacent to Type 1 waters: All activities prohibited except: … nonstructural shoreline protection; beach nourishment; or protection, restoration, or improvement of a feature as natural habitat for plants and wildlife.
(2) *Moderately Developed Barrier Beaches* adjacent to Type 1 waters: All activities prohibited except: … nonstructural shoreline protection; upland dredged material disposal; beach nourishment; or protection, restoration, or improvement of a feature as natural habitat for plants and wildlife.
(3) *Developed Barrier Beaches* adjacent to Type 1 waters: Activities allowed: nonstructural shoreline protection; upland dredged material disposal; beach nourishment. Activities prohibited: structural shoreline protection facilities.

RI Coastal Resources Management Program Policies. Section 110. Activity Matrices. Indicates that while beach nourishment is an allowed activity in tidal waters, beaches and dunes, undeveloped barriers, moderately developed barriers and developed barrier islands adjacent to all classes of waters (1-6), this activity will require a Category B assent (full review). Also indicates that beach nourishment is prohibited in coastal wetlands adjacent to all classes of waters. Beach nourishment projects may also be allowed under Category A following criteria in Section 300.9(B)(5).

RI Coastal Resources Management Program Policies. Section 300.2. Filling, Removing, or Grading of Shoreline Features. (B)(1) Nourishment is allowable on beaches and dunes adjacent to Type 1 and 2 waters where it will preserve or enhance the feature as a conservation area or natural buffer against storms. (C)(1) Nourishment projects may allow for removal or placement of sediments along jetties or groins.

RI Coastal Resources Management Program Policies. Section 300.7 (B)(1). Construction of Shoreline Protection Features. Section 300.7 (B)(3) Structural shoreline protection may be allowed only after all reasonable and practical alternatives have been exhausted including relocation of the structure and nonstructural shoreline protection methods including beach nourishment.

RI Salt Pond Region SAMP. 1999. Maschaug to Point Judith Ponds. 930.1 (B)(5), (E)(1)(a) Requires the disposal of sand dredged materials to replenish the following adjacent beaches:

Sand Hill Cove, East Matunuck, Charlestown Beach, Quonochontaug Barrier Beach. Prohibits, for beach restoration, mechanical removal or redistribution of the sand from the intertidal zone of the beach to increase the profile of the beach scarp; or construction of artificial dunes since they destabilize the beach, increase erosion along the beach and increase sedimentation in ponds. Specifies design guidelines for beach restoration. Identifies priority area for acquisition. 950 (2)(c), During post storm reconstruction, overwashed sand that is dredged for habitat restoration in the salt ponds must be placed on the adjoining ocean beach. (2)(d), Sand that is removed from paved roads must be returned to the adjacent ocean beach. (3) Beach replenishment is Council's method of choice for shoreline protection.

The Narrow River SAMP. 1999. 930.1 (A)(4)(a), (A)(4)(b), (A)(8), Suitable sand dredged from flood tidal deltas to support existing recreational use in the Narrow River shall be placed on the Narragansett Town Beach. (B)(4), Disposal of foreign dredged material is prohibited on the shoreline of the watershed unless a council approved beach replenishment program has been established.

1.4 Classification of Water Types

About 75% of Rhode Island's shoreline is in Type 1 or 2. Type 1 Waters: *Conservation Areas* – abut undisturbed shorelines or land that is unsuitable for development due to waves, flooding or erosion. Type 2 Waters: *Low Intensity Use Areas* – adjoin land dominated by low-intensity recreational and residential use. Type 3 Waters: *High Intensity Recreational Boating Areas* – abut marinas and other water dependent uses. Type 4 Waters: *Multipurpose Areas* – abut land with water dependent commercial, industrial or recreational uses. Type 5 Waters: *Commercial and Recreational Harbors* – abut commercial and recreational harbors. Type 6 Waters: *Industrial Waterfronts & Commercial Navigational Channels* – abut industrial waterfronts and commercial navigational channels.

2.0 Related Policies

2.1 Near Shore Sand Mining Regulations

RI Coastal Resources Management Program Policies. Section 300.2 (B)(1). Filling, removing or grading is prohibited on beaches, dunes, undeveloped barriers, coastal wetlands, cliffs, banks, and rocky shores adjacent to Type 1 and 2 waters unless the primary purpose of the alteration is to preserve or enhance a features as a conservation area or a natural buffer against storms. (B)(4). Mining is prohibited on coastal features.

RI Coastal Resources Management Program Policies. Section 110. Activity Matrices Mining is prohibited in all categories of tidal waters. Prohibition does not include dredging of tidal waters for navigation channel maintenance, habitat restoration and beach nourishment.

An offshore sidescan sonar survey for potential offshore sand sources was completed for CRMC by the University of Rhode Island Department of Geology in 1998. The results identify possible borrow sites below the sand return depth off the coast of the Misquamicut barrier/headland complex and the Charlestown barrier/Green Hill headland. Thickness of the sand sheets needs to be determined.

2.3 Sand Scraping/Dune Reshaping Regulations
RI Coastal Resources Management Program Policies. Section 210.7 (C)(3). Alteration of the foredune zone adjacent to Type 1 and 2 waters is allowed where the primary purpose is non-structural protection, restoration or improvement of a feature as a natural habitat for native plants and wildlife.

RI Coastal Resources Management Program Policies. Section 300.2 (B)(1). Filling, removing or grading is prohibited on beaches, dunes, undeveloped barriers, coastal wetlands, cliffs, banks, and rocky shores adjacent to Type 1 and 2 waters unless the primary purpose of the alteration is to preserve or enhance a feature as a conservation area or a natural buffer against storms.

2.4 Dune Creation/Restoration Regulations
RI Coastal Resources Management Program Policies. Section 210.7 (C)(3). Shoreline Features: Dunes. Alteration of the foredune zone adjacent to Type 1 and 2 waters is allowed where the primary purpose of the project is non-structural protection, restoration or improvement of the feature as a natural habitat for native plants and wildlife.

2.5 Public Access Regulations
RI Coastal Resources Management Program Policies. Section 335 (C)(4) [added in 1997]. Publicly funded beach nourishment projects must include a "public access" component.

3.0 Summary of Projects Funded

1) Sandy Point (1996)
   A. 60,000 cubic yards
   B. 2000 feet
   C. Little Narragansett Bay Federal Navigation Channel
   D. Hydraulic cutter head dredge
   E. $444,444 (100% Federal)
   F. private contractor - unknown

SOUTH CAROLINA

1.0 State Nourishment Policy

1.1 The state has some beach nourishment policies.

1.2 Policy Citation and Description

Coastal Management Act. S.C. Code Regs. §48-39-10 to 48-39-360. This statute implements a direct permit program for beachfront development including any land disturbing activities within a narrow band of four "critical areas" including "the beach/dune system." Also it covers erosion control devices and all beach nourishment projects. Rule making authority for permitting in beach and dune critical areas includes definitions, erosion control policies and sand dune management policies.

Beachfront Management Act. S.C. Code Regs. §48-39-320B. In 1992, South Carolina adopted a state beachfront management plan, which includes:

1) required studies of sand sources, sand transport
2) guidelines on beach nourishment
3) requirements on placement of beach quality sand on down drift beaches
4) Post Disaster Redevelopment Plans also required: 15 of 18 coastal communities have approved plans

Beachfront Management Act. S.C. Code Regs. §48-39-320B. Local Beachfront Management Plans are required to be adopted by July 1, 1992 based on State guidelines and approval/certification in order to be eligible to participate in state bonding programs for beach nourishment or other beach funding programs.

Coastal Management Regulations. S.C. Reg. 30-13(N)(2). Sand bags, sand scraping, and minor beach nourishment are allowable under "emergency orders" and within established guidelines.

Coastal Management Regulations. S.C. Reg. 30-11(B)(6) and 30-13(L)(3)(b). Places restrictions on beach nourishment during turtle nesting season.

1.0 Related Policies

2.1 Near Shore Sand Mining Regulations
Not applicable

2.2 Dredge and Fill Regulations
S.C. Code Regs. §48-39-130. Critical areas permits are required for dredge and fill activities that take place in critical areas (tidelands, coastal waters, and the beach/dune system). Coastal Management Regulations. S.C. Reg. 30-12G. Contains specific project regulatory standards for dredging and filling.

2.3 Sand Scraping/Dune Reshaping Regulations
Coastal Management Regulations. S.C. Reg. 30-13. Emergency order with guidelines allows sand scraping and placement of sand bags in front of threatened structures. No formal permit is required.

2.4 Dune Creation/Restoration Regulations
Coastal Management Regulations. S.C. Reg. 30-13(L). Allowed with permit.

2.5 Public Access Regulations
Local beachfront management plans are required to develop guidelines that accomplish a beach access program to ensure full and complete access to the beach.

2.0 Summary of Projects Funded (1995 - 2001)

1) Edisto Beach (1995)
A. 150,000 cubic yards
B. 2.0 miles
C. Offshore shoals
D. Hydraulic pipeline
E. $1.0 million – state, $500,000 – local government
F. Town of Edisto Beach

2) Greater Myrtle Beach (1996-98)
A. 2,500,000 cubic yards
B. 26.0 miles
C. Offshore shoals
D. Hopper dredge and hydraulic pipeline
E. $36.0 million – federal, $9.0 million – state, $9.0 million – local government
F. U.S. Army Corps of Engineers

3) Pawleys Island (1997-98)
A. 250,000 cubic yards
B. 2.5 miles
C. Nearby intertidal and subtidal sand deposits
D. Land-based equipment (trucks, pan scrapers)
E. $1.3 million – state
F. Town of Pawleys Island

4) Hilton Head Island (1997)
A. 2,000,000 cubic yards
B. 7.0 miles
C. Offshore shoals
D. Hydraulic pipeline

E. $11,000,000 - local government
F. Town of Hilton Head Island

5) Debidue Beach (1998)
A. 250,000 cubic yards
B. 1.5 miles
C. Inland sand pit
D. Land-based equipment (trucks)
E. $1,500,000 - local community association
F. Debordieu Colony Community Association

6) Daufuskie Island (1998)
A. 1,400,000 cubic yards
B. 3.5 miles
C. Offshore shoals
D. Hydraulic pipeline
E. $6,000,000 - local developer and community associations
F. Daufuskie Island Club and Resort

7) Hilton Head Island (1999)
A. 200,000 cubic yards
B. 0.8 miles
C. Offshore shoals
D. Hydraulic pipeline
E. $1,200,000 – local government
F. Town of Hilton Head Island

VIRGINIA

1.0 State Nourishment Policy

1.1 The commonwealth has policies regarding beach nourishment

1.2 Policy Citation and Description

Va. Code Ann. §10.1-704. The use of dredged material for beach nourishment is a priority. The beaches of the commonwealth are given priority consideration as sites for the disposal of dredged material determined to be suitable for beach nourishment. The Secretary of Natural Resources is responsible for determining whether the dredged material is suitable for beach nourishment.

2.0 Related Policies

2.1 Near Shore Sand Mining Regulations

Va. Code Ann. §62.1-190. Prohibits dredging, digging, or otherwise removing sand from the beach.

2.2 Dredge and Fill Regulations

Va. Code Ann. §10.1-704. Use of dredged material for beach nourishment is a priority. The beaches of the Commonwealth are given priority consideration as sites for the disposal of dredged material determined to be suitable for beach nourishment. The Secretary of Natural Resources is responsible for determining whether the dredged material is suitable for beach nourishment.

Va. Code Ann. §28.2-1200. Submerged Lands Act. It is unlawful for any person to build, dump, trespass or encroach upon or over, or take or use any materials from the beds of the bays, ocean, rivers, streams, or creeks which are property of the Commonwealth, unless such act is performed pursuant to a permit issued by the VA Marine Resources Commission.

Subaqueous Guidelines promulgated by the Virginia Marine Resources Commission which make available the policies and procedures of the Commission for the permitting of activities affecting the subaqueous lands of the Commonwealth also establish "Criteria for the Placement of Sandy Dredge Material Along Beaches of the Commonwealth" (VR 450-01-0052).

2.3 Sand Scraping/Dune Reshaping Regulations

Va. Code Ann. §28.2-1400. Coastal Primary Sand Dune Act and Coastal Primary Sand Dunes/Beaches Guidelines, Virginia Marine Resources Commission. Requires permits on coastal primary dunes and beaches for uses other than certain specified activities based on state standards and guidelines. There shall be no permanent alteration of, or construction on, coastal primary sand dunes, which would impair the natural functions of the dune or physically alter the contour of the dunes or destroy vegetation. Exceptions can be permitted when necessary and consistent with the public interest and listed in 28.2-13.25(3).

2.4 Dune Creation/Restoration Regulations
Not applicable.

2.5 Public Access Regulations
Not applicable.

3.0 Summary of Projects Funded (1995-98)

1) **Virginia Beach**, 1995 – Storm and Erosion – 18,480 ft. renourished. Cost: $990,860 (Federal)

2) **Virginia Beach**, 1996 – Storm and Erosion – 18,480 ft. renourished. Cost: 1,100,000 (Federal)

3) **Dam Neck Naval Base**, 1996 – Storm and Erosion – 9,200 ft. renourished. Cost: $3,800,000 (Federal)

*Source: Duke University Program for the Study of Developed Shorelines
Explanation of the funding category: this does not mean that all the funds used for a particular project were obtained exclusively from that source, but that the source listed was the primary source. For example, most federally funded projects are given authorization by Congress but local governments may still pay for 25% of the cost.

Appendix C Fish Habitat

EFH Requirements under the Magnuson-Stevens Fishery Conservation and Management Act

The 1996 amendments to the Magnuson-Stevens Fishery Conservation and Management Act, known as the Sustainable Fisheries Act (SFA), require that federal fishery management councils (Councils) describe and identify Essential Fish Habitat (EFH) for federally managed fishery species, identify adverse effects on EFH, and develop measures to conserve and enhance EFH (16 USC 1853). EFH is defined as "those waters and substrate necessary to fish for spawning, breeding, feeding, or growth to maturity." Waters include aquatic areas and their associated physical, chemical, and biological properties that are used by fish and may include aquatic areas historically used by fish where appropriate. Substrate includes sediment, hard bottom, structures underlying the waters, and associated biological communities. Necessary means the habitat required to support a sustainable fishery and the managed species' contribution to a healthy ecosystem. Spawning, breeding, feeding, or growth to maturity covers a species' full life cycle (67 FR 2343-2383 (17 January 2002)(Sec. 600.10)). Habitat Areas of Particular Concern (HAPC) are subsets of EFH containing particularly sensitive or vulnerable habitats, and should also be identified in FMPs. HAPCs are based on one or more of the following considerations: 1) importance of ecological function; 2) the extent to which the habitat is particularly sensitive to human-induced environmental degradation; 3) whether, and to what extent, development activities are, or will be stressing the habitat type; or 4) the rarity of the habitat type (600.815(a)(8)).

All habitats currently used by a species that is identified as overfished should be considered essential, in addition to certain historic habitats that are necessary to support rebuilding the fishery and for which restoration is technologically and economically feasible (600.815(a)(2)(ii)(B)). Of the 22 stocks managed by ASMFC (either exclusively, or jointly or in association with the Councils), there are currently six overfished stocks: Atlantic Sturgeon, Black Sea Bass, Bluefish, Red Drum, Scup, and Spiny Dogfish (USDOC/NOAA, 2001).

Councils are required to describe and identify EFH for each life stage, and summarize life history information necessary to understand each species' relationship to, or dependence on, its various habitats. Information should come from the best available sources and be organized according to four levels of EFH information available: Level 1 – distribution; Level 2 – habitat related densities; Level 3 – growth, reproduction, or survival rates within habitats; and Level 4 – production rates by habitat. The Councils should strive to describe EFH at the highest level of detail (level 4) of information (67 FR 600.815(a)(i-iii).

In addition to identifying fishing threats to EFH, FMPs must also identify non-fishing activities (i.e.: dredging, filling, discharge, etc.), and analyze how cumulative impacts influence the function of EFH on an ecosystem or watershed scale. Since loss of prey (including adverse effects to prey habitat) may be an adverse threat to EFH and managed species, major prey species and their habitat should be identified in each FMP (600.815(a)(4,5,7)).

Federal agencies are required to consult with the National Marine Fisheries Service (NMFS) regarding any activity, or proposed activity, authorized, funded, or undertaken by the agency that may adversely affect EFH (16 USC 305(b)(2)). If NMFS becomes aware of a federal action that will adversely affect EFH and the federal agency has not initiated an EFH consultation, NMFS may request a consultation or they can provide EFH Conservation Recommendations (67 FR 600.925 (b)). Adverse effects may include direct or indirect physical, chemical, or biological alterations of the waters or substrate and loss of, or injury to, benthic organisms, prey species and their habitat, and other ecosystem components, if such modifications reduce the quality of and/or quantity of EFH. Adverse effects to EFH may result from actions occurring within EFH or outside of EFH and may include site-specific or habitat-wide impacts, including individual, cumulative, or synergistic consequences of actions (600.810(a)). Federal agencies are not required to initiate consultation for actions that were completed prior to the approval of EFH designations by NMFS (16 USC 305(b)(2)).

The EFH Assessment is the assessment by the federal agency of the effects of the proposed project and must contain the following: i) A description of the proposed action; ii) An analysis of the potential adverse effects of the action on EFH and the managed species; iii) The federal agency's views regarding the effects of the action on EFH; and iv) Proposed mitigation, if applicable (67 FR 600.920 (e)(3)(i-iiii).

Consultations between the federal agency and NMFS for actions that may adversely impact EFH may be conducted using one of five different approaches, depending on the severity of impact: General Concurrence, programmatic consultation, abbreviated consultation, expanded consultation, or existing environmental review procedures (600.920 (f-j)). NMFS and the Councils are directed to provide comments and EFH Conservation Recommendations on actions that may adversely affect EFH. Such recommendations may include measures to avoid, minimize, mitigate, or otherwise offset adverse effects on EFH resulting from actions or proposed actions authorized, funded, or undertaken by that agency (16 USC 305(b)(3-4)). These recommendations are advisory in nature.

The federal agency is required to respond to recommendations made by NMFS and the Councils within 30 days. In the case where their actions are inconsistent with the Conservation Recommendations, the federal agency must respond to NMFS and the Councils at least 10 days prior to final approval of action (305(b)(4)(B)). The response must include a description of measures proposed by the agency for avoiding, mitigating, or offsetting the impact of the activity on EFH. If the response is inconsistent with the Conservation Recommendations, the Corps must explain the reasons for not following the recommendations, including the scientific justification for any disagreements with NMFS over the anticipated effects of the proposed action and the measures needed to avoid, minimize, mitigate, or offset such effects (67 FR 600.920 (k)).

State agencies are not required to consult with NMFS regarding EFH. NMFS will determine the most effective means for providing Conservation Recommendations for state actions that may adversely affect EFH. Councils may provide recommendations, but are not required to. Councils are required to provide comments and recommendations for any federal or state agency concerning an activity that is likely to substantially affect the habitat, including EFH, of an anadromous fishery (16 USC 305 (b)(3)).

Fish Habitat for Non-Federally Managed Species

The SFA does not included requirements for designating EFH for non-federally managed species, such as those managed solely by the Atlantic States Marine Fisheries Commission (ASMFC). The Commission does strive to maintain consistency in protecting habitat for species that they manage exclusively, compared to those that are managed jointly or in association with the Councils. Due to fiscal and legal constraints, the ASMFC has not adopted the term "essential fish habitat" for use in their FMPs, but the designation of fish habitat in Commission FMPs is similar in spirit to the definition of EFH. The Commission has adopted the term HAPC in their FMPs to focus protection efforts in these areas, but it is not a legal subset of EFH (Stephan, 1998). The Commission does not have the authority to comment on federal or non-federal activities that may affect EFH designated in federal FMPs or fish habitat designated in Commission FMPs.

There are 22 species that are managed by the Atlantic States Marine Fisheries Commission, 8 of which are managed jointly or in association with Councils. For each of these 8 stocks, EFH and HAPC has been designated within the respective FMP by the Councils, and these designations are provided in this appendix. For the other 14 stocks that are managed solely by the Commission, the most current habitat information that is contained within each interstate FMP is provided herein. Commission FMPs provide descriptions of fish habitat for various life stages, and may designate them as "essential habitat" "description of habitat" or other appropriate terms. For some species, HAPC has been identified. The format may vary between FMPs, especially for those FMPs whose habitat sections have not been updated since the SFA amendments.

The information provided in this appendix serves as a general description of species presence and life stages, and should not be considered the full body of information on the subject. There is also an Issues and Concerns section that identifies non-fishing threats to the habitat. Only those threats that are germane to the content of this paper are included (i.e. beach nourishment, dredging, shoreline armoring, etc.). The threats identified in this section may not be all of the known effects related to beach nourishment activities, but are those that have been identified in the FMPs. A brief description of prey species has also been included in the habitat summaries.

Citations contained in the FMPs have been omitted from this appendix to reduce the number of sources referenced in the bibliography. The FMPs that were used are identified at the end of each species section, and can be referred to for more information. For species that reside in freshwater habitats during a portion of their life, these habitat descriptions will be briefly mentioned; marine and estuarine habitats are discussed in detail where applicable. The habitat descriptions contained in this appendix are to be used only as a general reference for temporal and spatial location of the species. They are by no means the complete body of information on their presence, and should not be used as a reference for anyone engaged in activities that may affect inshore, nearshore, or offshore habitat. Information on habitat is continually evolving and some data sets may be incorporated into their respective FMPs at a later date.

American Eel

Description of Habitat

A habitat area of particular concern is defined, as those waters, substrate, and conditions required for population survival. Such habitat may be limiting for spawning, breeding, feeding, or growth to maturity.

Information inferred from commercial harvest records and various stock assessment efforts indicate that American eel are found in most types of habitats including the offshore, mid-water and bottom areas of lakes, estuaries and large streams. American eel are found to be most prevalent in the nearshore, shallow embayments and tributaries.

American eel are classified as a warmwater species that are most abundant in relatively warm streams and shallow lakes or embayments, while relatively scarce in deep, steep gradient cold-water lakes. Based on distribution and diet preferences, American eel appear to be very adaptable creatures with the ability to exploit many habitat and food types. Some juvenile American eel, for example, seek out riverine habitat until reaching maturity at which time they return to the ocean. These habitats provide the conditions needed by the organisms (insects, crustaceans, fishes) that eel forage upon.

American eel are bottom dwellers while in estuaries, rivers, and lakes. The presence of soft, undisturbed bottom sediments may be important to migrating elvers for shelter. American eel have been reported in mud burrows with their heads protruding. Few other freshwater fishes display similar habitat use, and as a result, interspecific competition for living space may be limited. Estimates of the home range of eel extend to 3.4 ha in small streams, tidal rivers, and tidal creeks.

Spawning Habitat - American eel are highly migratory, with spawning and larval development and migration occurring in the open ocean, feeding and growth occurring in estuaries and fresh waters, and migration of adults occurring in the ocean again to complete the life cycle (catadromous life cycle). American eel spawn in the Sargasso Sea although it has never been directly observed in the field. The Sargasso Sea is an oval area in the middle of the Atlantic Ocean, between the West Indies and the Azores, of nearly 5.2 million km^2 (2 million square miles). After spawning, the spent eel are assumed to die.

Eggs hatch in about two days in the winter and early spring, releasing the leptocephali. Leptocephali are transported from the spawning grounds to the eastern seaboard of North America by the Antilles Current, the Florida Current, and the Gulf Stream. The leptocephali drift and swim in the upper 300 m of the ocean for several months, growing slowly to a length of 5-6 cm. Most planktonic leptocephali undergo metamorphosis into glass eel at 5.5-6.5 cm in length at 8 to 12 months of age, that actively migrate from the offshore waters to the coastal embayments and rivers. American eel apparently take advantage of inflowing tides to move into tidal areas.

Nursery and Juvenile Habitat - Glass eel enter estuaries and ascend the tidal portion of rivers during winter and spring, earlier in the southern portion of the range, later in the northern portion by drifting on flood tides and holding position near bottom on ebb tides, a migratory tactic known as selective tidal stream transport. Glass eel also ascend by active swimming along shore in the estuaries, and above tidal influence.

Upstream migrating glass eel metamorphose into elvers. Glass eel and elvers burrow or rest in deep water during the day. Upstream migrations may be triggered by changes in water chemistry caused by the intrusion of estuarine water during high spring tides.

Elvers exhibit drab pigmentation, dark on the back and often yellowish on the ventral surface, leading to the name yellow eel for this stage. Yellow eel inhabit a variety of habitats and feed opportunistically on various bottom-and near bottom-dwelling animals, mostly invertebrates and slower fishes.

Adult Habitat - Yellow eel metamorphose into silver eel and migrate seaward to their spawning grounds. The American eel that are in freshwater drop downstream, traveling mostly at night. During outmigration, adults may inhabit a broad range of depths throughout the water column.

Adult oceanic habitat requirements are not known. However, American eel have been taken at depths greater than 6000 meters.

Identification of Habitat and Habitat Areas of Particular Concern

Ocean - Importance: Spawning - Reproduction for the panmictic population occurs in the Sargasso Sea, therefore, the area used for reproduction might be identified as a habitat area of particular concern. Until recently, no threats to the functional health of this area had been reported.

Continental Shelf - Importance: Larval migration, feeding, growth; juvenile metamorphosis, migration, feeding and growth.

Concern: Glass eel survival (growth, distribution and abundance) is probably impacted by a variety of activities. Channel dredging, shoreline filling, and overboard spoil disposal are common throughout the Atlantic coast, but currently the effects are unknown. Additionally, these activities may damage American eel benthic habitat. However, the significance of this impact also remains unknown. Changes in salinity in embayments, as a result of dredging projects, could alter American eel distribution.

Estuaries/Rivers - Importance: Juvenile, sub-adult and adult migration corridors and feeding and growth areas for juvenile and sub-adult.

Concern: Elver and yellow eel abundance is probably also impacted by physical changes in the coastal and tributary habitats. Habitat factors are probably impacting the abundance and survival of yellow and silver eel. The nearshore, embayments, and tributaries provide important feeding and growth habitat. The availability of these habitats influences the density of the fish and may influence the determination of sex. Therefore, since females may be more common in lower density settings, it is crucial that the quantity and quality of these habitats be protected and restored (including upstream access).

Issues and Concerns

Various habitat stresses and losses impact American eel abundance, health, distribution, and growth rates, but these impacts have not been adequately described. Channel dredging and overboard spoil disposal are common throughout the Atlantic coast, but currently have unknown effects on American eel. Changes in salinity as a result of dredging projects could alter American eel distribution. Additionally, dredging associated with whelk and other fisheries may damage American eel benthic habitat; however, the significance of this impact also remains unknown.

Prey Species

Eel are opportunistic feeders, requiring and utilizing multiple levels of the food chain including phytoplankton, insects, crustaceans, a multitude of fish species, and even larger prey.

For more information, refer to the Atlantic States Marine Fisheries Commission Fishery Management Plan for American Eel (November 2, 1999).

American Lobster

Description of the Resource / Species Life History

The American lobster is widely distributed over the continental shelf of the Western North Atlantic Ocean. Along the inshore waters of the Western North Atlantic, the American lobster ranges from Labrador to Virginia; and along the outer continental shelf and slope within the U.S. Exclusive Economic Zone (EEZ) it ranges from Georges Bank to North Carolina. It has been found in waters of the intertidal zone and to as deep as 700 meters.

The major lobster population centers are located within the Gulf of Maine and the New Brunswick and Nova Scotia coastal waters. These areas support inshore fisheries, which supply 90 percent of the total landings of American lobster. In waters of the United States, there are two important areas of population. The most important area is along the coastal zone from Maine to New Jersey and out to a depth of 40 meters (22 fathoms). This population supports the coastal trap fishery and accounted for 86 percent of the U.S. landings in 1993. A secondary area of production is on the continental shelf and margin from Corsair Canyon to Cape Hatteras in depths to 600 meters (333 fathoms). Offshore landings accounted for 14% of total U.S. landings in 1993.

Newly-hatched lobster larvae are planktonic and, therefore, can be dispersed over wide areas. Coastal lobsters are concentrated in rocky areas where shelter is readily available, although occasional high densities occur in mud substrates suitable for burrowing. Offshore populations are most abundant in the vicinity of submarine canyons along the continental shelf edge. Early tagging experiments conducted in more northern inshore areas showed most lobsters usually remain within a radius of 3-5 km. Lobster tagging studies conducted in offshore areas and in more southern inshore areas show significant movement of large, sexually mature lobsters, which depict well-defined shoalward migrations.

Habitat Considerations

Habitat may be defined according to an array of environmental factors, which include temperature, salinity, dissolved oxygen, light intensity, current, and substrate. These environmental factors are summarized below relative to three life history stages of the lobster: eggs/embryos, larvae/postlarvae, and juveniles/adults.

Temperature - The duration of the planktonic phase is dependent upon seawater temperature. Time from hatching to stage IV is approximately 10 days at 22- 24^{O} C and nearly 2 months at 10^{O} C. At 5^{O} C larvae generally die without reaching stage IV. Temperature may have a significant impact on juvenile and adult lobster growth, survival and reproduction. Juvenile and adult lobsters can be found seasonally in waters ranging from 0^{o} C to 25^{o} C. Acclimation to the upper lethal limit depends upon acclimation temperature but tolerance to any temperature declines as optimal dissolved oxygen and salinity levels decrease.

Currents - Larvae tend to concentrate in surface waters where currents converge and in windrows where floating debris may provide refuge. Thus, wind-induced circulation patterns, for example, prevailing southwesterly winds in the northeast U.S. during the period of larval availability, may influence larval recruitment to coastal areas.

Salinity - Larval lobsters are sensitive to salinities below 20 ppt and swim to greater depths to avoid lower salinity surface waters. In contrast, juveniles and adults can tolerate a broader range of salinities, from 15-32 ppt. Salinity presents a greater problem for pelagic larvae subject to rainfall than for juveniles and adults, although excessive run-off can lower bottom salinities and cause mortality.

Dissolved Oxygen - Larval lobsters appear twice as sensitive as juveniles and adults to reduced DO. The result may be retarded growth and molt rate. Juvenile and adult lobsters approaching molt are more susceptible to low DO since oxygen consumption peaks at this time. Oxygen consumption also increases with stress, feeding, increased activity and water temperature.

Light Intensity - Larval lobsters are phototaxic. A minimum light intensity is required to attract larvae to the sea surface but early stage larvae seek lower depths in bright sunlight. Juvenile and adult lobsters in Long Island Sound remained in burrows when ambient light exceeded 4×10^{-2} μW/c m2 (Weiss 1970s). Emergence from burrows occurred 25 minutes after sunset when underwater light intensity was 2×10^{-2} μW/cm2 from June - November. During December and January they waited until 40 minutes after sunset (0.02×10^{-2} μW/cm2).

Substrate - The pelagic larval period ends when stage IV postlarvae settle to the bottom. Postlarvae will actively seek suitable substrate with a series of descents and will delay molting to fifth stage until successful settlement is completed. Lobsters tend to choose gravel rather than silt/clay substrates. If macroalgal-covered rock is available, settling lobsters will prefer this substrate, followed by rocks on sand, mud, and sand. Postlarvae settle rapidly into rock/gravel, macroalgal-covered rock, salt-marsh peat, eel grass, and seaweed substrates. Postlarval lobster may also settle quickly into eelgrass, followed by rocks with algae in sand, then mud. Macroalgal-covered rock habitat is important because it allows for a faster settlement of post larval lobster into it compared to rock and mud, and a lower rate of lobster mortality experienced on it. Although mud habitat is the least preferred, the demonstrated ability of lobster to burrow into it implies that when mud habitat is the only option, postlarvae will settle into it and construct and maintain burrows there.

The importance of macroalgal covered rock, eel grass, peat and other habitat types which greatly exceed the total area that inshore cobble represents throughout the range of the lobster may have been underrated when considering a bottleneck hypothesis which isolates cobble as the key habitat. Appropriate habitats protect postlarvae from predation and provide food and shelter thereby minimizing movement and exposure. Lobster may not leave their burrows until they reach a carapace length between 20 and 40 mm. However, a shift from this shelter- based existence to a wider ranging, foraging lifestyle may occur with the greater energy needs and possible mitigation of predation associated with increasing body size.

Lobsters in this early benthic phase (5-40 mm CL) have been found to be most abundant in cobble and macroalgal-covered bedrock and rare in featureless mud, sand, or bedrock. However, it is difficult to conclude that shelter-providing substrate, cobble in particular, represents a natural demographic bottleneck when juvenile lobsters occur in other substrates, e.g. eelgrass, bedrock, and mud. The definition of suitable lobster habitat is complex with its attractiveness determined by shelter sites, prey distribution, species composition, abundance and availability. The range of habitat types available to juvenile lobsters increases as pressure from predation declines.

The need for specific shelter size may be resolved by the lobster's ability to manipulate its environment, which can result in the construction of suitable shelter from otherwise uninhabitable substrate. The excavation of shelters under man-made objects is common among juvenile and adult lobsters and may be important on featureless bottom.

Issues and Concerns

Human activities can have a significant impact on the lobster resource and its environment. Siltation and turbidity from deforestation and dredging are among some of the practices that can destroy lobster habitat and adversely affect larval growth, development, and survival. Ocean dumping can affect bathymetry, sediment grain size, and trace element concentration disturbing benthic biota and population structure. The disposal of soft sediments from harbor dredging can directly impact lobster habitat and disrupt food resources. The dumping of course, uncontaminated material may actually enhance lobster habitat once it is colonized with prey organisms.

Prey Species

The carnivorous habits of lobster larvae and postlarvae result in their almost exclusive dependence upon zooplankton during their first year. Copepods and decapod larvae are common prey items but cladocerans, fish eggs, nematodes and diatoms have been noted. Adult lobster are omnivorous, feeding largely on crabs, molluscs, polychaetes, sea urchins, and sea stars. Fish and macroalgae are also part of the natural diet. Lobster are opportunistic feeders so their diet may vary regionally depending upon the abundance of prey species.

For more information, refer to Amendment 3 to the Interstate Fishery Management Plan for American Lobster (December 1997).

Atlantic Croaker

Description of Stock / Species Distribution

The Atlantic croaker occurs in coastal waters from Cape Cod, Massachusetts to the Bay of Campeche, Mexico and possibly from southern Brazil to Argentina. While uncommon north of New Jersey, the croaker is one of the most abundant inshore demersal fishes from Chesapeake Bay south to Florida.

Atlantic croaker migrate seasonally along the coast, although little is known of migration patterns. They have been reported in southern Pamlico Sound to move out of the tributaries into deeper, more open water, in the fall. In winter, croaker have been recaptured in nearshore ocean waters south of Cape Hatteras, and south along the coast at least as far as Savannah, Georgia. Cape Lookout, North Carolina appears to be a primary overwintering area, at least for early one-year olds from southern Pamlico Sound. Other tagging studies in Chesapeake Bay, Delaware Bay, Georgia, and South Carolina have indicated that croaker migrate out of estuaries in fall and generally south along the coast.

Spawn, Larvae, and Juveniles - Evidence suggests that spawning occurs in fall in continental shelf waters some distance from shore. Atlantic croaker larvae have been collected from near the edge of the continental shelf to within estuaries. Larvae have been collected in shelf waters from August through March, although most were collected in November and December. Preflexion larvae are buoyant and occur in surface waters, probably becoming demersal during flexion and postflexion stages.

Recruitment of young-of-the-year croaker to estuarine areas occurs over an extended period of time but generally peaks in the fall north of Cape Hatteras, North Carolina and in the winter and early spring to the south. Young-of-the-year have been collected in October in the Delaware River, October to February in a Virginia Atlantic coast estuary, and July to November in Chesapeake Bay. Recruitment to estuaries south of Chesapeake Bay may occur as early as August in North Carolina, but usually occurs from late October to April, peaking in December through February for North Carolina, South Carolina, Georgia, and Florida.

Young-of-the-year croaker have been collected in the deeper waters and channels of the Delaware River, Chesapeake Bay and its tributaries, Cape Fear River, North Carolina, Doboy Sound, Georgia, as well as shallow areas of Pamlico Sound North Carolina.

Transport of post-larval and juvenile croakers within estuaries varies according to the type of estuarine circulation pattern. The majority of croaker larvae have been found in the inward-flowing lower layers at the mouth of the Chesapeake Bay. When deep channels are not available and there is no two-layer flow, croaker will go into marsh shallows. The circulation patterns of the shallow water column of Pamlico Sound is wind driven rather than tidally driven and juvenile croakers move into the salt marshes instead of concentrating in the channels.

Numerous studies along the Atlantic and Gulf coasts indicate that croaker generally use low salinity habitats as nursery areas. The smallest individuals are found at the upper reaches (oligohaline areas) of estuaries and larger croaker at the lower reaches. Juvenile croaker have been caught in open-water areas rather than submerged vegetation areas.

The reported time at which young-of-the-year begin to emigrate from estuarine nursery areas varies from spring along parts of the Gulf coast to late summer or fall on the Atlantic coast. Emigration descriptions in the literature vary from (1) gradual seaward movements, to (2) mass outward movements, to (3) a "bleeding off" of the larger individuals. One report found that immature croaker remained in the Chesapeake Bay until they were driven out by adverse temperatures, while another report found that a gradual emigration occurred through late summer and fall. In South Carolina most of the croaker population left inshore waters by late summer, followed by a mass exodus of the remaining fish when water temperatures began to decline. Studies in Florida have found that croaker do not move offshore until fall.

Croaker inter Chesapeake Bay and its tributaries in fall, remain in deeper waters during winter, move into lower salinity waters in spring, and return to higher salinity water in the summer. In North Carolina young croaker enter the sounds in fall and winter and are found in low salinity tidal creeks in the spring where they remain until late summer.

Adults – Croaker spend their second winter (age 1+) on the continental shelf and enter estuaries during the following spring and summer. Mature croaker return to shelf waters in late summer and fall of their second year to spawn, while younger fish emigrate with declining water temperatures. Croaker move back into estuarine waters in spring. In the South Atlantic Bight (Cape Fear, North Carolina to Cape Canaveral, Florida), the abundance of croaker in continental shelf waters varies seasonally, with maximum abundance in the late summer and early fall and lowest abundance during late winter and spring. Atlantic croaker was the second most abundant species, by number and weight, taken in a trawl survey of groundfish in coastal waters of the South Atlantic Bight (1987).

Habitat Areas of Particular Concern / Issues and Concerns

Habitat alterations within estuarine areas are probably damaging to croaker stocks since these areas are utilized for nursery grounds. Most estuarine areas of the United States have been altered to some degree by such activities as agricultural drainage, flood control and development. The National Estuary Study, completed in 1970, indicated that 73% of the nation's estuaries had been moderately or severely degraded. Damage and / or destruction of estuaries have largely been by filling, the dredging of navigation channels, and pollution. In the Atlantic coast states, which contain 3,152,800 acres of estuarine habitat, an estimated 129,700 acres were lost to dredging and filling from 1954 to 1968. Unfortunately, the effects of habitat alterations, such as channel dredging and increased turbidity associated with dredging have rarely been quantified. It is also worth noting that a Habitat Suitability Index (HIS) was developed for juvenile Atlantic croaker for use in impact assessment and habitat management. Included in the water quality assumptions of the model were (1) high turbidity levels are positively related to croaker abundance and (2) low levels of dissolved oxygen (<3 mg/l) are not suitable.

Prey Species

The Atlantic croaker is an opportunistic bottom-feeder which eats a variety of invertebrates, including polychaetes, mollusks, ostracods, copepods, amphipods, mysids, and decapods, and occasionally fish. Ontogenetic shifts in diet have been reported for croaker as well as geographic and seasonal variations in diet which are probably attributable to availability of prey species.

For more information, refer to the Atlantic States Marine Fisheries Commission Fishery Management Plan for Atlantic Croaker (October 1987).

Atlantic Herring

Essential Fish Habitat

Eggs - Bottom habitats with a substrate of gravel, sand, cobble and shell fragments, but also on aquatic macrophytes, in the Gulf of Maine and Georges Bank as depicted in Figure 3.1 in the NEFMC EFH Amendment to the Multispecies FMP. Eggs adhere to the bottom, forming extensive egg beds, which may be many layers deep. Generally, the following conditions exist where Atlantic herring eggs are found: water temperatures below 15° C, depths from 20 – 80 meters, and a salinity range from 32 – 33 0/00. Herring eggs are most often found in areas of well-mixed water, with tidal currents between 1.5 and 3.0 knots. Atlantic herring eggs are most often observed during the months from July through November.

Larvae – Pelagic waters in the Gulf of Maine, Georges Bank, and southern New England that comprise 90% of the observed range of Atlantic herring larvae as depicted in Figure 3.2 in the NEFMC EFH Amendment to the Multispecies FMP. Generally, the following conditions exist where Atlantic herring larvae are found: sea surface temperatures below 16° C, water depths from 50 – 90 meters, and salinities around 32 0/00. Atlantic herring larvae are observed between August and April, with peaks from September through November.

Juveniles – Pelagic waters and bottom habitats in the Gulf of Maine, Georges Bank, southern New England and the middle Atlantic south to Cape Hatteras as depicted in Figure 3.3 in the NEFMC EFH Amendment to the Multispecies FMP. Generally, the following conditions exist where Atlantic herring juveniles are found: water temperatures below 10° C, water depths from 15-135 meters, and a salinity range from 26-32 0/00.

Adults – Pelagic waters and bottom habitats from the Gulf of Maine, Georges Bank, southern New England and the middle Atlantic south to Cape Hatteras as depicted in Figure 3.4 in the NEFMC EFH Amendment to the Multispecies FMP. Generally, the following conditions exist where Atlantic herring juveniles are found: water temperatures below 10° C, water depths from 20-130 meters, and salinities above 28 0/00.

Spawning Adults – Bottom habitats with a substrate of gravel, sand, cobble and shell fragments, but also on aquatic macrophytes, in the Gulf of Maine and Georges Bank, southern New England and the middle Atlantic south to Delaware Bay as depicted in Figure 3.4 in the NEFMC EFH Amendment to the Multispecies FMP. Generally, the following conditions exist where spawning Atlantic herring adults are found: water temperatures below 15° C, depths from 20 – 80 meters, and a salinity range from 32 – 33 0/00. Herring eggs are spawned in areas of well-mixed water, with tidal currents between 1.5 and 3.0 knots. Atlantic herring are most often observed spawning during the months from July through November.

Habitat Areas of Particular Concern

HAPC for Atlantic herring cannot be identified at this time.

Issues and Concerns

Channel dredging is a frequent long-term maintenance activity associated with coastal development, port and harbor development, and vessel activity. The short-term impacts to habitat can be substantial, such as: 1) resuspended sediments and associated contaminants; 2) degradation of habitat quality and fish populations; 3) changes in tidal prism, depth, water temperature, salinity, water velocity, bottom topography, and sediment type; 4) decreased dissolved oxygen and SAV distribution and density, and smothering of the surrounding benthic community; 5) reconfiguration of sediment type and the removal of biogenic structure which may decrease the stability of the bottom and increase the ambient turbidity levels; 6) increased transport of sediment and siltation rates in the embayment resulting in alteration of local habitats, and changes to spawning, feeding, and recruitment habitat; 7) fragmentation of habitat can hinder the movements (i.e. dispersal, recruitment, migrations, etc.) of organisms; and 8) continued maintenance dredging may change the indigenous habitat and population dynamics of the region.

As more people move to the coast, development pressure increases and structures are often constructed along the coastline to prevent erosion and stabilize shorelines. Attempts to protect beaches and reduce shoreline erosion are associated with the development of the coast. Bulkheads, seawalls, jetties, and groins are structures designed to slow or stop the shoreline from eroding. In many cases the opposite occurs with erosion rates increasing along the regulated area. Adjacent coastal habitat is altered and potential short-and long-term impacts to fish and shellfish stocks are associated with the presence of the erosion control structures.

Disposal of dredged material can disrupt and degrade natural habitat and biotic communities. The stresses associated with dredged material (i.e. oil, heavy metals, nutrients, suspended particles, etc.) can threaten the habitat of the dump site and adjacent areas. Along with contaminating the habitat, direct disturbance of the benthic and pelagic communities occurs with disposal. Benthic communities are smothered, associated physiochemical conditions are altered, and increased turbidity may hinder pelagic processes (e.g. photosynthesis of algae) by material settling to the bottom. The potential deleterious impacts of dredged material disposal can alter local and surrounding community structure.

Prey Species

Larval Atlantic herring feed opportunistically on whatever zooplankton of appropriate size are abundant. Their primary prey are copepods, in particular, *Pseudocalanus* sp., *Paracalanus parvus*, and *Centropages typicus*. Juveniles feed on up to 15 different groups of zooplankton; the most common are copepods, decapod larvae, cirriped larvae, cladocerans, and pelecypod larvae. Adults have a diet dominated by euphausiids, chaetognaths, and copepods.

For more information and maps of Atlantic herring abundance for various life history stages, refer to the Essential Fish Habitat Amendment to the Atlantic Herring Fishery Management Plan.

Atlantic Menhaden

Description of Habitat

Atlantic menhaden occupy a wide variety of habitats during their life history. Adult Atlantic menhaden spawn primarily offshore in continental shelf waters. Larvae enter estuaries and transform into juveniles, utilizing coastal estuaries as nursery areas before migrating to ocean waters in the fall. They make extensive north-south migrations in the near-shore ocean.

Identification and Distribution of Essential Habitat

Almost all of the estuarine and nearshore waters along the Atlantic coast from Florida to Nova Scotia, serve as important habitat for juvenile and/or adult Atlantic menhaden. Spawning occurs in oceanic waters along the Continental Shelf, as well as in sounds and bays in the northern extent of their range. Larvae are carried by inshore currents into estuaries from May to October in the New England area, from October t June in the mid-Atlantic area, and from December to May in the south Atlantic area. After entering the estuary, larvae congregate in large concentrations near the upstream limits of the tidal zone, where they undergo metamorphosis into juveniles. The relative densities of juvenile menhaden have been shown to be positively correlated with higher chlorophyll α levels in the lower salinity zones of estuaries. As juvenile menhaden grow and develop, they form dense schools and range throughout the lower salinity portions of the estuary, most eventually migrating to the ocean in late fall-winter.

Many factors in the estuarine environment affect the behavior and well-being of menhaden. The combined influence of weather, tides, and river flow can expose estuarine fish to rapid changes in temperature and salinity. It has been reported that salinity affects menhaden temperature tolerance, activity and metabolic levels, and growth. Factors such as waves, currents, turbidity, and dissolved oxygen levels can impact the suitability of the habitat, as well as the distribution of fish and their feeding behavior. However, the most important factors affecting natural mortality in Atlantic menhaden are considered to be predators, parasites and fluctuating environmental conditions.

It is clearly evident that estuarine and coastal areas along the Atlantic coast provide essential habitat for most life stages of Atlantic menhaden. However, an increasing number of people live near the coast, which precipitates associated industrial and municipal expansion, thus. Accelerating competition for use of the same habitats. Consequently, estuarine and coastal habitats have been significantly reduced and continue to be stressed adversely by dredging, filling, coastal construction, energy plant development, pollution, waste disposal, and other human-related activities.

Issues and Concerns

Pollution and habitat degradation threaten the Atlantic menhaden population, particularly during the estuarine residency of larvae and juveniles. Concern has been expressed that the outbreaks of ulcerative mycosis in the 1980s may have been symptomatic of deteriorating water quality in estuarine waters along the East Coast. The growth of the human population and increasing development in the coastal zone are expected to further reduce water quality unless steps are taken to ameliorate their effect on the environment. Other potential threats to the coastal menhaden population are posed by offshore dumping of sewage sludge, dredge spoil, and industrial wastes, as well as oil spills.

Prey Species

Menhaden are extremely abundant in nearshore coastal waters because of their ability to directly utilize phytoplankton, which is the basic food resource in aquatic systems. Other species of marine fish are not equipped to filter such small organisms from the water. Consequently, such large populations of other species cannot be supported. Because menhaden are so abundant in nearshore coastal and estuarine waters, they are an important forage fish for a variety of larger piscivorous fishes, birds, and marine mammals. In ecological terms, menhaden occupy a very important link in the coastal marine food chain, transferring planktonic material into animal biomass. As a result of this, menhaden influence the conversion and exchange of energy and organic matter within the coastal ecosystem throughout their range.

Because menhaden only remove planktonic organisms larger than 13-16 microns (7 microns for juveniles) from the water, the presence of large numbers of fish in a localized area could alter the composition of plankton assemblages. It has been estimated that juvenile menhaden consume 6-9% of the annual phytoplankton production in eight estuaries on the East Coast, and up to 100% of the daily production in some instances.

For more information, refer to Amendment 1 to the Interstate Fishery Management Plan for Atlantic Menhaden (July 2001).

Atlantic Sturgeon

Habitat Important to the Spawning Stocks

Historically, Atlantic sturgeon were present in many of the river systems in New England. Currently, it is likely that the estuarine complex of the Kennebec, Androscoggin, and Sheepscot Rivers in Maine is the only system in New England, which supports a spawning population of Atlantic sturgeon. In the mid-Atlantic, the Hudson, and Delaware Rivers and their associated estuaries and the Atlantic Ocean offshore historically and currently support Atlantic sturgeon.

Atlantic sturgeon were once abundant in the Chesapeake Bay and tributaries, and historically important fisheries for the species occurred in the Susquehanna, Potomac, York, and James Rivers. Currently, there is evidence for sturgeon spawning only in the James and perhaps the York Rivers in Virginia. The entire Chesapeake historically served as nursery habitat for sturgeon spawned in its tributaries and should still be so considered, despite the relatively low abundance of the species at present.

Atlantic sturgeon were historically present in all of the larger coastal rivers and their associated estuaries in the South Atlantic region. Presently, there is evidence of spawning only on the Albemarle Sound and Cape Fear River systems in North Carolina; Winyah Bay and tributaries, and Savannah River, South Carolina; Altamaha River Ogeechee River, and Satilla River, Georgia. Additional systems which hosted Atlantic sturgeon and should be considered functional habitat for the purposes of restoration include the Pamlico Sound and tributaries, North Carolina; St. Mary's River, Georgia, and St. Johns River in Florida.

Identification and Distribution of Essential Habitats / Issues and Concerns

The ASMFC considers all presently identified spawning, nursery, migration and wintering habitats, both historical and currently used by Atlantic sturgeon, as summarized above and described in detail in the Source Document (ASMFC in preparation) and the Stock Assessment, essential habitats for the purposes of restoration and recovery of the species.

The present status of habitats in the Connecticut River was not assessed by Kahnle et al. (1998), however, there are indications that adequate habitat is thought to exist in the estuarine portion of the system, given the seasonal presence of juvenile Atlantic sturgeon.

The Cape Fear River estuary has been heavily altered by dredging for use by both military and commercial shipping. Ports located at Sunny Point and Wilmington necessitate the maintenance of shipping channels and turning basins. Continued deepening of the channels and expansion of port facilities has resulted in extension of the salt wedge upstream, with consequent alteration of adjacent wetland ecosystems as salt-intolerant vegetation is replaced by more salt-tolerant species. This system does still support both Atlantic and shortnose sturgeon.

The Winyah Bay system is dredged regularly to maintain the shipping channel to the Port of Georgetown.

Prey Species

Atlantic sturgeon are bottom feeders whose prey includes mussels, worms, shrimp, and small bottom-dwelling fish.

For more information, refer to Amendment 1 to the Interstate Fishery Management Plan for Atlantic Sturgeon (July 1998).

Black Sea Bass

Essential Fish Habitat

Eggs - EFH is the estuaries where black sea bass eggs were identified in the ELMR database as common, abundant, or highly abundant for the "mixing" and "seawater" salinity zones. Generally, black sea bass eggs are found from May through October on the Continental Shelf, from southern New England to North Carolina.

Larvae – 1) North of Cape Hatteras, EFH is the pelagic waters found over the Continental Shelf (from the coast out to the limits of the EEZ), from the Gulf of Maine to Cape Hatteras, North Carolina, in the highest 90% of all the ranked ten-minute squares for the area where black sea bass larvae are collected in the MARMAP survey. 2) EFH also is estuaries where black sea bass were identified as common, abundant, or highly abundant in the ELMR database for the "mixing" and "seawater" salinity zones. Generally, the habitats for the transforming (to juveniles) larvae are near the coastal areas and into marine parts of estuaries between Virginia and New York. When larvae become demersal, they are generally found on structural inshore habitat such as sponge beds.

Juveniles – Offshore, EFH is the demersal waters over the Continental Shelf (from the coast out to the limits of the EEZ), from the Gulf of Maine to Cape Hatteras, North Carolina, in the highest 90% of all the ranked ten-minute squares for the area where black sea bass larvae are collected in the NEFSC trawl survey. 2) Inshore, EFH is the estuaries where black sea bass are identified as being common, abundant, or highly abundant in the ELMR database for the "mixing" and "seawater" salinity zones. Juveniles are found in the estuaries in the summer and spring. Generally, juvenile black sea bass are found in waters warmer than 43° F with salinities greater than 18 pp. and coastal areas between Virginia and Massachusetts, but winter offshore from New Jersey and south. Juvenile black sea bass are usually found in association with rough bottom, shellfish and eelgrass beds, man-made structures in sandy-shelly areas; offshore clam beds and shell patches may also be used during the wintering.

Adults – Offshore, EFH is the demersal waters over the Continental Shelf (from the coast out to the limits of the EEZ), from the Gulf of Maine to Cape Hatteras, North Carolina, in the highest 90% of all the ranked ten-minute squares for the area where black sea bass larvae are collected in the NEFSC trawl survey. 2) Inshore, EFH is the estuaries where black sea bass are identified as being common, abundant, or highly abundant in the ELMR database for the "mixing" and "seawater" salinity zones. Black sea bass are generally found in estuaries from May through October. Wintering adults (November through April) are generally offshore, south of New York to North Carolina. Temperatures above 43° F seem to be the minimum requirements. Structure habitats (natural and man-made), sand and shell are usually the substrate preference.

Habitat Areas of Particular Concern

No strong association between habitat type or location and recruitment for black sea bass has been identified yet.

Issues and Concerns

Hard structures and beach nourishment have been identified as potentially harmful threats to black sea bass EFH. Hard structures can cause: 1) erosions to downdrift beaches; 2) elimination of interaction between organisms and intertidal habitat during high tide; 3) further destabilization of adjacent benthic habitats; and 4) toxic chemicals from treated timber to be leached into the water. Recommendations include discouraging the use of hard structures when practicable alternatives exist, and insuring that borrow material is acceptable when beach nourishment is the preferred alternative. Dredging and disposing of dredged material as a “beneficial use” can also pose threats to black sea bass EFH. The dredging process may cause: 1) direct removal/burial of organisms; 2) increase turbidity/siltation effects, including increased light attenuation from turbidity, alteration of bottom type, and physical effects of suspended sediments on organisms; 3) release of contaminants; 4) release of oxygen-consuming sulfides; 5) changes to the hydrodynamic regime and physical habitat; and 6) loss of wetland and SAV beds. Any “beneficial use” proposal should be compatible with existing uses by black sea bass. Conflicting uses, such as creation of bird breeding islands in shallow water habitats, only deplete black sea bass habitat.

Prey Species

The diets of black sea bass larvae are poorly known and can be expected to be mostly zooplankton. Juveniles prey on small benthic crustacea (isopods, amphipods, small crabs, sand shrimp, copepods) and other epi- or semi-benthic estuarine taxa, such as mysids or smaller fish. They are also known to feed on polychaetes. Adults may feed on various crabs, eelgrass fragments, isopods, caprellid amphipods, shrimp, small bait fish (anchovies and silversides, *Menidia* sp.), and plant detritus.

For more information and maps of black sea bass presence for various life history stages, refer to Amendment 12 to the Summer Flounder, Scup, and Black Sea Bass Fishery Management Plan (October 1998). Time constraints prevented incorporating all state data into this Amendment. As more state data becomes available, additional designations may be included to supplement EFH information contained in this FMP.

Bluefish

Essential Fish Habitat

Eggs – 1) North of Cape Hatteras, pelagic waters found over the Continental Shelf (from the coast out to the limits of the EEZ) at mid-shelf depths, from Montauk Point, NY south to Cape Hatteras in the highest 90% of the area where bluefish eggs were collected in the MARMAP surveys; and 2) South of Cape Hatteras, 100% of the pelagic waters over the Continental Shelf (from the coast out to the eastern wall of the Gulf Stream) through Key West, Florida at mid-shelf depths. Bluefish eggs are generally not collected in estuarine waters and thus there is no EFH designation inshore. Generally, bluefish eggs are collected between April through August in temperatures greater than 64° F and normal shelf salinities (>31 ppt).

Larvae – 1) North of Cape Hatteras, pelagic waters found over the Continental Shelf (from the coast out to the limits of the EEZ) most commonly above 49 ft, from Montauk Point, New York south to Cape Hatteras, in the highest 90% of the area where bluefish larvae were collected in the MARMAP surveys; and 2) South of Cape Hatteras, 100% of the pelagic waters greater than 15 meters over the Continental Shelf (from the coast out to the eastern wall of the Gulf Stream) through Key West, Florida; and 3) the "slope sea" and Gulf Stream between latitudes 29° 00 N and 40° 00 N. Bluefish larvae are not generally collected inshore so there is not EFH designation inshore for larvae. Generally, bluefish larvae are collected April through September in temperatures greater than 64° F in normal shelf salinities (>30 ppt).

Juveniles – 1) North of Cape Hatteras, pelagic waters found over the Continental Shelf (from the coast out to the limits of the EEZ) from Nantucket Island, Massachusetts south to Cape Hatteras, in the highest 90% of the area where juvenile bluefish are collected in the NEFSC trawl survey; 2) South of Cape Hatteras, 100% of the pelagic waters over the Continental Shelf (from the coast out to the eastern wall of the Gulf Stream) through Key West, Florida; 3) the "slope sea" and Gulf Stream between latitudes 29° 00 N and 40° 00 N; and 4) all major estuaries between Penobscot Bay, Maine and St. Johns. River, Florida in Table 10. Generally juvenile bluefish occur in North Atlantic estuaries from June through October, Mid-Atlantic estuaries from May through October, and South Atlantic estuaries March through December, within the "mixing" and "seawater" zones. Distribution of juveniles by temperature, salinity, and depth over the continental shelf is undescribed.

Adults – 1) North of Cape Hatteras, over the Continental Shelf (from the coast out to the limits of the EEZ) from Cape Cod Bay, Massachusetts south to Cape Hatteras, in the highest 90% of the area where adult bluefish eggs wee collected in the NEFSC trawl survey; 2) South of Cape Hatteras, 100% of the pelagic waters over the Continental Shelf (from the coast out to the eastern wall of the Gulf Stream) through Key West, Florida; and 3) all major estuaries between Penobscot Bay, Maine and St. Johns. River, Florida in Table 10. Adult bluefish are found in North Atlantic estuaries from June through October, Mid-Atlantic estuaries from April through October, and in South Atlantic estuaries from May through January in the "mixing" and "seawater" zones. Bluefish adults are highly migratory and distribution varies seasonally and according to the size of the individuals comprising the schools. Bluefish are generally found in normal shelf salinities (>25 ppt).

Habitat Areas of Particular Concern

There are no available data sets that adequately describe the distribution of the egg and larval life history stage of bluefish. Consequently, HAPC for bluefish cannot be identified at this time.

Issues and Concerns

Hard structures and beach nourishment have been identified as potentially harmful threats to bluefish EFH. Hard structures can cause: 1) erosions to downdrift beaches; 2) elimination of interaction between organisms and intertidal habitat during high tide; 3) further destabilization of adjacent benthic habitats; and 4) toxic chemicals from treated timber to be leached into the water. Recommendations include discouraging the use of hard structures when practicable alternatives exist, and insuring that borrow material is acceptable when beach nourishment is the preferred alternative. Dredging and disposing of dredged material as a “beneficial use” can also pose threats to bluefish EFH. The dredging process may cause: 1) direct removal/burial of organisms; 2) increase turbidity/siltation effects, including increased light attenuation from turbidity, alteration of bottom type, and physical effects of suspended sediments on organisms; 3) release of contaminants; 4) release of oxygen-consuming sulfides; 5) changes to the hydrodynamic regime and physical habitat; and 6) loss of wetland and SAV beds. Any “beneficial use” proposal should be compatible with existing uses by bluefish. Conflicting uses, such as creation of bird breeding islands in shallow water habitats, only deplete bluefish habitat.

Prey Species

The results of several studies suggest that bluefish juveniles and adults eat whatever taxa are locally abundant. They are known to feed on at least 70 species of fish, including butterfish, alewife, menhaden, round herring, sand lance, silverside, Atlantic mackerel, anchovy, Spanish sardine, gizzard shad, weakfish, rainbow smelt, silver hake, spotted sea trout, Atlantic croaker, sea lamprey, spot, and juvenile winter flounder. They also feed on invertebrates including shrimp, lobster, squid, crab, annelid worms, and surf clams. Juvenile bluefish in the Hudson River are known to feed on bay anchovy, white perch, American shad, river herring, striped bass, and Atlantic tomcod. Juvenile bluefish in Maine are reported to consume mysids, copepods, fish, and large crustaceans.

For more information and maps of bluefish presence for various life history stages, refer to Amendment 1 to the Bluefish Fishery Management Plan (October 1998). Time constraints prevented incorporating all state data into this Amendment. As more state data becomes available, additional designations may be included to supplement EFH information contained in this FMP.

Horseshoe Crab

Description of Habitat

Essential habitat is defined as those waters and substrate necessary for fish spawning, breeding, feeding, or growth to maturity. Horseshoe crabs use a different habitat at different life stages. Protected beaches provide essential habitat for horseshoe crab spawning efforts, while nearshore shallow waters are essential for nursery habitat.

Spawning Habitat - Spawning adults prefer sandy beach areas within bays and coves that are protected from wave energy. Beach habitat also must include porous, well-oxygenated sediments to provide a suitable environment for egg survival and development. Optimal spawning areas are limited by the availability of suitable sandy beach habitat. However, spawning may occur along peat banks if there is sand in the upper intertidal regions and along the mouths of salt marsh creeks. Spawning may also occur along muddy tidal stream banks, but not on peat banks because adults are sensitive to hydrogen sulfide and anaerobic conditions. Spawning habitat varies throughout the horseshoe crab range. In Massachusetts, New Jersey, and Delaware, beaches are typically coarse-grained and well-drained as opposed to Florida beaches, which are typically fine-grained and poorly drained. These differences affect nest-site selection and nesting synchrony. Horseshoe crabs may select spawning sites located adjacent to large intertidal sand flat areas, which provide protection from wave energy and an abundance of food for juveniles. Spawning occurs predominantly from April-May in Florida, from May-June in Delaware Bay, and from June-July from Cape Cod northward.

Nursery Habitat - The shoalwater and shallow water areas of bays where wave energy is low (e.g., Delaware Bay and Chesapeake Bay) are essential nursery areas. Juveniles usually spend their first two years in inshore nursery habitats. However, older juveniles and adults are exclusively subtidal, except during spawning. Juveniles on the Cape May shore of the Delaware Bay stay in the immediate nearshore area, and will migrate to deeper offshore waters as they mature. They are active in the summer when the tide recedes along moist surfaces, or in shallow water in sloughs. During the fall and winter, juveniles are believed to burrow into the sand and enter into a state of dormancy, throughout their range, except for Florida.

Adult Habitat - Specific requirements for adult habitat are not known. Although horseshoe crabs have been taken at depths >200 meters, adults prefer depths <30 meters. During spawning season adults typically inhabit bay areas adjacent to spawning beaches and feed on bivalves. In the fall, adults may remain in bay areas or migrate into the Atlantic Ocean to overwinter on the continental shelf.

Identification and Distribution of Essential Habitat

Beach areas that provide spawning habitat are considered essential habitats for adult horseshoe crabs. Nearshore, shallow water, intertidal flats are considered essential habitats for the juvenile development. Almost without exception, juvenile horseshoe crabs are found in salinities >5 parts per thousand. Larger juveniles and adults use deep water habitats to forage for food, but these are not considered essential habitat. Of these habitats, the beaches are the most critical. Optimal spawning beaches may be a limiting reproductive factor for the horseshoe crab population. It has been estimated that, based on geomorphology, only 10 percent of the New Jersey shore adjacent to Delaware Bay provided optimal horseshoe crab spawning habitat. The densest concentrations of horseshoe crabs in New Jersey occur on small sandy beaches surrounded by salt marshes or bulkheaded areas.

Prime spawning habitat is widely distributed throughout Maryland's Chesapeake and coastal bays, including tributaries. Horseshoe crabs are restricted to areas that exceed 7 parts per thousand salinity. In the Chesapeake Bay, spawning habitat generally extends to the mouth of the Chester River, but can occur farther north during years of above normal salinity levels. Prime spawning beaches within the Delaware Bay consist of sand beaches between Maurice River and the Cape May Canal in New Jersey and between Bowers Beach and Lewes in Delaware.

Present Condition of Habitats and Essential Habitats

Assessments conducted in the 1980s estimated that there were 49,100 acres of marine intertidal habitat within the southeastern United States (from North Carolina to Florida). While these values represent maximum potential spawning habitat for horseshoe crabs, actual spawning habitat used by horseshoe crabs is considerably less. Horseshoe crabs typically select beaches based on geochemical criteria. One survey conducted along the New Jersey side of the Delaware Bay found that only 10.6 percent of the total area sampled provided optimal spawning habitat, and only 21.1 percent provided suitable spawning habitat. This study suggests that viable spawning habitat throughout the Atlantic coast represents only a fraction of total marine intertidal areas.

Issues and Concerns

Habitat degradation is likely an important component of the population dynamics of horseshoe crabs. Groins and bulkheads may adversely impact horseshoe crab spawning habitat. Bulkheads may block access to intertidal spawning beaches, while groins and seawalls intensify local shoreline erosion and prevent natural beach migration. An estimated 10 percent of the New Jersey shoreline adjacent to the Delaware Bay has been severely disturbed by shoreline protection structures. Rip-rap and revetments also adversely impact horseshoe crabs by minimizing potential spawning sites and by entrapping and stranding them. A contributing factor in the decline of horseshoe crabs in the Delaware Bay between 1871 and 1981 may be the increased number of jetties and residential development. Shoreline erosion combined with shoreline development results in the loss of potentially suitable spawning beaches. Hard structures associated with beach development interfere with the natural beach migration, resulting in a loss of habitat.

Shoreline areas with high concentrations of silt or peat are less favorable to horseshoe crabs because the anaerobic conditions reduce egg survivability. Horseshoe crabs may detect hydrogen sulfide (which is produced in the anaerobic conditions of peat substrates) or low oxygen conditions, and actively avoid such areas. Erosion affects spawning by influencing beach characteristics that are most important in site selection, such as beach topography, sediment texture, and geochemistry.

Impacts on beaches from development and related infrastructure (e.g., bulkheads, groins, revetments, and seawalls) continue to degrade essential horseshoe crab habitat. Areas in New Jersey and Maryland where seawalls are prominent have eliminated areas once used for spawning. Erosion and shoreline protection structures compromise the integrity of essential habitat through both the erosional process itself and interference with natural beach migration. Channel dredging and overboard spoil disposal are common throughout the Atlantic coast, but effects on horseshoe crabs are currently unknown.

Dredging and beach nourishment have also been identified as threats because it removes sand and animals from their sand bar and other habitats, deposits additional substrate over habitat and animals, and disrupts the food supply and water flow and currents within existing habitats. Often the sand that is pumped onto beaches for renourishment is taken directly from juvenile habitats. Renourishment and dredging affects spawning habitats by altering beach erosion rates, burying or exposing eggs, and changing the environmental conditions available for egg development (altering sediment type, beach characteristics, etc.).

Of note, is the northernmost breeding grounds in the state of Maine. Horseshoe crabs are at the extreme of their geographic range, adults are small in size, juveniles are slow growing, and population densities are low and scattered. All of these factors make them susceptible to depletion and possible local extinction.

Prey Species

Larvae feed on a variety of small polychaetes and nematodes. Juvenile and adult horseshoe crabs feed mainly on molluscs including razor clam (*Ensis* spp.), macoma clam (*Macoma* spp.), surf clam (*Spisula solidissima*), blue mussel (*Mytilus edulis*), wedge clam (*Tellina* spp.), and fragile razor clam (*Siliqua costata*). Horseshoe crabs also prey on a wide variety of benthic organisms including arthropods, annelids, and nemertean worms, and even vascular plant material.

For more information, refer to the Interstate Fishery Management Plan for Horseshoe Crab (December 1998).

Northern Shrimp

Description of Habitat

Spawning Habitat – In the Gulf of Maine, northern shrimp spawn in offshore waters beginning in late summer months. The precise locations of spawning grounds are not well documented but it is reasonable to conclude that spawning occurs in offshore summertime population centers in deep mud basins in the southwestern Gulf. Ovigerous females remain in cold, stratified bottom waters offshore through the fall until near-shore waters have cooled, at which time they begin an inshore migration to release their eggs. Inshore migration routes followed by the northern shrimp are not well known, but due to their well established preference for organic-rich mud bottoms, it has been suggested that female shrimp probably move inshore over muddy substrates and are eventually concentrated in, but not limited to, mud-bottom channels near-shore.

Eggs and Larval Habitat - After their arrival in near-shore waters, the female shrimp's mature eggs begin to hatch. Hatching occurs as early as February and lasts through April after which time female shrimp return to offshore waters in the western Gulf. The pelagic larvae are planktotrophic, feeding primarily on diatoms and zooplankton. A survey of larval shrimp distribution conducted by Apollonio and Dunton (1969) showed that larvae were abundant almost exclusively within 10 miles of shore. Little is known about the vertical distribution of larval shrimp within the water column. While in the plankton, northern shrimp pass through six larval stages before completing a final metamorphosis to a juvenile stage and settling to the bottom in near-shore waters after about 30 to 60 days. It is important to note that time of egg release and larval development rate are temperature related, with colder water temperatures resulting in slower developmental progress. Thus, the timing of egg release and length of pelagic larval stages may vary slightly from year to year as a result of annual mean water temperature fluctuations in the Gulf of Maine.

Juvenile Habitat - Adult shrimp distributions appear to be governed by seasonal changes in water temperature. During the summer months, adult shrimp are confined to cold waters (4-6^{0}C) found only in the deeper basins (92-183 m) in the southwestern Gulf of Maine. Female shrimp are found in abundance in near-shore waters only during the late winter and spring when coastal waters are coldest. Within their preferred temperature range, northern shrimp occur mainly on mud bottom habitats where the organic matter content of the sediment is high. Bigelow and Schroeder (1939) and Wigley (1960) found a direct correlation between shrimp abundance and sediment organic matter content. Apollonio et al. (1986) argued that temperature is the most important factor driving the distributional patterns of shrimp in the Gulf. They suggest that correlations between shrimp abundance and fine sediments with high organic matter content may be purely coincidental because deep, quiescent environments in the Gulf of Maine are characterized by both cold, unmixed water and accumulation of fine sediments.

Mud bottom habitats that support large populations of shrimp include: Jeffrey's basin, Cashes basin, Scantum basin and the region southeast of Mount Desert Island, Maine. There are small populations in deep, cold water pockets in Penobscot Bay and in the Sheepscot River.

During the winter and spring, when near-shore and offshore surface waters have cooled to the temperature range of shrimp, the amount of habitat available to adult shrimp increases. A wintertime fishery for northern shrimp extends as far south as the outer arm of Cape Cod, reaches as far north as Jonesport, Maine.

Identification and Distribution of Habitat Areas of Particular Concern

Near-shore waters (out to 10 miles) - Near-shore waters provide habitat for the larval and juvenile stages of northern shrimp. The survival of these early life-history stages is essential to the success of the species. Near-shore habitats are impacted by a myriad of anthropogenic activities including coastal development, pollutant run-off, harbor dredging, etc. The effects of these and other human activities on habitat quality for larval and juvenile northern shrimp are not known at this time.

Deep, muddy basins in the southern region of the Gulf of Maine - Deep, muddy basins in the southwestern region of the Gulf of Maine act as cold water refuges for adult shrimp during periods when most water in the Gulf reaches temperatures that are lethal to this arctic/sub-arctic species. Changes in the oceanographic conditions due to the North Atlantic Oscillation or other natural factors may cause warm water to intrude into some of the deep basins in the southwestern Gulf rendering this habitat unsuitable for shrimp and possibly resulting in extirpation of local populations.

Present Conditions of Habitats and Habitat Areas of Particular Concern / Issues and Concerns

Near-shore waters - Near-shore habitats are impacted by a myriad of anthropogenic activities including coastal development, pollutant run-off, harbor dredging, etc. At this time, the inshore habitats occupied by larval and juvenile shrimp have not been mapped, and therefore it is not possible to identify the condition of, or specific anthropogenic threats to these habitats.

Prey Species

There is strong evidence that northern shrimp leave the bottom at night and distribute themselves throughout the water column, presumably to feed. Gut contents of this species have been shown to include planktonic crustaceans. After spending the night dispersed in the water column, shrimp return to the bottom around dawn where they feed on a wide variety of soft bottom benthic invertebrates.

For more information, refer to the Report on Northern Shrimp Habitat for Development of the Habitat Section for the Fisheries Management Plan for Northern Shrimp (*Pandalus borealis*)

Red Drum

Description of Habitat

Spawning Habitat – Early studies led investigators to conclude that red drum spawned in nearshore areas in the vicinity of inlets and passes throughout their range. However, evidence now suggests that red drum also utilize high-salinity estuarine areas along the coast. These expansive areas offer adequate conditions for survival of eggs and larvae and favorable circulation patterns that help transport larvae to suitable nursery areas. Red drum spawning has been documented from nearshore waters, in the vicinity of passes and inlets and inside estuaries such as Pamlico Sound and Mosquito Lagoon.

Eggs and Larvae Habitat – Red drum eggs have been commonly encountered in several southeastern estuaries, in salinities above 25 ppt. Indeed, laboratory experiments in Texas established that optimum temperature and salinity for hatching and survival of red drum larvae are 25^{o}C and 30 ppt, respectively. The spatial distribution and relative abundance of eggs in estuaries, as expected, mirrors that of spawning adults and eggs and early larvae utilize high salinity waters inside inlets and passes and in the estuary proper.

Viable red drum eggs have been collected in Mosquito Lagoon, Florida. Red drum larvae along the Atlantic coast are reportedly common in most major southeastern estuaries, with the exception of Albemarle Sound, and they are abundant in the St. Johns and Indian River estuaries, Florida. Data on the spatial distribution of red drum larvae in the Gulf of Mexico has been summarized by Mercer (1984).

More recently, there has been reported evidence of diel vertical stratification among red drum larvae found in depths < 25 m at both offshore and nearshore locations. Larvae (1.7 – 5.0 mm mean length) were found at depth during the night and higher in the water column during the day. No consistent relationship between the distribution of larvae and tidal stage was detected.

Juvenile Habitat - Juvenile red drum utilize a variety of inshore habitats throughout their range including tidal freshwater habitats, low-salinity reaches of estuaries, estuarine emergent vegetated wetlands, estuarine scrub/shrub, submerged aquatic vegetation, oyster reefs, shell banks, and unconsolidated bottom. In general, juvenile red drum are found throughout southeastern estuaries in all of these habitat types.

Southeastern estuaries where juveniles (including subadults) are abundant include Bogue Sound, NC; Winyah Bay, SC; Ossabaw Sound, and St. Catherine/Sapelo Sound, GA; and the St. Johns River, FL. They are highly abundant in the Altamaha River and St. Andrew/St. Simon Sound, GA, and the Indian River, FL. Juvenile red drum are consistently abundant in shallow waters (< 5 feet) near the mouths of the Pamlico and Neuse Rivers and in smaller bays and rivers between them. In general, habitats supporting juvenile red drum in North Carolina can be characterized as detritus or mud-bottom tidal creeks in western Pamlico Sound and mud or sand bottom habitat in other areas. Within SAV beds, investigations have shown juveniles to prefer areas with patchy grass coverage over sites with homogeneous vegetation.

Subadult Habitat - Red drum begin the subadult phase of their life cycle upon leaving the shallow nursery habitat, whereupon, they utilize a variety of habitats within the estuary. Despite limitations using aerial surveys, schools have been detected in flats at the confluence of rivers, inside inlets, creeks, sounds and bays. Typical habitats where subadult red drum are found in South Carolina are of two general types. In the northern portion of the coast, typical subadult habitat consists of broad (up to 200 m or more in width), gently sloping flats often leading to the main channel of a river or sound. Along the southern portion of the coast, subadult red drum habitat consists of more narrow (50 m or less), fairly level flats traversed by numerous small channels, typically 5-10 m wide by less than 2 m deep at low tide).

Adult Habitat – Along the Atlantic Coast adult red drum migrate North and inshore in the spring. In the fall, they migrate offshore and south. Overall, adults tend to spend more time in coastal waters after reaching sexual maturity. However, they do continue to frequent inshore waters on a seasonal basis.

Less is known about the biology of red drum once they reach the adult stage and accordingly, there is a lack of information on habitat utilization by adult fish. The SAFMC's Habitat Plan (SAFMC 1998) cited high salinity surf zones and artificial reefs as essential fish habitat (EFH) for red drum in oceanic waters, which comprise the area from the beachfront seaward. In addition, nearshore and offshore hard/live bottom areas have been known to attract concentrations of red drum. Besides natural hard/live bottom habitats, red drum also utilize artificial reefs and other man-made structures. Adult red drum have been found from late November until the following May at natural and artificial reefs along tide rips or associated with the plume of major rivers in Georgia. Data from this study suggested high seasonal fidelity to a specific area.

Identification and Distribution of Habitat Areas of Particular Concern

Habitat Areas of Particular Concern (HAPCs) are defined by the Atlantic States Marine Fisheries Commission as areas within the species habitat which satisfy one or more of the following criteria: (1) provide important ecological function, (2) are sensitive to human-induced environmental degradation, (3) are susceptible to coastal development activities, or (4) are considered to be rarer than other habitat types. For red drum, this includes the following habitats: tidal freshwater, estuarine emergent vegetated wetlands (flooded saltmarshes, brackish marsh, and tidal creeks), estuarine scrub/shrub (mangrove fringe), submerged rooted vascular plants (sea grasses), oyster reefs and shell banks, unconsolidated bottom (soft sediments), ocean high salinity surf zones, and artificial reefs. The South Atlantic Fisheries Management Council (SAFMC) which has a similar designation for their HAPCs has recognized HAPCs for red drum along the U.S. coast including all coastal inlets, all state-designated nursery habitats (i.e. Primary Nursery Areas in North Carolina), sites where spawning aggregations of red drum have been documented and spawning sites yet to be identified, and areas supporting submerged aquatic vegetation (SAV). The SAFMC (1998) also cites barrier islands off the South Atlantic states as being of particular importance since they maintain the estuarine environment in which young red drum develop. Passes between barrier islands are of concern because the productivity of the estuary depends on the slow mixing of fresh and seawater that occurs in these areas. Finally, inlets, channels, sounds and outer bars are of particular importance to red drum since spawning activity is known to occur in these areas throughout the South Atlantic. Moreover, subadult and adult red drum utilize these areas for feeding and daily movements.

As previously mentioned, evidence suggests that spawning occurs within passes and inlets and inside high salinity estuaries of the southeast U.S. coast. Hence, all such geographic features throughout the red drum's range constitute potential spawning habitat and are of critical importance to the species' survival. Specific areas of the Atlantic coast where red drum spawning is currently known to take place are: North Carolina – waters of Pamlico Sound near Hatteras, Ocracoke and Drum Inlets and between the Neuse and Pamlico rivers in the western portion of the sound; South Carolina – main channel leading to Charleston Harbor and estuarine waters of St. Helena Sound; Georgia – the Altamaha River estuary; Florida – Ponce de Leon inlet and the Mosquito Lagoon system.

A species' primary nursery areas are indisputably essential to its continuing existence. Primary nursery areas for red drum can be found throughout estuaries, usually in shallow waters of varying salinities that offer certain degree of protection. Such areas include coastal marshes, shallow tidal creeks, bays, tidal flats of varying substrate, tidal impoundments, and seagrass beds. Since red drum larvae and juveniles are ubiquitous in such environments, it is impossible to designate specific areas as deserving more protection than others. Moreover, these areas are not only primary nursery areas for red drum, but they fulfill the same role for numerous other resident and estuarine-dependent species of fish and invertebrates.

Similarly, subadult red drum habitat extends over a broad geographic range and adheres to the criteria that define HAPCs. Subadult red drum are found throughout tidal creeks and channels of southeastern estuaries, in backwater areas behind barrier islands and in the front beaches during certain times of the year. Therefore, the estuarine system as a whole, from the lower salinity reaches of rivers to the mouth of inlets, is vital to the continuing existence of this species.

Present Conditions of Habitats and Habitat Areas of Particular Concern / Issues and Concerns

Coastal Waters - The most conspicuous threat to the spawning habitat for red drum is navigation and related activities such as dredging and hazards associated with ports and marinas. According to the SAFMC (1998), impacts from navigation related activities on habitat include direct removal/burial of organisms from dredging and disposal of dredged material, effects due to turbidity and siltation; release of contaminants and uptake of nutrients, metals and organics; release of oxygen-consuming substances, noise disturbance, and alteration of the hydrodynamic regime and physical characteristics of the habitat. All of these impacts have the potential to substantially decrease the quality and extent of red drum spawning habitat. Maintenance and stabilization of coastal inlets is of concern in certain areas of the southeast. Studies have implicated jetty construction to alterations in hydrodynamic regimes thus affecting the transport of larvae of estuarine-dependent organisms through inlets.

Estuarine Waters - Coastal wetlands and their adjacent estuarine waters constitute primary nursery, juvenile and sub-adult habitat for red drum along the coast. Throughout the coast, the condition of red drum estuarine habitat varies according to location and the level of urbanization. In general, it can be expected that estuarine habitat adjacent to highly developed areas will exhibit poorer environmental quality than more distant areas. Urban and suburban development are perhaps the most immediate threat to red drum habitat in the southeast. Estuarine habitats can also be negatively impacted by hydrologic modifications, including flood control.

Nearshore and Offshore Waters - Threats to the red drum's adult habitat are not as numerous as those faced by postlarvae, juveniles and subadults in the estuary and coastal waters. According to the SAFMC (1998), threats to the nearshore and offshore habitats that adult red drum utilize in the South Atlantic include dumping of dredged material and mining for sand. Associated threats with mining sand for beach nourishment projects include burial of bottoms near the mine site or near disposal sites, release of contaminants directly or indirectly associated with mining (i.e. mining equipment and materials), increase in turbidity to harmful levels, and hydrologic alterations that could result in diminished desirable habitat.

Prey Species

Dietary analysis of red drum (5-300 mm SL) stomach contents was conducted in 1988. Prey varied with fish size. Copepods were predominant prey by volume for fish 5-15 mm SL, representing 27% of the total volume. Mysids comprised 34% of the total volume of prey for fish 16-30 mm. The highest level of fish consumption occurred in juvenile red drum in the 76 and 100 mm size class (72% by volume) found in 70% of the individual samples. Fish were also a major component of juvenile red drum in both the 100-125 mm SL 951% by volume) and the 125-150 mm SL (60% by volume) size classes. A shift in composition of prey species was observed for red drum 200-300 mm SL. The predominant species observed in this size class included decapods (mainly mud crabs and fiddler crabs) accounting for 96% by volume and 95% of the (83) individuals analyzed. Stomach contents were also analyzed in 1984 for red drum, which ranged from 101 mm to 1,100 mm collected in Glynn County Georgia from January 1979 through June 1982. Red drum 300-600 mm in length were found to have 17% fish, 72% arthropods and 11% plant material, with fiddler crabs (16%) and white shrimp (11%) being the predominant food item by occurrence. Red drum 601-1,100 mm in length were found to have 36% fish, 59% arthropods and 5% plant material, with fiddler crabs (14%) and mud crabs (11%) being the predominant food item by occurrence.

For more information, refer to Amendment 2 to the Interstate Fishery Management Plan for Red Drum.

Scup

Essential Fish Habitat

Eggs – EFH is estuaries where scup were identified as common, abundant, or highly abundant in the ELMR database for the “mixing” (defined in ELMR as 0.5 to 25.0 ppt) and “seawater” (defined in ELMR as greater than 25 ppt) salinity zones. In general scup eggs are found from May through August in southern New England to coastal Virginia, in waters between 55 and 73° F and in salinities greater than 15 ppt.

Larvae - EFH is estuaries where scup were identified as common, abundant, or highly abundant in the ELMR database for the “mixing” and “seawater” salinity zones. In general scup larvae are most abundant nearshore from May through September, in waters between 55 and 73° F and in salinities greater than 15 ppt.

Juveniles – 1) Offshore, EFH is the demersal waters over the Continental Shelf (from the coast out to the limits of the EEZ), from the Gulf of Maine to Cape Hatteras, North Carolina, in the highest 90% of all the ranked ten-minute squares for the area where summer flounder juveniles are collected in the NEFSC trawl survey. 2) Inshore, EFH is the estuaries where scup are identified as being common, abundant, or highly abundant in the ELMR database for the “mixing” and “seawater” salinity zones. Juvenile scup, in general during the summer and spring are found in estuaries and bays between Virginia and Massachusetts, in association with various sands, mud, mussel and eelgrass bed type substrates and in water temperatures greater than 45° F and salinities greater than 15 ppt.

Adults – Offshore, EFH is the demersal waters over the Continental Shelf (from the coast out to the limits of the EEZ), from the Gulf of Maine to Cape Hatteras, North Carolina, in the highest 90% of all the ranked ten-minute squares of the area where adult scup are collected in the NEFSC trawl survey. 2) Inshore, EFH is the estuaries where scup were identified as being common, abundant, or highly abundant in the ELMR database for the “mixing” and “seawater” salinity zones. Generally, wintering adults (November through April) are usually offshore, south of New York to North Carolina, in waters above 45° F.

Habitat Areas of Particular Concern

No strong association between habitat type or location and recruitment for scup has been identified yet.

Issues and Concerns

Hard structures and beach nourishment have been identified as potentially harmful threats to scup EFH. Recommendations include discouraging the use of hard structures when practicable alternatives exist, and insuring that borrow material is acceptable when beach nourishment is the preferred alternative. Dredging and disposing of dredged material as a “beneficial use” can also pose threats to scup EFH. The dredging process may cause: 1) direct removal/burial of organisms; 2) increase turbidity/siltation effects, including increased light attenuation from turbidity, alteration of bottom type, and physical effects of suspended sediments on organisms; 3) release of contaminants; 4) release of oxygen-consuming sulfides; 5) changes to the hydrodynamic regime and physical habitat; and 6) loss of wetland and SAV beds. Any "beneficial use" proposal should be compatible with existing uses by scup. Conflicting uses, such as creation of bird breeding islands in shallow water habitats, only deplete scup habitat.

Prey Species

Juvenile scup in Long Island Sound feed mainly on polychaete worms (e.g., maldanids, nephthids, nereids, and flabelligerids) epibenthic amphipods, other small crustacea, small molluscs, and fish eggs and larvae. Juvenile and adult scup in lower Delaware Bay, near an artificial reef, ate amphipods, razor clams, hydroids, blue mussels, anemones, and mysids. Both juvenile and adult scup are benthic feeders that "root their prey from the sand or mud." Adults are known to feed on small crustacea (including zooplankton), polychaete worms, molluscs, small squid, vegetable detritus, insect larvae, hydroids, sand dollars, and small fish.

For more information and maps of scup presence for various life history stages, refer to Amendment 12 to the Summer Flounder, Scup, and Black Sea Bass Fishery Management Plan (October 1998). Time constraints prevented incorporating all state data into this Amendment. As more state data becomes available, additional designations may be included to supplement EFH information contained in this FMP.

Shad and River Herring

Description of Habitat

Habitats used by all Atlantic anadromous alosine species include spawning sites in coastal rivers and nursery areas, which include primarily freshwater portions of the rivers and their associated bays and estuaries. In addition to the spawning and nursery areas, adult habitats also consist of the nearshore ocean. Adult American shad have also been found to migrate up to 60 miles off the coast. These habitats are distributed along the East Coast from the Bay of Fundy, Canada to Florida. Use of these habitats by migratory alosines may increase or diminish as the size of the population changes.

The following habitats are deemed essential to the sustainability of the four anadromous alosine stocks as they presently exist. Due to decreasing stock sizes of all alosine species along the Atlantic coast, it is difficult to determine if adequate spawning, nursery, and adult habitat presently exist to sustain the stocks at recovered levels.

Spawning Habitat

American Shad – American shad spawn in rivers throughout the species' range. Historically, the species probably spawned in virtually every accessible river and tributary along the Atlantic coast. However, blockage of spawning rivers by dams and other impediments and degradation of water quality and physical habitat in spawning reaches have severely depleted suitable American shad spawning habitat. American shad migrate from the sea to coastal rivers in the spring and begin spawning when water temperatures range from about 16-19° C. Water temperature is the primary factor that triggers spawning, but photoperiod, current velocity, and turbidity also exert some influence. American shad can spawn as early as mid-November in Florida to as late as July in some Canadian rivers. If possible, adults migrate far upstream and typically spawn in freshwater areas dominated by extensive flats and over sandy or rocky shallows, including the mouths of larger tributary streams. However, substrate type should be relatively unimportant to successful American shad spawning since the eggs are broadcast into the water column over a range of substrate and most are carried downstream. Only in areas where the eggs settles to the bottom, were covered by silt or sand and then smothered would substrate become a critical habitat problem.

Hickory Shad – Historically, hickory shad spawned in rivers and tributaries along the Atlantic coast from the Bay of Fundy, Canada to the Tomoka River, Florida, but now the species' range is uncertain. The most detailed information available in spawning habitat comes from Maryland, Virginia, North Carolina, and Georgia. Hickory shad anadromous and begin to ascend freshwater streams for spawning in early spring. Spawning can occur between March and early June, depending on latitude, over a water temperature range of 12 to 22° C. Adult hickory shad appear to spawn in a diversity of physical habitats ranging from backwaters and sloughs, to tributaries, to mainstream portions of large rivers in tidal and non-tidal freshwater areas. Major hickory shad spawning sites in Maryland and Virginia occur in mainstem rivers at the fall line, but some appear to spawn further downstream and also in tributaries. In North

Carolina, the freshwater reaches of coastal rivers are the major spawning sites for hickory shad. However, shad have been found in the Neuse River in flooded swamps and sloughs off the channels of tributary creeks and not in the mainstem river. In Georgia, hickory shad apparently spawn in flooded areas off the channel of the Altamaha River, and not in the mainstem of the upper reaches.

Alewife and Blueback Herring – Alewife spawn in rivers and tributaries from northeastern Newfoundland to South Carolina, but are most abundant in the mid-Atlantic and northeastern states. At the extreme southern end of their range, alewife begin spawning in late February, but they may not commence spawning until late April or early June at the northern end of their range. Blueback herring spawn in rivers and tributaries from Nova Scotia to northern Florida, but are most numerous in warmer waters from Chesapeake Bay south. At the extreme southern end of their range, spawning can begin in December or January, but may not commence until June near the northern end of their range and can continue through August. Alewife spawn in a diversity of physical habitats that includes large rivers, small streams, ponds, and large lakes over a range of substrates such as gravel, sand detritus, and submerged vegetation. Blueback herring spawning sites include swift flowing sections of freshwater tributaries, channel sections of fresh and brackish tidal rivers, and Atlantic coastal ponds over gravel and clean sand substrates, especially in northeastern rivers where alewife and blueback herring coexist. In southeastern rivers where alewife are few, blueback herring exhibit more of a variety in their spawning sites including; shallow areas covered with vegetation, rice fields, swampy areas, and in small tributaries upstream from the tidal zone. Upstream distribution of adults is a function of habitat suitability and hydrologic conditions permitting access to these sites. Immediately after spawning, surviving adult river herring migrate rapidly downstream.

Nursery Habitat

American Shad – Nursery habitats for American shad are downstream of spawning grounds because juveniles begin to disperse downstream upon transformation from the larval stage. These nursery habitats usually occur in deep pools away from the shoreline in non-tidal areas, although juveniles occasionally move into shallow water areas. In the Chesapeake Bay system, juveniles are usually found in tidal freshwater reaches of the spawning rivers. Juvenile American shad leave the nursery areas by late fall and may remain in the estuaries and nearshore ocean until they reach one year of age. As young-of-the-year, they presumably join other schools of young shad in the ocean, where they grow and develop for three to six years before returning to their natal streams to spawn. Subadults appear to migrate farther offshore than sexually mature adults.

Hickory Shad – Documentation of hickory shad nursery area is difficult because capture of juveniles is rare. Studies suggest that most juveniles leave freshwater and brackish areas in early summer and migrate to estuarine nursery areas. Other studies completed in North Carolina suggest that juveniles migrate directly to saline areas; they do not use the oligohaline portion of the estuary as a nursery area.

Alewife and Blueback Herring – Nursery habitats for alewife and blueback herring occur in non-tidal freshwater and semi-brackish areas during spring and early summer, moving upstream during periods of decreased flows and encroachment of saline waters. Juvenile alewife and blueback herring begin migrating from their nursery areas as water temperatures decline in the fall. However, in some instances, it appears that a high abundance of juveniles may trigger very early emigration of large numbers of small juveniles from the nursery area.

Adult Resident Habitat and Migratory Routes

American Shad – American shad are currently distributed from the Bay of Fundy, Canada southward to the St. Johns River in Florida, and move along the Atlantic coast between summer feeding grounds in the Gulf of Maine and coastal wintering areas mainly off the mid-Atlantic states. Adult shad migrate to spawning grounds beginning as early as mid-November for southern stocks (Florida) and as late as July in some Canadian rivers. Those fish that return to rivers north of Cape Hatteras usually begin migration later in the spring and follow a route farther seaward into the Mid-Atlantic Bight where water temperatures have risen sufficiently. After spawning is complete, adult and immature shad migrate out of tributaries and rivers and proceed northward along the Atlantic coast to their summer feeding grounds in the Gulf of Maine, Bay of Fundy, the St. Lawrence estuary and along the Labrador coast, and remain in that vicinity throughout the summer into fall. In mid-fall, a southward migration begins, with overwintering occurring off Florida, in the mid-Atlantic area, and in the Scotian Shelf-Gulf of Maine.

Hickory Shad – Hickory shad are currently distributed from the Connecticut River to the Tomoka River, Florida. The distribution and movements of adult hickory shad at sea are essentially unknown. Adults have been captured along the southern New England coast during summer and fall. These observations suggest that hickory shad may migrate northward from the mid-Atlantic and southeast Atlantic spawning rivers in a pattern that is similar to the coastal migrations of American shad.

Alewife and Blueback Herring – Alewife are currently distributed from northeastern Newfoundland to South Carolina, but are most numerous in the mid-Atlantic and northeastern states. Blueback herring are distributed from Nova Scotia to northern Florida, and are most abundant from the Chesapeake Bay south. However, little information is available concerning the distribution and movements of adult and subadult alewife and blueback herring once they emigrate to the sea. Various studies have determined that alewife and blueback herring are capable of migrating long distances (over 2000 km) in ocean waters of the Atlantic seaboard, and that patterns of river herring migration may be similar to those of American shad.

Present Status of Habitats / Issues and Concerns

Concerns that the declines in anadromous alosine populations are related to habitat degradation has been alluded to in past evaluation of these stocks. However, it has never been possible to rigorously quantify the magnitude of this contribution. The quality of alosine habitat has been compromised largely by impacts resulting from human activities. Several impacts, including turbidity in spawning areas, have been suggested as contributing factors in declining alosine populations.

Potentially serious threats stem from the continued alteration of freshwater flows and discharge patterns to spawning and nursery habitats in rivers and estuaries. Placement of jetties, which disrupt current flow patterns into and out of coastal estuaries and lagoons, may affect migration patterns or habitat use.

Prey Species

As larvae, American shad consume copepods, midge larvae, midge pupac and small crustaceans. As juveniles, they feed on crustacean zooplankton, midge larvae and pupae, caddis fly larvae and adult insects, and small fishes (i.e. striped anchovy, bay anchovy, and mosquitofish). As adults, shad are believed to be primarily planktivorous, consuming mainly copepods, mysid shrimp, and other zooplanktors. Hickory shad are known to feed on small fish, squid, fish eggs, small crabs, and pelagic crustacean during their coastal migration. Juvenile alewife and blueback herring feed mainly on zooplankton.

For more information, refer to the Interstate Fishery Management Plan for Shad & River Herring (April 1999).

Spanish Mackerel

Distribution and Seasonal Movements

The Spanish mackerel is restricted to the eastern Atlantic coast of the U.S. and the Gulf of Mexico. The Atlantic Migratory Group ranges from the Florida Keys northward to New York or southern New England, although occasional strays are found to the Gulf of Maine. Spanish mackerel make seasonal migrations along the Atlantic coast and appear to be much more abundant in Florida during the winter. They move northward each spring to occur off the Carolinas by April or May, off Chesapeake Bay by May or June, and some years, as far north as Narragansett Bay by July. Results of tagging studies in North Carolina have confirmed a southern movement to Florida in the winter and movement north to Virginia in the summer and fall.

General Behavior

Spanish mackerel are fast-moving, surface-feeding fish that form immense schools of similar sized individuals. Schools are often known to pass very near to the beach on their seasonal migrations. They frequently enter tidal estuaries, bays, and lagoons, and most commonly occur within the jurisdictional waters of the Atlantic and Gulf states.

Habitat and Distribution

Adult Habitat - Adult Spanish mackerel inhabit coastal waters out to the edge of the continental shelf in the Atlantic Ocean, and also enter tidal estuaries. Temperature and salinity are believed to be the most important factors governing their distribution. Spanish mackerel are reported to prefer water temperatures of 21 to 27°C, and they are rarely observed in waters cooler than 18°C. Spanish mackerel usually inhabit waters with salinities of 32 to 36 ppt.

Larval Habitat - Spanish mackerel larvae have been found in nearshore shallow water environments from Cape Canaveral, Florida to Cape Hatteras, North Carolina. Another study found larvae occurring predominantly between late May and mid-June in waters at Breech Inlet, South Carolina. Larvae are known to concentrate at depths less than 9 m, and exhibit vertical migration to the surface at night. Juveniles have been found in salinities as low as 4.7 0/00 in the Neuse River, North Carolina.

Condition of Habitat

Adult Habitat - Spanish mackerel spend most of their life cycle in the ocean where environmental conditions are more stable and man's effect is less severe. Adverse effects of habitat degradation on adult Spanish mackerel have not been demonstrated. Adults may be impacted through predator-prey relations.

Larval Habitat – The larval habitat of Spanish mackerel is the water column in inshore waters. Juveniles have been found in salinities as low as 4.7 0/00 in the Neuse River, North

Carolina. Offshore areas used by Spanish mackerel eggs and larvae appear to be the least affected by nearshore habitat alterations and water quality degradation.

Habitat Areas of Particular Concern

Critical habitat of Spanish mackerel are spawning grounds and areas where eggs and larvae develop. Such areas are still poorly known and require further delineation before specific critical habitats can be designated. Larvae have been collected annually in Breech Inlet, SC in neuston samples since 1984. Estuarine habitats may therefore serve as nursery areas as well as provide prey species along migration pathways.

Issues and Concerns

All of the Atlantic coast estuaries have been impacted to some degree by natural and man-induced changes, which have altered freshwater inflow and removed much habitat. Major man-induced activities that have impacted environmental gradients in the estuarine zone include construction and maintenance of navigation channels, and dredge and fill for land use development.

Prey Species

Spanish mackerel is a major predator on small schooling fishes of the families Cleupidae, Carangidae, and Engraulidae. They prefer herring-like fishes (scaled sardine and Atlantic thread herring), anchovies, Spanish sardine, Atlantic bumper, round scad, shrimp, and squid.

For more information, refer to the Interstate Fishery Management Plan for Spanish Mackerel (November 1990).

Spiny Dogfish

Essential Fish Habitat

The descriptions below outline spiny dogfish distribution and habitat use from the NEFSC's bottom trawl surveys, the Massachusetts trawl survey, and several key spiny dogfish studies. There is no information on eggs and larvae because dogfish are oviviparous (no placenta, live birth).

Juvenile Habitat - Juveniles occurred in waters with a bottom depth range between 23 and 1,280 ft (7 and 390 m), while most were caught in waters with bottom depths between 164 and 492 ft (50 and 150 m). The juvenile spiny dogfish caught during the spring surveys were concentrated in offshore waters from North Carolina to the eastern edge of Georges Bank; the highest numbers occurred along the outer shelf (200-660 ft; 60-200m). Juveniles were nearly absent in the northwest portion of the Gulf of Maine.

Juveniles are also abundant around the southwest part of Martha's Vineyard, south of Nantucket Island, along the northeast edge of Cape Cod, and north of Cape Cod Bay in the spring. They occurred at bottom depths ranging from 7-64m; most were caught at depths between 10-44m. During the autumn NEFSC surveys, juveniles occurred in waters with bottom depths ranging from 39 to 1201 ft (2 to 366m), while most were caught in waters with bottom depths between 82 and 246 ft (25 and 75 m). The autumn distribution and relative abundance for juvenile spiny dogfish indicated the highest numbers were evident: 1) around Nantucket Shoals; 2) on Georges Bank and; 3) in waters between Lurcher Shoal and German Bank off the coast of Nova Scotia. It should be noted that juveniles were widespread throughout the Gulf of Maine. During the autumn Massachusetts bottom trawl survey, juveniles occurred at depths between 8-82 m; most were caught at depths between 15-34 m.

The winter distribution of juvenile spiny dogfish was widespread across the shelf from North Carolina to the eastern edge of Georges Bank.

Juvenile spiny dogfish in the Delaware 30-foot trawl survey were observed at stations from the mouth of Delaware Bay up to approximately the Cross Ledge Light; although sampling extends much farther up the Bay. They were present in the survey catches in the months of April - May and September - December. November and December were the months of highest abundance. Survey depths ranged from 13 - 92 ft (4 - 28 m). Juvenile spiny dogfish were encountered at depths ranging from 23 -79 ft (7 - 24 m), with most being taken between 26-49 ft (8-15m).

Adult Habitat - In the spring, the distribution and relative abundance of adults in the NEFSC survey were somewhat similar to that of the juveniles. High numbers of dogfish were seen along the outer shelf from North Carolina to the northeast peak of Georges Bank, continuing onto Browns Bank. Lesser numbers occurred inshore from Cape Hatteras to Long Island, the western portion of Georges, and central Gulf of Maine. Trawl stations occupied during the spring had a bottom depth range from 16 to 1440 ft (5 to 439 m). Adults occurred in waters with a bottom depth range between 23 to 1440 ft (7 and 439 m), while most were caught in waters with bottom depths between 164 and 489 ft (50 and 149m).

In the spring Massachusetts bottom trawl surveys, adult spiny dogfish were collected in the southern portions of the survey area and were most abundant on the south shores of Nantucket Island, northeast of Cape Cod, and in Cape Cod Bay. They were caught at depths less than 45m.

During the autumn NEFSC surveys, adults occurred in waters with a bottom depth range between 39-1128 ft (12-344m), while most were caught in waters with bottom depths between 32-161 ft (10-49m). Adults were absent across the shelf from North Carolina to the area just south of the Hudson Canyon. Low numbers occurred along the nearshore area of Long Island. The highest abundance was seen off Nantucket Shoals, then north along the eastern edge of Cape Cod, and into Cape Cod and Massachusetts bays. Another area of high abundance occurred just southwest of Nova Scotia. To a lesser degree than juveniles, adults were scattered throughout the Gulf of Maine and along the northwest edge of Georges Bank.

In the autumn Massachusetts surveys, the highest catches of adults occurred along the eastern shore of Cape Cod near Nauset Beach, near the tip of the Cape, and within Cape Cod Bay. Adult spiny dogfish were caught at depths between 10-34m. Winter distribution of adult spiny dogfish was very similar to that of winter juveniles. Distribution was widespread across the shelf from Cape Hatteras, North Carolina to the eastern edge of Georges Bank. Adults were nearly absent in the New York Bight, Nantucket Shoals, and completely absent on the western portion of Georges Bank.

Adult spiny dogfish in the Delaware 30-foot trawl survey were observed at stations from approximately the Cross Ledge Light to the mouth of Delaware Bay. Adult spiny dogfish were present in survey catches from March - May and October - December. Adults were found at depths ranging from 23-79 ft (7-24 m). Most adults were collected at depths between 26-46 ft (8 - 14m).

Identification and Distribution of Habitat Areas of Particular Concern

Dogfish are predominately epibenthic species, with no known associations to any particular substrate, submerged aquatic vegetation, or any other structural habitat. However, its life history does focus towards the ocean bottom and spiny dogfish may be potentially adversely impacted if this bottom were to be negatively impacted. In addition, spiny dogfish may rely heavily on estuarine areas for habitat as well as a source of some of their prey such as menhaden.

Present Conditions of Habitats and Habitat Areas of Particular Concern / Issues and Concerns

Many anthropogenic actions threaten the integrity of dogfish habitat. Coastal development, water withdrawal, nonpoint source pollution, dredging, port development, marinas, wetland loss, and sewage disposal all impact estuarine areas which spiny dogfish may rely on for habitat and as a source for prey.

Prey Species

Fish, including herrings, Atlantic mackerel, American sand lance, and codfishes (including Atlantic cod, haddock, silver hake, red hake, white hake, and spotted hake) are the primary prey of spiny dogfish. Other important contributors to the diet of spiny dogfish include *Loligo* and *Illex* squid, ctenophores, crustaceans (principally decapod shrimp and crabs) and bivalves (principally scallop viscera). Spiny dogfish exhibit high variability in their diet across seasons, areas, and years, which can be tied to availability of prey abundance.

For more information and maps of spiny dogfish presence for various life history stages, refer to the Spiny Dogfish Fishery Management Plan (February 1999).

Spot

Species Distribution

Spot range from the Gulf of Maine to the Bay of Campeche, Mexico in estuarine and coastal waters to depths of at least 205 m. The area of greatest abundance and center of the commercial fishery on the Atlantic coast extends from Chesapeake Bay to South Carolina. Spot migrate seasonally between estuarine and coastal waters. They enter bays and sounds during spring where they remain until late summer or fall, and then move offshore to spawn and escape low water temperature.

Spawn, Larvae, and Juveniles – Spot eggs have not been identified in ichthyoplankton collections; however, spawning is believed to occur outside of estuaries based on size distributions of larvae collected along the coast, and infrequent collections of fish in spawning condition from offshore.

Spot larvae have been collected from within estuaries to the edge of the continental shelf from October through May. Larvae were smaller and more numerous offshore than inshore, indicating that more spawning occurs offshore. Spot larvae may be present at any depth but occur more frequently near the bottom; some studies have found this to be true only at night. Direct across-shelf transport has been suggested as the major transport mechanism for larvae of sciaenids and other species along the mid-Atlantic coast.

Postlarval spot have been collected in estuarine nursery areas chiefly in April in Delaware Bay, and in January or February in Chesapeake Bay, North Carolina, South Carolina, Georgia, and Florida. Low salinity bay waters and tidal marsh creeks with mud and detrital bottoms constitute the primary nursery habitat for juvenile spot in Delaware, Virginia, North Carolina, South Carolina, Georgia, and Florida. It has been suggested that for spot, some oligohaline wetland habitats may be of equal importance to higher salinity marshes. Juvenile spot are also associated with eelgrass beds in Chesapeake Bay, and in North Carolina; however, by late spring densities in tidal creeks are often several times higher than in nearby seagrass habitats or shoal areas.

Working experiments have concluded that young-of-the-year spot recruited into tidal creeks and were largely resident for the duration of warm weather. As temperatures drop in the fall, mass emigrations to deeper estuarine waters or the ocean are apparently stimulated. Young-of-the-year have been reported overwintering in the deeper waters of the Chesapeake Bay, although other studies have only collected spot from April or May through December in the York River and Chesapeake Bay. Spot was found to be a dominant species in the winter (November – June) fish community of eelgrass beds in Bogue Sounds and the Newport River, North Carolina. Young spot are year-rounds residents of the inshore waters (rivers, sounds, and coastal waters) of South Carolina. Spot have been trawled in Georgia creeks, sounds, and outside waters year-round with the largest numbers taken in the creeks during winter.

Adults – Adult spot migrate seasonally between estuarine and coastal waters. They enter bays and sounds during spring, but seldom occur as far up-estuary as do the young. They remain in these areas until late summer or fall before moving offshore to spawn or escape low water temperature.

Spot ranked first both in total number and total weight of all species taken in trawl surveys of groundfish in coastal waters of the South Atlantic Bight (Cape Fear, North Carolina to Cape Canaveral, Florida). There was no significant difference in frequency of occurrence between season.

Condition of the Habitat

Climatic, physiographic, and hydrographic differences separate the ocean region south of Massachusetts to Florida into two distinct areas: the Middle Atlantic area and South Atlantic area, with the natural division occurring at Cape Hatteras. A major zoogeographic faunal change occurs at Cape Hatteras as a result of those differences.

The Middle Atlantic area is relatively uniform physically and is influences by large estuarine areas including Chesapeake Bay, Narragansett Bay, Long Island Sound, the Hudson River, Delaware Bay, and the nearly continuous band of estuaries behind the barrier beaches from New York to Virginia. The southern edge of the region includes the estuarine complex of Currituck, Albemarle, and Pamlico sounds, a 2,500-square mile system of large interconnecting sounds behind the Outer Banks of North Carolina.

The South Atlantic region is characterized by three long crescent-shaped embayments, demarcated by four prominent points of land: Cape Hatteras, Cape Lookout, and Cape Fear in North Carolina, and Cape Romain in South Carolina. Low barrier islands skirt most of the coast south of Cape Hatteras although the sounds behind them are at most only a mile or two wide. Along the coast of Georgia and South Carolina, the barriers become a series of rather large, irregularly shaped sea islands, separated from the mainland by one of the largest coastal salt-water marsh areas in the world, through which cuts a system of anastomosing waterways. The east coast of Florida is bordered by a series of islands, separated in the north by broad estuaries, which are usually deep and continuous with large coastal rivers and in the south by narrow, shallow lagoons.

At Cape Hatteras, the continental shelf (characterized by water <198 m in depth) extends seaward approximately 32 km and widens gradually to 113 km off New Jersey. The substrata of the shelf in this region is predominantly sand interspersed with large pockets of sand-gravel and sand-shell. South of Cape Hatteras the shelf widens to 132 km near the Georgia-Florida border and narrows to 56 km off Cape Canaveral, Florida and 16 km or less off the southeast coast of Florida and the Florida Keys.

The movements of the oceanic waters along the South Atlantic Coast are not well defined. Portions of the Gulf Stream, which flows northward following the edge of the continental shelf, break off and become incorporated into the coastal water masses. Features of these gyres change seasonally; the inshore flow is northward along the coast to Cape Hatteras in winter and spring and southward in summer and fall. North of Hatteras, surface circulation on the shelf is generally southwesterly during all seasons. There may be a shoreward component to this drift during the warm half of the year and an offshore component during the cold half. This drift, fundamentally the result of temperature-salinity distribution, may be made final by the wind. A persistent bottom drift at speeds of tenths of nautical miles per day extends from beyond mid-shelf toward the coast and eventually into the estuaries. Offshore, the Gulf Stream flows northeasterly.

Habitat Areas of Particular Concern / Issues and Concerns

Habitat alterations within estuarine areas are probably damaging to spot stocks since these areas are utilized for nursery grounds. Most estuarine areas of the United States have been altered so some degree by activities including flood control and development. The National Estuary Study, completed in 1970, indicated that 73% of the nations' estuaries had been moderately or severely degraded. Damage and / or destruction of estuaries have largely been by filling, the dredging of navigation channels, and pollution. The Atlantic coast states contain 3,152,800 acres of estuarine habitat, of which an estimated 129,700 acres were lost to dredging and filling from 1954 to 1968. Unfortunately, the effects of habitat alterations, such as channel dredging and increased turbidity associated with dredging have rarely been quantified.

Prey Species – It is worth noting that spot are opportunistic bottom feeders that mainly eat polychaetes, small crustaceans and mollusks, and detritus. The mole crab (*Emerita talpoida*) and donax (*Donax* spp.) have been shown to be impacted by beach nourishment, and are readily consumed by Spot.

For more information, refer to the Atlantic States Marine Fisheries Commission Fishery Management Plan for Spot (October 1987).

Spotted Seatrout

Species Distribution

Spotted seatrout occur in estuarine and coastal waters from Cape Cod, Massachusetts to Carmen Island in the lower Gulf of Campeche, Mexico. Spotted seatrout are rare in and north of Delaware Bay, and the center of abundance extends from Florida to Texas.

The spotted seatrout is primarily an estuarine species associated with areas of submerged vegetation, sandy bottoms, and shell reefs. Spotted seatrout are year-round residents of estuaries along the South Atlantic coast, moving into deeper channels and holes, and occasionally offshore along the beaches to avoid extreme cold. Spotted seatrout are apparently migratory in Chesapeake Bay, moving offshore and south in fall and returning to the bay in spring. In North Carolina spotted seatrout are caught year-round in the estuaries, as well as in coastal oceanic waters in winter.

Differences in age and growth characteristics throughout the range, the non-migratory nature of spotted seatrout and the isolation of estuarine areas, and electrophoretic studies indicate that there are distinct subpopulations of spotted seatrout along the east coast of Florida and the in the Gulf of Mexico. A Georgia tagging study indicated that movement was seasonal and generally short range. The stock structure on the Atlantic coast has not been determined.

Habitat Areas of Particular Concern

The association of juvenile and adult spotted seatrout with seagrass beds is well documented. Seagrass beds along the coast of Mississippi were virtually destroyed during Hurricane Camille in August 1969; however, it is not known what effects this had on spotted seatrout populations in Mississippi Sound. Declines in spotted seatrout landings in Tampa Bay, Florida have occurred concomitantly with large declines in seagrass acreage. An unprecedented decline in submerged aquatic vegetation has occurred in Chesapeake Bay in the last 15 to 20 years. Major changes in vegetation patterns began in 1972, the year of Tropical Storm Agnes, which lowered salinities for periods of up to four weeks and transported large quantities of suspended sediment into the estuarine system. The causes of the Chesapeake Bay decline in seagrass beds are not known but may be related to nutrient enrichment affecting the quantity and quality of light reaching the plant surface. Implications for species inhabiting grass beds have not been determined but could be considerable.

Condition of Habitat / Issues and Concerns

Estuarine habitats, where nearly the entire commercial and recreational catches of spotted seatrout are made, have deteriorated rapidly since approximately 1950, mostly as a result of industrial and human population growth. The National Estuary Study, completed in 1970, indicated that 73% of the Nation’s estuaries had been moderately or severely degraded. Damage and/or destruction of estuaries has largely been by dredging and filling for waterfront property, dredging of navigation channels, construction of causeways and bridges, installation of ports and marinas, alteration of freshwater flow, and pollution. Unfortunately the effects of habitat alterations have rarely been quantified.

Prey Species

Spotted seatrout are carnivorous, feeding primarily on crustaceans (penaeid shrimp and crabs) and fishes (anchovies, menhaden, mullet, pinfish, and silversides). Juveniles (<150 mm SL) feed on copepods, mysids, caridean and palaemonid shrimps, amphipods, and polychaetes.

For more information, refer to the Interstate Fishery Management Plan for Spotted Seatrout (October 1984).

Summer Flounder

Essential Fish Habitat

Eggs – 1) North of Cape Hatteras, EFH is the pelagic waters found over the Continental Shelf (from the coast out to the limits of the EEZ), from the Gulf of Maine to Cape Hatteras, North Carolina, in the highest 90% of all the ranked ten-minute squares for the area where summer flounder eggs are collected in the MARMAP survey. 2) South of Cape Hatteras, EFH is the waters over the Continental Shelf (from the coast out to the limits of the EEZ), from Cape Hatteras, North Carolina to Cape Canaveral, Florida, to depths of 360 ft. In general, summer flounder eggs are found between October and May, being most abundant between Cape Cod and Cape Hatteras, with the heaviest concentrations within 9 miles of shore off New Jersey and New York. Eggs are most commonly collected at depths of 30 to 360 ft.

Larvae – 1) North of Cape Hatteras, EFH is the pelagic waters found over the Continental Shelf (from the coast out to the limits of the EEZ), from the Gulf of Maine to Cape Hatteras, North Carolina, in the highest 90% of all the ranked ten-minute squares for the area where summer flounder larvae are collected in the MARMAP survey. 2) South of Cape Hatteras, EFH is the nearshore waters of the Continental Shelf (from the coast out to the limits of the EEZ), from Cape Hatteras, North Carolina to Cape Canaveral, Florida, in nearshore waters (out to 50 miles from shore). 3) Inshore, EFH is all the estuaries where summer flounder were identified as being present (rare, common, abundant, or highly abundant) in the ELMR database, in the "mixing" (defined in ELMR as 0.5 to 25.0 ppt) and "seawater" (defined in ELMR as greater than 25 ppt) salinity zones. In general, summer flounder larvae are most abundant nearshore (12-50 miles from shore) at depths between 30 to 230 ft. They are most frequently found in the northern part of the Mid-Atlantic Bight from September to February, and in the southern part from November to May.

Juveniles – 1) North of Cape Hatteras, EFH is the demersal waters over the Continental Shelf (from the coast out to the limits of the EEZ), from the Gulf of Maine to Cape Hatteras, North Carolina, in the highest 90% of all the ranked ten-minute squares for the area where summer flounder juveniles are collected in the NEFSC trawl survey. 2) South of Cape Hatteras, EFH is the waters over the Continental Shelf (from the coast out to the limits of the EEZ), to depths of 500 ft, from Cape Hatteras, North Carolina to Cape Canaveral, Florida. 3) Inshore, EFH is all the estuaries where summer flounder were identified as being present (rare, common, abundant, or highly abundant) in the ELMR database for the "mixing" and "seawater" salinity zones. In general, juveniles use several estuarine habitats as nursery areas, including salt marsh creeks, seagrass beds, mudflats, and open bay areas in water temperatures greater than 37° F and salinities from 10 to 30 ppt range.

Adults –1) North of Cape Hatteras, EFH is the demersal waters over the Continental Shelf (from the coast out to the limits of the EEZ), from the Gulf of Maine to Cape Hatteras, North Carolina, in the highest 90% of all the ranked ten-minute squares for the area where summer flounder adults are collected in the NEFSC trawl survey. 2) South of Cape Hatteras, EFH is the waters over the Continental Shelf (from the coast out to the limits of the EEZ), to depths of 500 ft, from Cape Hatteras, North Carolina to Cape Canaveral, Florida. 3) Inshore, EFH is the estuaries where summer flounder were identified as being common, abundant, or highly abundant in the ELMR database for the “mixing” and “seawater” salinity zones. Generally summer flounder inhabit shallow coastal and estuarine waters during warmer months and move offshore on the outer Continental Shelf at depths of 500 ft in colder months.

Habitat Areas of Particular Concern

All native species of macroalgae, seagrasses, and freshwater and tidal macrophytes in any size bed, as well as loose aggregations, within adult and juvenile summer flounder EFH is HAPC. If native species of SAV are eliminated then exotic species should be protected because of functional value, however, all efforts should be made to restore native species.

Issues and Concerns

Hard structures and beach nourishment have been identified as potentially harmful threats to summer flounder EFH. Hard structures can cause: 1) erosions to downdrift beaches; 2) elimination of interaction between organisms and intertidal habitat during high tide; 3) further destabilization of adjacent benthic habitats; and 4) toxic chemicals from treated timber to be leached into the water. Recommendations include discouraging the use of hard structures when practicable alternatives exist, and insuring that borrow material is acceptable when beach nourishment is the preferred alternative. Dredging and disposing of dredged material as a “beneficial use” can also pose threats to summer flounder EFH. The dredging process may cause: 1) direct removal/burial of organisms; 2) increase turbidity/siltation effects, including increased light attenuation from turbidity, alteration of bottom type, and physical effects of suspended sediments on organisms; 3) release of contaminants; 4) release of oxygen-consuming sulfides; 5) changes to the hydrodynamic regime and physical habitat; and 6) loss of wetland and SAV beds. Any “beneficial use” proposal should be compatible with existing uses by summer flounder. Conflicting uses, such as creation of bird breeding islands in shallow water habitats, only deplete summer flounder habitat.

Prey Species

Summer flounder early-stage larvae are known to feed on immature copepodites, copepod nauplii, and tintinnids, as well as bivalve larvae and copepod eggs. Late larval and juvenile estuarine summer flounder are opportunistic feeders, but there are also ontogenetic changes in their diet. Smaller flounder typically feed on crustaceans and polychaetes and larger juveniles feed on fish. Metamorphic summer flounder usually feed on pelagic prey, and late-stage flounder feed on benthic organisms.

Common prey species in Great Bay-Little Egg Harbor (NJ) include silversides, mummichogs, anchovies, sticklebacks, grass shrimp, and sand shrimp. In the Delaware region, they are known to feed on the shrimp *Paleomonetes vulgaris*, and portunid and blue crabs. Mysids, including *Neomysis americana*, amphipods, small fishes, small gastropod molluscs, and plant material are common prey among postlarvae fish in the Virginia region, and juvenile spot, pipefish, mysid Neomysis americana, and shrimps (*P. vulgaris*, *C. septemspinosa*) are targeted by larger juvenile and adult summer flounder. Juvenile summer flounder in North Carolina are known to feed on polychaetes, primarily spionids (*S. benedicti*); invertebrate parts, primarily clam siphons; shrimp, consisting of the mysids *Neomysis americana* and palmonid shrimp; calanoid copepods, primarily *Paracalanus*; amphipods of the genus *Gammarus*; crabs, primarily *Callinectes sapidus*; and fish. In South Carolina, mysids and caridean shrimps, bay anchovy, and mummichogs are prevalent in their diet. In Georgia, they feed primarily on harpacticoid copepods, mysids, crabs, *Paleomonetes*, as well as polychaetes.

For more information and maps of summer flounder presence for various life history stages, refer to Amendment 12 to the Summer Flounder, Scup, and Black Sea Bass Fishery Management Plan (October 1998). Time constraints prevented incorporating all state data into this Amendment. As more state data becomes available, additional designations may be included to supplement EFH information contained in this FMP.

Tautog

General Distribution

Tautog are distributed along the northeast Atlantic coast of North American from the outer coast of Nova Scotia to Georgia. They are most abundant from Cape Cod to the Chesapeake Bay. North of Cape Cod, they are usually found within 4 miles of shore in waters less than 60 feet deep. South of Cape Cod, they can be found up to 40 miles offshore and at depths up to 120 feet.

Identification and Distribution of Essential Habitats

Essential habitats for tautog are described below and include spawning grounds, nursery areas, feeding areas, shelter areas, and migration routes. All are essential to tautog at different stages of their life cycle.

Spawning Habitat - After migrating inshore in the spring, spawning occurs primarily at or near the mouths of estuaries and nearshore marine waters. The most extensive inshore/offshore migrations appear to occur in the northern portion of the species range, although little data are available for more southern areas. Tautog in spawning condition have been found on offshore hard bottom sites in Maryland and Virginia. Spawning activity may also occur in continental shelf waters based on eggs and larvae collected from Georges Bank to North Carolina and concentrated off of southern New England.

Eggs and Larval Habitat – Tautog eggs are buoyant and are found near the surface in large numbers in both estuaries and nearshore waters. Larvae are also found in estuaries and nearshore waters, staying near the surface during the day and sometimes going deeper at night. Although no specific data are available, it is possible that eggs and larvae, because of their lack of (eggs), and relatively weak (larvae) swimming ability, may accumulate in marine frontal or other boundary features. Eggs and larvae are possibly transported onshore from offshore spawning sites, and seasonally high abundances of larvae and eggs offshore could be due to transport from estuarine and nearshore producer locations. However, recent research indicates that tautog do spawn at offshore sites in Virginia.

Juvenile Habitat – Juveniles settle to the bottom at around 3 weeks of age and tend to stay in waters less than 3 feet deep. They prefer vegetated over unvegetated areas, although a laboratory study indicates that some juveniles may prefer boulders to artificial vegetation. Vegetation can include sea grass move gradually to deeper waters but are seldom found deeper than around 25 feet. Juveniles have been known to move from their home sites during the summer if conditions become unsuitable due to loss of vegetative cover, high temperatures, or storm conditions. Larger juveniles become associated with various reef-like habitats and hard surfaces as long as the main habitat requirement of shelter is met.

Juvenile tautog remain inshore during the winter. When water temperatures drop below 40° F some large juveniles may move to deeper, more protected locations. Juveniles remaining inshore in shallow water can be found in a variety of shelters including grass and macroalgal beds, shells, discarded soda cans and bottles, fish pots, crevices and even in bottom depressions covered with silt. It is unknown if tautog larvae settle out of the water column in offshore locations or if small juvenile tautog are found in offshore habitats.

Adult Habitat – Adults occupy habitats similar to those of large juveniles and can be found in a variety of complex, structured coastal locations. These can include: vegetation, rocks, natural and artificial reefs, pilings, jetties and groins, mussel and oyster beds, wrecks, and submerged trees, logs and timbers. Mouths of estuaries as well as other inlets and artificial reefs may be extremely important habitats for tautog, particularly south of Long Island where there are fewer natural rocky outcrops to provide shelter than in the more northern portion of the range. Localized populations form during the summer, in co-existence with large juveniles. Adults will leave a site if conditions become unsuitable (i.e., high water temperature, decline in mussel abundance).

Most adult tautog form schools and migrate offshore to deep water locations (80-150 feet) with rugged bottom when water temperatures drop below 52° F in the late fall, although this is known primarily from the northern portion of the species range. When water temperatures are low, adults become torpid. Some adults overwinter inshore and some also remain active throughout the year.

Issues and Concerns

Tautog occur near areas immediately associated with human activity (shallow estuarine areas, rocky and artificial reefs, and submerged stormwater and sewage outfall pipes, etc.) which has resulted in past and current changes in habitat availability and quality. Development of nearshore areas through such activities as dredging of material for channel maintenance, marina construction, and other shoreline development resulting in pollutant discharges will impact tautog populations at all life history stages.

Loss or destruction of vegetated bottom areas eliminates juvenile nursery areas. Increased turbidity and siltation due to dredging activities may inhibit feeding in larvae, degrade submerged aquatic vegetation beds used as nursery habitat, as well as damage adult spawning areas. Contaminants, disturbed in the dredging process, and brought into the water column could affect egg, larval and juvenile survival directly, or indirectly, through their food sources.

Prey Species

Larval tautog probably feed on water column plankton although no specific data are available. Juvenile tautog feed primarily on small benthic and pelagic invertebrates including: copepods, amphipods, isopods, ostracods, polychaetes, crabs, and mussels. The composition of the juvenile diet changes with fish size. Adult tautog feed primarily on blue mussel and other shellfish throughout the year. The diet can be extremely varied depending on location and availability. The following organisms have been found to be eaten by adult tautog: barnacles, various crabs, sand dollars, amphipods, isopods, shrimp, lobsters, periwinkles, scallops, soft shell clams, and razor clams.

For more information, refer to the Atlantic States Marine Fisheries Commission Fishery Management Plan for Tautog (April 1996).

Weakfish

Description of Habitat / Essential Habitats

Habitats used by weakfish include: spawning sites in coastal bays, sounds and the nearshore Atlantic ocean and nursery areas that include the lower portions of the rivers and their associated bays and estuaries. These types of habitats are distributed along the coast from Maine through Florida. Use of these habitats by weakfish may increase or diminish as the size of the population changes.

All habitats described below are potentially essential to the continued sustainability of the Atlantic Coast weakfish stocks as it presently exists. Maps of weakfish distribution and abundance can be used as a surrogate to define essential habitat until more detailed analyses of weakfish habitat use become available. It is difficult at present to assess how much additional habitat may be "essential" in the absence of a specific goal for recovery of additional areas that were historically but are not presently used by weakfish.

Spawning Habitat – Weakfish spawn in estuarine and nearshore habitats throughout the species range. The principal spawning area is from North Carolina to Montauk, NY, although extensive spawning and presence of juveniles has been observed in the bays and inlets of Georgia and South Carolina. Spawning occurs after the spring inshore migration. Timing of spawning is variable, beginning as early as March in North Carolina, and as late as May to the north. Peak spawning occurs from April to June in North Carolina. Peaks in the New York Bight estuaries occur in May and June.

Eggs and larvae are planktonic and are primarily found nearshore. They are carries by currents inshore to estuarine and nearshore nursery areas.

Nursery Habitat – Nursery habitats are those areas in which larval and juveniles weakfish reside or migrate after hatching until they reach sexual maturity (90% by age 1, 100% by age 2). These include the nearshore waters as well as the bays, estuaries and sounds to which they are transported by currents or in which they hatch. Juvenile weakfish inhabit the deeper waters of bays, estuaries and sounds, including their tributary rivers. In North Carolina, they are associated with sand or sand / seagrass bottom. They feed initially on zooplankton, switching to mysid shrimp and anchovies as they grow. In Chesapeake and Delaware Bays, they migrate to the Atlantic Ocean by December.

Adult Resident Habitat and Migratory Routes – Adult weakfish reside in both estuarine and nearshore Atlantic Ocean habitats. Warming of coastal waters in spring keys migration inshore and northward from the wintering grounds to bays, estuaries and sounds. Larger fish move inshore first and tend to congregate in the northern part of the range. Catch data from commercial fisheries in Chesapeake and Delaware Bays and Pamlico Sound indicate that the larger fish are followed by smaller weakfish in summer. Shortly after their initial spring appearance, weakfish return to the larger bays and nearshore ocean to spawn. In northern areas, a greater portion of the adults spend the summer in the ocean rather than estuaries.

Weakfish form aggregations and move offshore as temperatures decline in fall. They move generally offshore and southward. The Continental Shelf from Chesapeake Bay to Cape

Lookout, North Carolina, appears to be the major wintering ground. Winter trawl data indicate that most weakfish were caught between Ocracoke Inlet and Bodie Island, NC, at depths of 18-55 meters (59-180 feet). Some weakfish may remain in inshore waters from North Carolina southward.

Present Status of Habitats and Impacts on Fisheries / Issues and Concerns

Fisheries management measures cannot successfully sustain weakfish stocks if the quantity and quality of habitat required by the species are not available. Harvest of fish is a major factor impacting population status and dynamics and is subject to control and manipulation; however, without adequate habitat quantity and quality, the population cannot thrive.

It is generally assumed that weakfish habitats have undergone some degree of loss and degradation; however, few studies exist that quantify impacts in terms of the area of habitat lost or degraded.

Loss due to water quality degradation is evident in the northeast Atlantic coast estuaries. The New York Bight is one example of an area that has regularly received deposits of contaminated dredge material, sewage sludge and industrial wastes. These deposits have contributed to oxygen depletion and the creation of large masses of anoxic waters during the summer months.

Some losses have likely occurred due to the intense coastal development that has occurred during the last several decades, although no quantification has been done. Losses have likely resulted from dredging and filling activities that have eliminated shallow water nursery habitat. Further functional losses have likely occurred due to water quality degradation resulting from point and non-point source discharges. Intensive conversion of coastal wetlands to agricultural use also is likely to have contributed to functional loss of weakfish nursery area habitat.

Other functional loss of riverine and estuarine areas may result from changes in water discharge patterns resulting from withdrawals or flow regulation. Estuarine nursery areas for weakfish, as well as adult spawning and pre-spawning staging areas, may be affected by prolonged extreme conditions resulting from inland water management practices.

Prey Species

Weakfish feed primarily on penaeid and mysid shrimps, anchovies, and clupeid fishes (menhaden, river herring, shad). Juvenile weakfish feed mostly on mysid shrimp and anchovies. Older fish feed on clupeids or anchovies and other fishes including butterfish, herrings, sand lance silversides, juvenile weakfish, Atlantic croaker, spot, scup and killifishes. Invertebrates in the diet in addition to shrimps include squids, crabs, annelid worms and clams. Weakfish are important top carnivores in Chesapeake Bay where they consume high percentages of blue crabs and spot while cruising around the edges of eelgrass habitats. Weakfish are also found in estuaries without eelgrass, such as in the bays and estuaries of South Carolina.

For more information, refer to the Interstate Fishery Management Plan for Weakfish (May 1996)

Winter Flounder

Essential Fish Habitat

Eggs – Bottom habitats with a substrate of sand, muddy sand, mud, and gravel on Georges Bank, the inshore areas of the Gulf of Maine, southern New England, and the middle Atlantic south to the Delaware Bay as depicted in Figure 15.1 in the NEFMC EFH Amendment to the Multispecies FMP. Generally, the following conditions exist where winter flounder eggs are found: water temperatures less than 10° C, salinities between 10-30 0/00, and water depths less than 5 meters. On Georges Bank, winter flounder eggs are generally found in water less than 8° C and less than 90 meters deep. Winter flounder eggs are often observed from February to June with a peak in April on Georges Bank.

Larvae – Pelagic and bottom waters of Georges Bank, the inshore areas of the Gulf of Maine, southern New England, and the middle Atlantic south to the Delaware Bay as depicted in Figure 15.2 in the NEFMC EFH Amendment Multispecies FMP. Generally, the following conditions exist where winter flounder larvae are found: sea surface temperatures less than 15° C, salinities between 4-30 0/00, and water depths less than 6 meters. On Georges Bank, winter flounder larvae are generally found in water less than 8° C and less than 90 meters deep. Winter flounder larvae are often observed from March to July with peaks in April and May on Georges Bank.

Juveniles – *Young-of-the-Year*: Bottom habitats with a substrate of mud or fine grained sand on Georges Bank, the inshore areas of the Gulf of Maine, southern New England and the middle Atlantic south to the Delaware Bay as depicted in Figure 15.3 in the NEFMC EFH Amendment to the Multispecies FMP. Generally, the following conditions exist where winter flounder young-of-the-year are found: water temperatures below 28° C, depths from 0.1–10 meters, and salinities between 5-33 0/00. *Age 1+ Juveniles*: Bottom habitats with a substrate of mud or fine grained sand on Georges Bank, the inshore areas of the Gulf of Maine, southern New England and the middle Atlantic south to the Delaware Bay as depicted in Figure 15.3. Generally, the following conditions exist where juvenile winter flounder are found: water temperatures below 25° C, depths from 1-50 meters, and salinities between 10-30 0/00.

Adults – Bottom habitats including estuaries with a substrate of mud, sand, and gravel on Georges Bank, the inshore areas of the Gulf of Maine, southern New England and the middle Atlantic south to the Delaware Bay as depicted in Figure 15.4 in the NEFMC EFH Amendment to the Multispecies FMP. Generally, the following conditions exist where winter flounder adults are found: water temperatures below 25° C, depths from 1-100 meters, and salinities between 15-33 0/00.

Spawning Adults – Bottom habitats including estuaries with a substrate of sand, muddy sand, mud, and gravel on Georges Bank, the inshore areas of the Gulf of Maine, southern New England and the middle Atlantic south to the Delaware Bay as depicted in Figure 15.4 in the NEFMC EFH Amendment to the Multispecies FMP. Generally, the following conditions exist where winter flounder adults are found: water temperatures below 15° C, depths less than 6 meters, except on Georges Bank where they spawn as deep as 80 meters, and salinities between 5.5-36 0/00. Winter flounder are most often observed spawning during the months February-June.

Habitat Areas of Particular Concern

HAPC for winter flounder cannot be identified at this time.

Issues and Concerns

Channel dredging is a frequent long-term maintenance activity associated with coastal development, port and harbor development, and vessel activity. The short-term impacts to habitat can be substantial, such as: 1) resuspended sediments and associated contaminants; 2) degradation of habitat quality and fish populations; 3) changes in tidal prism, depth, water temperature, salinity, water velocity, bottom topography, and sediment type; 4) decreased dissolved oxygen and SAV distribution and density, and smothering of the surrounding benthic community; 5) reconfiguration of sediment type and the removal of biogenic structure which may decrease the stability of the bottom and increase the ambient turbidity levels; 6) increased transport of sediment and siltation rates in the embayment resulting in alteration of local habitats, and changes to spawning, feeding, and recruitment habitat; 7) fragmentation of habitat can hinder the movements (i.e. dispersal, recruitment, migrations, etc.) of organisms; and 8) continued maintenance dredging may change the indigenous habitat and population dynamics of the region.

As more people move to the coast, development pressure increases and structures are often constructed along the coastline to prevent erosion and stabilize shorelines. Attempts to protect beaches and reduce shoreline erosion are associated with the development of the coast. Bulkheads, seawalls, jetties, and groins are structures designed to slow or stop the shoreline from eroding. In many cases the opposite occurs with erosion rates increasing along the regulated area. Adjacent coastal habitat is altered and potential short-and long-term impacts to fish and shellfish stocks are associated with the presence of the erosion control structures.

Disposal of dredged material can disrupt and degrade natural habitat and biotic communities. The stresses associated with dredged material (i.e. oil, heavy metals, nutrients, suspended particles, etc.) can threaten the habitat of the dump site and adjacent areas. Along with contaminating the habitat, direct disturbance of the benthic and pelagic communities occurs with disposal. Benthic communities are smothered, associated physiochemical conditions are altered, and increased turbidity may hinder pelagic processes (e.g. photosynthesis of algae) by material settling to the bottom. The potential deleterious impacts of dredged material disposal can alter local and surrounding community structure.

Prey Species

Winter flounder prey on mainly nauplii, harpacticoids, calanoids, polychaetes, invertebrate eggs, and phytoplankton. Small larval fish prefer invertebrate eggs and nauplii, while large larvae prefer polychaetes and copepods. Copepods and harpacticoids are important to metamorphosing and recently metamorphosed fish. Amphipods and polychaetes gradually become more important for both YOY and yearling flounder. Adults are described as omnivorous or opportunistic feeders, with polychaetes and crustaceans (mostly amphipods) making up the bulk of their diet. They may also feed on bivalves, capelin eggs, and fish. Adult winter flounder are sight feeders and it has been suggested that increased turbidity may affect success rate of capturing prey.

For more information and maps of winter flounder abundance for various life history stages, refer to the Essential Fish Habitat Amendment to the Multispecies Fishery Management Plan.