5C. Marine Systems

The management and protection of pelagic, migratory, or other marine species fall under a host of jurisdictions in North Carolina depending on the location of the species at a given point in time, as does the management of coastal, estuarine and marine habitats that are critical to marine species survival. This presents a constant challenge to resource managers in that coordinated efforts among multiple agencies are necessary to effectively manage the fish and wildlife resources of the state.

Pelagic and marine species were not directly prioritized in the process described in Chapter 2, for reasons of jurisdictional limitations, a lack of information, and/or practicality within the time-frame for completion of the first iteration of the Plan. However, we cannot ignore the marine habitats of North Carolina within the Plan. In this chapter, like those previous, we outline critical direction for the management and conservation of those resources. We have developed the chapter, and the priorities identified within, by reviewing existing information sources on marine and pelagic species and habitats.

Pelagic Birds

North Carolina plays a key role in the life cycle of many migratory shorebirds, thus conservation activities directed at shorebird stopover or breeding habitats (primarily beach, dune, estuarine, and coastal marsh habitats) can have a substantial impact on shorebird conservation. The impact that conservation efforts in North Carolina can have on pelagic birds (birds that spend most of their life feeding and living on the open ocean, coming to land only to breed) is less direct, especially since none of the pelagic bird species listed below breed in North Carolina (except the occasional sooty tern). Key breeding areas for these pelagic species include the Arctic region, the north Atlantic, the West Indies/Caribbean, and other portions of the south Atlantic. Still, all efforts to promote activities that aid in research, management, and conservation of pelagic bird species should be pursued whenever possible in North Carolina.

Priority Species

The following list (Table 5C.1) identifies pelagic bird species priorities in the Southeast, as indicated by various bird conservation efforts. (*Note:* Some species may be priorities in the region but are, in fact, extremely rare to North Carolina waters).

Key Pelagic Habitats

The Gulf Stream, a warm water current which runs roughly parallel to the North Carolina coast, is a critical region for pelagic birds in North Carolina between the months of May and October (especially that segment offshore from Oregon Inlet to south of Cape Hatteras) due to the interplay with the southbound Labrador current, which creates an up-welling of nutrient-rich waters. Key pelagic species with this region include the black-capped petrel and other tubenoses. Cold inshore waters are a critical zone during wintertime. Key pelagic species associated with this region include gannets, loons, and alcids.

Management

Management of pelagic birds in the United States falls under the jurisdiction of the US Fish & Wildlife Service. To address concerns about negative interactions with marine fisheries, the National Oceanic and Atmospheric Administration (NOAA) Fisheries Unit (hereafter NOAA Fisheries) works with the US Fish & Wildlife Service, regional fisheries management councils and coastal states through the Interagency Seabird Working Group. As a part of this Working Group's effort, in 2001 NOAA Fisheries (then called the National Marine Fisheries Service, NMFS) began implementing the National Plan of Action for Reducing the Incidental Catch of Seabirds in Longline Fisheries (NMFS 2001). In that same year it was established that, by Executive Order, every Federal agency whose actions are likely to negatively impact migratory bird populations must enter into a Memorandum of Understanding with the US Fish & Wildlife Service (Murphy 2004a).

Table 5C.1. Priority pelagic bird species in the southeastern United States.

Species	Priority Listing Source[1] and Associated Conservation Rank				Federal Protection Status
	USFWS[2]	NC PIF[3]	NAWCP[4]	SAMBI[5]	
Bermuda Petrel	IM	EH	HC	H	Endangered
Black-capped Petrel	IM	EH	H	H	
Fea's Petrel		EH			
Herald (Trinidade) Petrel		EH	HC		
Audubon's Shearwater	IM	H	H	H	
Cory's Shearwater	MA	H	M	M	
Greater Shearwater	MA	PR	HC	HC	
Manx Shearwater	MA		M	HC	
Sooty Shearwater	MA		M	H	
Band-rumped Storm-petrel	MA		H		
Leach's Storm-petrel			L	M	
Wilson's Storm-petrel		PR		L	
Red Phalarope	MA				
Bridled Tern	MA		HC	HC	
Roseate Tern	PR		HC	H	Threatened
Sooty Tern			M	M	
Long-tailed Jaeger			L	M	
Parasitic Jaeger			L	L	
Pomarine Jaeger			L	L	
Northern Gannet	MA			H	
White-tailed Tropicbird			HC	HC	
Common Loon	MA	M		*	
Red-throated Loon	MA			*	

The South Atlantic Migratory Bird Initiative (SAMBI) Pelagic Bird Conservation Plan (2004), while still in draft format, is a key resource to direct conservation and management actions for pelagic bird species in the southeastern United States. The plan identifies information on ecology and status, priority species, species suites, and habitat requirements, population issues, habitat issues, implementation recommendations and opportunities, conservation strategies, inventory and monitoring needs, research needs, education and outreach needs, and potential partners. Key information taken from that report is summarized below. The Partners In Flight bird conservation plan for the South Atlantic Coastal Plain (Hunter et al. 2001) also presents similar information.

Threats

The major issues facing pelagic seabirds in offshore and nearshore waters are 1) conflicts with fisheries, 2) oil and hazardous materials, and 3) debris ingestion and entanglement.

[1] See the Key to Abbreviations and Acronyms for a complete listing of all abbreviations and acronyms used herein.

[2] USFWS key (Hunter 2004a): IM = Immediate Management needed; MA = Management Attention needed; PR = Long-term planning and responsibility needed

[3] NC PIF key (Johns 2004): EH = Extremely high conservation concern; H = High conservation concern; M = Moderate conservation concern; PR = Present (or possible) but not a priority for physiographic area; may need further monitoring/research attention in NC, more information on current distribution and trends may be needed in localized areas

[4] NAWCP key (Kushlan et al. 2002): H = Highly imperiled; HC = High concern; M = Moderate concern; L = Low concern

[5] SAMBI key (SAMBI 2004): H = Highly imperiled; HC = High concern; M = Moderate concern; L = Low concern; *added due to inshore bycatch

Conflicts with Fisheries

Marine fisheries exact a significant toll on ocean-feeding birds through incidentally catching and killing seabirds (bycatch). Long line, gillnets, and other fishing gear can prove fatal. In North Carolina, the red-throated loon may be the most heavily impacted by gillnets. Excessive bycatch of forage fish as well as fisheries using the same prey used by waterbirds can reduce the birds' food supplies. Trawls that affect the sea bottom alter the habitat on which the prey of seabirds and coastal waterbirds depend.

Oil and Hazardous Materials

Oil is a major environmental threat to pelagic species, especially along major shipping transportation corridors. Oil may be released during platform construction, offshore drilling, and shipping and spillage. Waterbirds are commonly injured by oil spills, chronic oil discharge in bilge water, and hazardous materials releases. Additionally, lights on drilling structures may disorient, attract, or confuse some pelagic birds, resulting in injury or death.

Debris Ingestion and Entanglement

Seabirds ingest materials and debris as a natural consequence of foraging. Ingesting plastics and other artificial flotsam can be detrimental. Additionally, seabirds are caught in discarded fishing line, nets, and other waste.

Habitat Issues

Major habitat issues for all species include loss and degradation of habitat.

Loss of Habitat

Seabirds congregate throughout the year, and in non-nesting seasons they congregate at roosts and loafing areas. These sites require both protection and management to maintain their value to seabirds.

Degradation of Habitat

Conflicts with fisheries, oil and hazardous material issues, and offshore pollution contribute to the degradation of foraging habitat for many pelagic species, particularly in shipping channels and areas heavily used by the marine fisheries industry. Mass harvest of sargassum would affect forage prey base for pelagic species. Harvest or overharvest of menhaden populations may affect forage prey base for pelagic seabirds.

Conservation Recommendations

Where appropriate, the recommendations put forth in the SAMBI Plan, and included below, should be incorporated into pelagic bird conservation efforts in North Carolina by all partnering agencies and organizations. (*Note:* Some the recommendations are not necessarily attainable in North Carolina, but are included below in order to highlight the need for cooperation and coordination among states and countries to affect change.)

Implementation Recommendations and Opportunities

- Key needs are detailed for black-capped and Bermuda petrels, most of which are centered in the Caribbean (Bermuda, Hispaniola, Lesser Antilles).
- Follow through on all South Atlantic-Caribbean seabird connections as outlined in the forthcoming publication, *Atlas of Breeding Seabirds of the West Indies—an International Workshop*, to set regional priorities for all the West Indies.
- International cooperation on a "Housing Grant" for white-tailed tropicbirds within the West Indies (transportable artificial nesting structures).

Policy

- Seabird conservation efforts should develop partnerships with fishery industries and sport anglers.
- Impacts to seabirds from offshore and inshore fisheries should be addressed in all future fishery plans.
- The policy of elimination of waterbird by-catch in fisheries should be embraced by all fisheries management entities (in North Carolina, appropriate agencies include the Commission, NC Division of Marine Fisheries, NOAA Fisheries, the US Fish & Wildlife Service, and the Atlantic States Marine Fisheries Commission). Two specific issues relevant to North Carolina include:
  - Bird by-catch in gillnets (especially for red-throated loon, common loon, and northern gannet) (Hunter 2004b).
  - Pelagic longline by-catch (especially for black-capped petrel, Bermuda petrel, Audubon's shearwater) (Hunter 2004b).
- Oil effects on seabirds should be minimized through increased enforcement of shipping activities, safe operational procedures, spill clean-up, and rehabilitation of oiled birds.
- Dumping of debris, line, and nets should be prohibited and strictly enforced.
- Non-persistent lines, nets, and traps should be developed.

Inventory and Monitoring

- Species specific monitoring needed for: white-tailed tropicbird, Audubon's shearwater, and roseate tern.
- Death and morbidity of seabirds should be monitored wherever it occurs.
- Important foraging, migrating, and wintering seabird areas should be identified and monitored.
- Increase monitoring of seabird by-catch (*also see above to related policy needs*).
- Seasonal population estimates, distribution, and abundance information for seabirds is needed in the Southeastern United States Continental Shelf.

Research

- Examine the role of commercial fisheries in seabird mortality.
- Determine population level effects of oil and hazardous materials on seabirds.
- Assess mercury loads in seabirds.
- Identify key marine habitats.
- Examine value of sargassum to seabirds.
- Examine effects of sargassum harvest to seabird habitat and populations.
- Along south Atlantic coast beaches, research into the rates of and reasons for wintering common loon mortality should help provide for a better understanding of the risks to seabird populations in this area.
- Establish whether foraging black-capped petrels within the Gulf Stream (especially off of Cape Hatteras, North Carolina) are the same concurrently breeding in Haiti (Hunter 2004b).

Education and Outreach

Follow the recommendations put forth in the North American Waterbird Conservation Plan—"40 ideas for outreach projects" (Kushlan et al. 2002).

Potential Partners and Partnerships

- Partners in Flight
- The Waterbird Conservation Council
- Waterbird Monitoring Partnership – Patuxent
- Circumpolar Seabird Working Group
- Waterbird Society
- Society of Caribbean Ornithology
- International Association of Fish & Wildlife Agencies (Shorebird and Waterbird Working Group)
- National Marine Fisheries Service, National Oceanic and Atmospheric Administration
- South Atlantic Migratory Bird Initiative partners
- National Audubon Society and state Audubon chapters
- Region 4 US Fish & Wildlife Service, Seabird Working Group
- State fish and wildlife agencies
- South Atlantic Fisheries Management Council
- North Carolina State Museum of Natural Sciences
- American Bird Conservancy

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Marine and Estuarine Species

Surveys, monitoring and research on estuarine and marine species is difficult, making the collection of data, the synthesis of information, and the protection of those species that much more challenging. There have been no recent systematic accounts of species rarity or distribution for marine or estuarine fish species in the state (LeGrand et al. 2004). Some federally protected species, such as sea turtles, receive significant attention when nesting on our beaches, but the majority of their lives are spent at sea. Four agencies have jurisdiction and authority over particular estuarine and marine species in the state: the NC Division of Marine Fisheries, the National Oceanic and Atmospheric Administration (NOAA), the US Fish & Wildlife Service, and the Commission (when the species are in inland waters). There is great need to continue cooperative efforts among these agencies in order to expand our understanding of and protection for those species.

Marine Species Regulation and Management

State Regulations

North Carolina is a member of the Atlantic States Marine Fisheries Commission (ASMFC). The ASMFC represents the 15 Atlantic coast states as a deliberative body, coordinating the conservation and management of the states shared near shore (within state waters) fishery resources—marine, shell, and anadromous—for sustainable use. The ASMFC promotes interstate fisheries management, law enforcement, research and statistics, fisheries, science, and habitat conservation.

The NC Division of Marine Fisheries (NCDMF) is responsible for the stewardship of the state's marine and estuarine fisheries resources. NCDMF jurisdiction encompasses all coastal waters and extends to 3 miles offshore. Fisheries Management Section staff are active in federal and regional management of migratory species, serving as technical advisors and committee members for coast-wide or regional fishery management issues. They work closely with the Commission, as well as with NOAA Fisheries, the Atlantic States Marine Fisheries Commission, and the Mid-Atlantic and South Atlantic Fisheries Management councils on inter-state Fisheries Management Plans (FMPs) (see below for more information). NCDMF is also responsible for preparing FMPs for adoption by the North Carolina Marine Fisheries Commission for all commercially and recreationally significant species or fisheries that comprise state marine or estuarine resources. The goal of these plans is to ensure long-term viability of these fisheries. State FMPs have been developed for:

- Southern flounder
- Blue crab
- Striped bass
- Red drum
- Oyster
- Hard clam
- Striped mullet

The Habitat Protection Section is responsible for the development of the Coastal Habitat Protection Plan (CHPP) (Street et al. 2004) to conserve and protect important marine fisheries habitat (*further details regarding the CHPP are in the following section*).

Federal Regulations

NOAA Fisheries is responsible for the management, conservation and protection of living marine resources within the United States Exclusive Economic Zone (3-200 miles offshore), including sea turtles, marine and anadromous fish, plants and invertebrates, cetaceans, and pinnipeds[6]. Central to that mission are the objectives to: 1) protect ocean, coast, and Great Lakes resources, 2) recover protected species, and 3) rebuild and maintain sustainable fisheries.

The NOAA Fisheries Office of Protected Resources (OPR) is charged with the implementation of the Endangered Species Act (ESA) of 1973 for marine and anadromous species. OPR develops, implements, and administers programs for the protection, conservation, and recovery of species protected under the ESA. The Office also develops and implements policies, procedures, and regulations for permits to take (harass, harm, pursue, hunt, shoot, wound, kill, trap, capture, or collect) listed species according to the ESA. Additionally, the Office establishes cooperative

[6] NOAA Fisheries jurisdiction also extends into state waters for protected marine species.

agreements with states regarding listed species management and protection and identifies endangered species research needs to collect appropriate information for management decisions (e.g., NOAA Fisheries has a cooperative agreement with the Commission regarding sea turtle nesting and strandings on North Carolina beaches).

Under the Marine Mammal Protection Act (MMPA) all marine mammals are protected from take in United States waters and by United States citizens on the high seas, and marine mammals and marine mammal products are prohibited from importation into the United States. NOAA Fisheries grants at-risk marine mammal species a variety of protection levels under the ESA and the MMPA. Among these are endangered status, threatened status and depleted status. Under the MMPA, a species is designated as depleted when it falls below its optimum sustainable population (see Glossary). Once a species has been designated as depleted, a conservation plan is developed to guide research and management actions to restore the health of the species. Take reduction teams (TRTs) are formed and convened with the purpose of developing take reduction plans to assist in the recovery or to prevent the depletion of strategic marine mammal stocks that interact with various fisheries. A strategic stock is one which is listed as endangered or threatened under the ESA, is declining and likely to be listed as threatened under the ESA, is listed as depleted under the MMPA, or has direct human-caused mortality exceeding the stock's Potential Biological Removal level (see Glossary). TRTs consist of a balance of representatives from the fishing industry, fishery management councils, state and federal resource management agencies, the scientific community, and conservation organizations. To date, six TRT's have been established:

- Atlantic Large Whale Take Reduction Team
- Atlantic Offshore Cetacean Take Reduction Team
- Western North Atlantic Coastal Bottlenose Dolphin Take Reduction Team
- Gulf of Maine Harbor Porpoise Take Reduction Team
- Mid Atlantic Harbor Porpoise Take Reduction Team
- Pacific Offshore Cetacean Take Reduction Team

FMPs are developed by Regional Fishery Management Councils for species commercially and recreationally harvested and are implemented by NOAA Fisheries Regional Offices. North Carolina is a member of the Mid-Atlantic Fishery Management Council and the South Atlantic Fishery Management Council.

The Mid-Atlantic Fishery Management Council (MAFMC) is responsible for management of fisheries in federal waters which occur predominantly off the mid-Atlantic coast (North Carolina to New York). FMPs developed and implemented by the MAFMC include:

- Summer Flounder
- Scup
- Black Sea Bass
- Dogfish
- Surf Clam and Quahog
- Atlantic Mackerel
- Squid and Butterfish
- Bluefish
- Tilefish
- Monkfish

The South Atlantic Fishery Management Council (SAFMC) is responsible for the conservation and management of fish stocks within the federal 200-mile limit of the Atlantic off the coasts of North Carolina, South Carolina, Georgia and east Florida to Key West. Within the SAFMC, efforts continued on the development, monitoring, implementation, and revision of FMPs for:

- Blue Crab
- Menhaden
- Striped Mullet
- Shrimp
- Striped Bass
- Spanish Mackerel
- Oyster
- Black Drum
- Red Drum
- Spotted Seatrout
- Bluefish
- Flounder
- Croakers and other bottom fish
- Conch
- Eel
- Sheepshead

The Highly Migratory Species Division of NOAA Fisheries manages Atlantic highly migratory species (HMS), including tunas, sharks, swordfish and billfish, and implements the FMP for Atlantic tunas, swordfish, and sharks. Management of HMS requires international cooperation, and rebuilding programs must reflect traditional participation in the fisheries by United States fishermen, relative to foreign fleets. Along with the Magnuson-Stevens Act, United States fisheries management must be consistent with the requirements of other laws including the Atlantic Tunas Convention Act, Marine Mammal Protection Act, the Endangered Species Act, the Migratory Bird Treaty Act, and several other Federal laws.

Priority Species

The following marine or estuarine species, known to occur currently or historically in North Carolina coastal waters, are listed as:

Federally endangered *(legal protection status under ESA/MMPA*):
- Smalltooth Sawfish (*Pristis pectinata*)
- Shortnose Sturgeon (*Acipenser brevirostrum*)
- Fin Whale (*Balaenoptera physalus*)
- Humpback Whale (*Megaptera novaeangliae*);
- Northern Right Whale (*Eubalaena glacialis*)
- Sperm Whale (*Physeter macrocephalus*)
- West Indian Manatee (*Trichechus manatus*)
- Hawksbill Sea Turtle (*Eretmochelys imbricata imbricate*)
- Kemp's Ridley Sea Turtle (*Lepidochelys kempii*)
- Leatherback Sea Turtle (*Dermochelys coriacea*)

Federally threatened (*legal protection status under ESA*):
- Green Sea Turtle (*Chelonia mydas*)
- Loggerhead Sea Turtle (*Caretta caretta*)

Species of concern (*no legal protection status under ESA; only those species that are being actively considered for ESA listing are also "Candidate Species"; none of the species below are considered "Candidate species"*):
- Dusky Shark (*Carcharhinus obscurus*)
- Sand Tiger Shark (*Odontaspis taurus*)
- Night Shark (*Carcharhinus signatus*)
- Barndoor Skate (*Raja laevis*)
- Atlantic Sturgeon (*Acipenser oxyrinchus oxyrinchus*)
- Speckled Hind (*Epinephelus drummondhayi*)
- Goliath Grouper (*Epinephelus itajara*)
- Warsaw Grouper (*Epinephelus nigritus*)
- Nassau Grouper (*Epinephelus striatus*)

Depleted (*legal protection status under MMPA*):
- Western North Atlantic Coastal Bottlenose Dolphin (*Tursiops truncatus*)

State special concern *(legal protection status by the NC Wildlife Resources Commission*):
- Diamondback Terrapin (*Malaclemys terrapin*)

Significantly rare (as of 2001) (*a NC Natural Heritage Program designation carrying no legal protection*)[7]:

- Spinycheek Sleeper (*Eleotris pisonis*)
- Lyre Goby (*Evorthodus lyrinus*)
- Marked Goby (*Gobionellus stigmaticus*)
- Freckled Blenny (*Hypsoblennius ionthas*)
- Opossum Pipefish (*Microphis brachyurus*)

Musick et al. (2000) identified marine, estuarine and diadramous fish stocks at risk of extinction in North America. While the North Carolina coast is not an identified "hotspot" for species at risk, our coastal waters fall within the potential range of 17 species listed in the publication, seven of which do not carry any listing status from above (Table 5C.2).

Table 5C.2. Fish species at risk of extinction in North America, whose current or historical range includes North Carolina coastal or offshore waters (from Musick et al. 2000).

Common Name	Official Status (as of 2004)	Risk Category within Range[8]	Factor(s) that Put Species at Risk[9]
Whale Shark	Protected under an FMP	CD	R,L
Sand Tiger Shark	Species of concern	V	L
Basking Shark	Protected under an FMP	CD	L
White Shark	Protected under an FMP	CD	L
Dusky Shark	Species of concern	V	L
Smalltooth Sawfish	Endangered	E	L
Barndoor Skate	Species of concern	V	L
Shortnose Sturgeon	Endangered	E	V, L
Atlantic Sturgeon	Species of concern	E	V, L
Marbled Grouper	None	V	R, L
Speckled Hind	Species of concern	E	L
Yellowedge Grouper	None	E	L
Warsaw Grouper	Species of concern	E	L
Snowy Grouper	None	V	L
Black Grouper	None	V	L
Gag	None	V	L
Scamp	None	V	L

Some species listed above may also be found in estuarine or inland waters (e.g., diamondback terrapin, manatee, anadromous fish) or on North Carolina beaches (e.g., sea turtles). Others species not directly mentioned above may also use marine or estuarine environments (e.g., beach nesting birds). For those typically marine species that are also associated with coastal estuaries and beaches or that travel into inland waters, we have addressed appropriate conservation needs within those particular habitat types (see 'Beach and dune', and 'Estuarine communities' within the Mid-Atlantic Coastal Plain portion of the Plan, Chapter 5A).

[7] As of 2004, the NC Natural Heritage Program is no longer tracking (nor including on the Watch List) marine and estuarine fishes. This decision is not due to their lack of state listing; rather, they receive few data on such species, survey for such species can be cumbersome, protection of them is difficult if not impossible, and there has been no recent systematic account of the rarity and distribution of the hundreds of such fishes that occur in our salt or brackish waters.

[8] Risk categories: Endangered (E)- high risk of extinction in the wild in the immediate future; Vulnerable (V)- special concern, but not endangered or threatened severely but at possible risk of falling into one of those categories in the near future; Conservation Dependent (CD)- reduced but stabilized or recovering under a continuing conservation plan.

[9] Factors: Rarity (R); Vulnerable habitat (V); Life history limitations (L)

Threats

The successful conservation of marine species will require the mitigation of threats both within North Carolina borders and beyond. Thus, interstate and international partnerships and cooperation are critical components of marine species conservation.

Descriptions of the threats listed below were taken from various marine species recovery plans. Recovery plans can be accessed at http://www.nmfs.noaa.gov/pr/PR3/recovery.html

Nesting threats (these threats primarily impact beach nesting sea turtles and birds)

- Beach erosion – Erosion can result in partial or total loss of suitable nesting habitat; coastal development and associated activities have accelerated erosion rates and interruption of natural shoreline migration.
- Shoreline modifications – Fortifications put in place as a result of shoreline development (including sea wall, rip rap, groins, jetties) can accelerate beach erosion rates and reduce available nesting habitat; improperly placed drift fences can impede nesting attempts and/or trap hatchlings or nesting female sea turtles.
- Beach nourishment – If nourishment occurs during nesting season direct impacts can include burial of nests and nest disturbance; dissimilar sand sources can impact site selection, digging behavior, incubation, and hatchling success; beach nourishment can also result in significant compaction or concretion of the beach.
- Artificial lighting – Lighting associated with beachfront development (condominiums, street lights, vehicles) can severely impact emerging hatchlings by causing disorientation which drastically increases fatalities; artificial lighting causes hatchlings to head in the opposite direction of the water, exposing themselves to predators, entrapment in vegetation, and/or vehicle strikes; adult nesting sea turtles may abort nesting attempts at greater frequencies near lighted areas.
- Beach cleaning – Mechanical raking (using heavy machinery) can compact or destroy nests; disposal of debris near the dune line can cover incubating clutches, entrap emergent hatchlings, and/or alter nest temperatures.
- Increased human presence – Disturbance to nesting sea turtles is the most critical threat caused by human presence on beaches; night-time human activity can cause female turtles to abort nesting attempts.
- Recreational beach equipment (including vehicular driving) – Beach chairs, tents, and other recreational equipment can directly impacting nests (covering or disturbing incubating nests) or indirectly cause disturbance such that female turtles abort nesting attempts; vehicle use on beaches has similar effects as heavy machinery used in beach cleaning efforts (compact or destroy nests, entrap nestlings); vehicle lighting can disorient hatchlings and adults alike.
- Exotic dune and beach vegetation – Non-native vegetation can outcompete native vegetation such as sea oats and dune grass; often less-stabilizing, non-native vegetation can lead to erosion and degradation of nesting habitat.
- Nest depredation – Predation by ghost crabs, raccoons, foxes, or fire ants is a significant threat to eggs and hatchlings (both sea turtle and shorebirds); disorientation of emergent hatchlings by artificial lighting increases their chances of being depredated by one of these animals.

Marine threats (these threats may impact sea turtles, fish species, and marine mammals)

- Vessel interactions (including collisions) – Propeller and collision injuries are a significant threat, especially to marine mammals and sea turtles; these types of injuries are reported at higher frequencies in areas that have heavy boating and vessel traffic.
- Oil and gas exploration – Oil spills have been shown to impact respiration, blood chemistry and salt-gland function in sea turtles; spills in the vicinity of nesting beaches can place nesting adults, eggs, and or hatchlings in significant risk; oil deposits on the ocean floor can reduce food sources for all marine species and result in ingestion of tar balls.

- Dredging – Dredging can result in direct destruction or degradation of habitat and/or incidental take of marine species; channelization of inshore and nearshore habitats can result in the disposal of dredge material on beaches and shallow habitats, impacting nesting success or foraging grounds.
- Pollution – Pesticides, polychlorinated biphenyls, and heavy metals have been detected in marine species, though levels that result in adverse effects are difficult to quantify.
- Fisheries – By-catch of marine organisms occurs in a number of different fisheries, including trawl, purse seine, hook and line, gill net, pound net, long-line, and trap fisheries; these interactions often lead to serious injury or death.
- Power plant entrapment – Saltwater cooling intake systems at coastal power plants have been reported to entrap marine species.
- Underwater explosions – Use of underwater explosives to remove abandoned oil platforms, for military activities, or for oil exploration can result in injury or death to marine species in the vicinity of the explosion.
- Entanglement – Marine species can become entangled in a variety of materials other than active fishing gear, including steel or monofilament line, synthetic or natural rope, or discarded plastic material, often resulting in injuries which can lead to weakened individuals who are more susceptible to death by other factors, or to direct mortalities.
- Ingestion of marine debris – Marine species may ingest a variety of potentially harmful debris materials, including plastic bags, balloons, Styrofoam, and tar balls; effects of debris ingestion can include obstructions of the gut, absorption of toxic byproducts, reduced absorption of nutrients.
- Poaching – Illegal harvest of marine species has declined considerably since the development and enforcement of protection regulations, however arrests are still made for illegal capture and possession of marine species.
- Noise – The impacts of noise from shipping, industrial, or military activities on the communication, behavior and distribution of whales and other marine species remains unknown but is suspected to be significant.

Conservation Recommendations

The following recommendations apply broadly to all efforts towards marine mammal and fish conservation:

- Continue and expand cooperation between NOAA Fisheries and the appropriate state agencies to facilitate marine species management, protection, and research, especially for listed species.
- Support the implementation of FMPs to manage and protect marine species.
- Support and assist in the attainment of the goals, objectives, strategies, and performance measures set forth in the NOAA Fisheries Strategic Plan (NOAA 2003).
- Support the recommendations put forth in the CHPP (Street et al. 2004) to promote fisheries habitat protection in North Carolina and to facilitate the necessary policy decisions.

Directed marine conservation needs relative to North Carolina include:

- Development of more precise population estimates for all marine taxa.
- Genetics research to further understand stock structure in North Carolina and beyond (e.g., bottlenose dolphin and pilot whale).
- Examination of pollution effects on coastal and estuarine species.
- Coordination between NOAA Fisheries and NC Division of Marine Fisheries to look at gear modifications to reduce dolphin by-catch in fisheries; SeaGrant Fisheries Resource Grants and NOAA Fisheries support much of this work.

- Public education and other efforts to reduce discarded "ghost" fishing gear to reduce marine species entanglement; potential development of a fishing line recycling program (potential to model from Florida's existing monofilament recycling program).
- Improved communications and coordination with other NOAA offices, state and federal marine resource agencies, and universities to combat common threats and develop efficient and effective conservation strategies for all marine species and their habitats.
- Continued cooperation with fisheries resource managers, commercial fisherman, and regulatory agencies to reduce by-catch and unintentional take of protected marine resources (e.g., explore diamondback terrapin by-catch in crab pots).

Additional Resources

- FMPs can be found at each Regional Fisheries Management Council website:
  - Mid-Atlantic Fisheries Management Council: http://www.mafmc.org/mid-atlantic/mafmc.htm
  - South Atlantic Fisheries Management Council: http://www.safmc.net/fmpro?-db=content&-format=default1.html&-view
- FMPs are available for Atlantic Tunas, Swordfish, and Sharks (highly migratory species) at: http://www.nmfs.noaa.gov/sfa/hms/hmsdocuments.html#fmps.
- Recovery plans are available, or are in development, for the following listed species (*list is limited to those species that can inhabit North Carolina coastal or offshore waters*) and can be accessed at http://www.nmfs.noaa.gov/prot_res/PR3/recovery.html:
  - Green Sea Turtle
  - Hawksbill Sea Turtle
  - Leatherback Sea Turtle
  - Loggerhead Sea Turtle
  - Kemp's Ridley Sea Turtle
  - Right Whale
  - Humpback Whale
  - Sperm Whale (*in development*)
  - Fin/Sei Whale (*draft*)
  - Shortnose Sturgeon
- Marine mammal stock assessment reports for all Atlantic species can be found at: http://www.nmfs.noaa.gov/prot_res/PR2/Stock_Assessment_Program/individual_sars.html
- Take Reduction Plans can be accessed at http://www.nmfs.noaa.gov/pr/PR2/Fisheries_Interactions/TRT.htm

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Coastal Habitat Protection Plan

We were fortunate that the development of the Plan overlapped with the development of a complimentary report focused on the long-term enhancement of coastal fisheries associated with coastal habitats in North Carolina, the Coastal Habitat Protection Plan (CHPP) (Street et al. 2004) (see Figure 5C.1). Specific to in-shore marine fish, we have used the recommendations and information compiled in the CHPP to develop the following section.

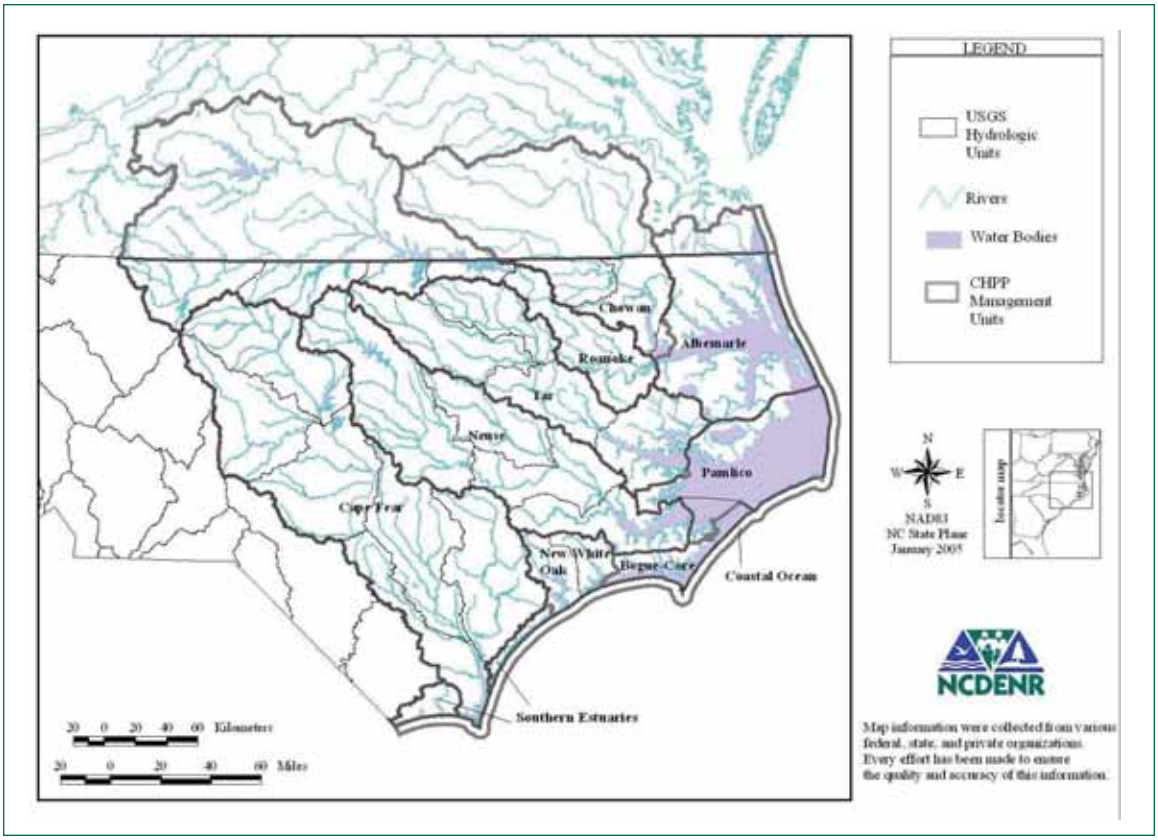

Figure 5C.1. Coastal Habitat Protection Plan management units (source: NC Division of Marine Fisheries, 2004).

Development of the CHPP was a provision of the 1997 Fisheries Reform Act. The CHPP was completed in 2004, and was adopted in 2005 by the three regulatory commissions who oversee coastal and marine resources in the state (the Environmental Management, Coastal Resources, and Marine Fisheries Commissions) to ensure a coordinated management approach. The CHPP includes information on habitat descriptions, distribution, ecological role and function for fish species, status and trends, threats, and management needs. The CHPP identifies recommendations to meet four goals for protection of coastal fisheries habitat:

1. Improve effectiveness of existing rules and programs protecting coastal fisheries habitats
2. Identify, designate, and protect all Strategic Habitat Areas
3. Enhance habitat and protect it from physical impacts
4. Enhance and protect water quality

During 2005, each commission will develop a Coastal Habitat Protection Implementation Plan, which will use the threats, management needs, and recommendations identified in the CHPP to develop specific priorities, actions, and measures of success.

We have relied on the CHPP to develop the following habitat sections. While the CHPP is not focused on "species in greatest need of conservation," it is the most comprehensive resource on coastal and marine habitat protection available in the state and it provides critical direction for protection of coastal and marine resources. The final CHPP document is more than 600 pages in length, far too lengthy to simply insert here for use as a planning tool. So in the following sections **we have inserted text from the CHPP that provides key information related to the focus of the Plan**[10]. Readers should refer to the original document (Street et al. 2004) for follow-up on any points made herein. The complete CHPP report can be downloaded in its entirety, or chapter by chapter, at: http://www.ncfisheries.net/habitat/index.html.

Fisheries and Protected Species in the CHPP

Within the CHPP, the term "fish" is used to include "All marine mammals; all shellfish; all crustaceans and all other fishes" [G.S. 113-129 (7)]. Coastal fish species are grouped into three overlapping classes based on management considerations: 1) fisheries species, 2) forage species, and 3) protected species.

- Fisheries species are those finfish, crustaceans, and mollusks that may be harvested in North Carolina's Coastal and Inland Fishing Waters (MFC 2003) by commercial and recreational fishermen. ***Habitats supporting fishery species are the primary focus of the CHPP***.
- Forage species make up a significant portion of the diet of fishery species (e.g., killifish, grass shrimp, menhaden, mullet).
- Protected species meet two criteria: 1) listed according to state law [G. S. 113-331] or through the federal Endangered Species Act by the relevant state or federal agency or protected under the federal Marine Mammal Protection Act, and 2) require aquatic or wetland habitat within North Carolina's coastal river basins or nearshore ocean waters at some point in their life cycle. Protected species are important in the CHPP process because they can be indicators of ecological stress (Ricklefs 1993). In addition, their habitat needs provide support for designating strategic habitat in locations where the distribution of fishery and protected species overlap, as well as in upstream areas important for maintaining estuarine water quality.

Habitats[11]

Water Column

The water column habitat surrounds and supports all aquatic organisms and connects all coastal fish habitats. Consequently, clean and healthy waters are critical to the overall viability of coastal fish habitats and aquatic organisms. The general distribution of fish within the water column is determined by the physical and chemical properties of each unique water body (i.e., salinity, temperature), while the abundance, diversity, and health of coastal fish and invertebrates are strongly influenced by water quality conditions (i.e., oxygen, turbidity, nutrients). The water column provides the necessary medium for spawning and transport of eggs and larvae to habitats favorable for survival and growth. In addition, coastal waters are an important source of primary production, providing food for the survival of early life stages of aquatic organisms. Another critical function of the water column is to support other important food sources for pelagic species, such as river herring, bluefish, and Spanish mackerel, and to serve as a critical corridor for migration. Particularly important areas of the water column include inlets, shallow estuarine nursery areas, anadromous fish spawning and nursery areas, and the nearshore surf zone.

Well-documented occurrences of low oxygen events, fish kills, and harmful algal blooms during the 1980s and 1990s provided visible indicators that coastal waters were declining in quality. Although severe water quality problems are variable and appear to have diminished in recent years, many coastal waters remain impaired. The primary threats to the water column are hydrological modifications and water quality degradation (Table 5C.3).

[10] See the Key to Abbreviations and Acronyms for a complete listing of all abbreviations and acronyms used herein.

[11] Text taken directly from habitat chapter summaries, Street et al. 2004.

The hydrology of North Carolina has been altered dramatically, with over 2,000 dams obstructing and modifying water flow to the coast, numerous surface water withdrawals, and extensive channelization of streams. Physical obstructions in streams from structures such as dams and road crossings (fill causeways, culverts), as well as alteration of flow conditions, are a major threat to anadromous fish species, some of which are classified as Overfished by NCDMF (American shad, the central/southern stock of striped bass, and the Albemarle Sound stock of river herring). Removing obstructions and restoring flow in streams and rivers have been highly successful in some areas for restoring striped bass and American shad populations and should continue to be a high priority.

Water quality degradation affects aquatic organisms in many ways. Excessive sediment loading increases turbidity and sedimentation, which can result in a decrease in biological productivity, clogging of fish gills, reduced recruitment of invertebrates, increased mortality, and filling in of rivers and creeks.

Important fishery and prey species in North Carolina that are impacted by alterations or degradation of the water column include pelagic-oriented species such as blueback herring, American shad, striped bass, Atlantic menhaden, bluefish, and anchovies. The condition of the water column also influences other coastal fish habitats. For example, waters depleted of oxygen can result in extensive mortality of individuals inhabiting shell bottom and soft bottom communities. Moreover, excess sedimentation and turbidity can shade submerged vegetation, while the associated sediment can smother hard bottom communities.

Primary sources of sediment are nonpoint runoff from land disturbance associated with building and road construction and agricultural drainage. A predicted increase in the rate of sea level rise will accelerate coastal erosion and impact sedimentation-related issues. NCDWQ data show the greatest impairment to coastal freshwater streams is due to not only excessive sediment loading but also low dissolved oxygen.

Low dissolved oxygen has been responsible for many fish kills in coastal river basins, especially the Neuse, Cape Fear and Tar-Pamlico. The estuarine species most frequently affected by fish kills have been menhaden and flounder; the most frequently reported freshwater species have been sunfish and catfish. Such oxygen depletion can occur naturally, but is greatly aggravated and intensified by eutrophication. This excessive loading of nutrients can also contribute to toxic algal blooms and may contribute to *Pfiesteria* outbreaks. Primary sources of excessive nutrients in the water column include point source wastewater discharges, and nonpoint runoff from crop agriculture, animal operations, urban development, and air emissions from industries and vehicles. Another serious concern for estuarine and ocean water quality is bacterial contamination, both for habitat and health reasons. Fecal coliform contamination in estuarine waters is a major cause of water quality impairment, originating primarily from nonpoint sources. Bacterial contamination has resulted in consistent increases in shellfish harvest closures over time, including closures in Outstanding Resource Waters, North Carolina's highest quality waters (over 1,000 acres closed in ORW waters since 1990). When stormwater is discharged on ocean beaches, it contaminates the surf zone with not only bacteria, but also a variety of other toxins. Runoff from roads, agriculture, and marina-related activities are common sources of toxins in coastal waters.

While toxins are a concern to the water column, these pollutants tend to settle and become incorporated into soft bottom habitat relatively quickly, where they can be resuspended or can adversely affect organisms in the bottom sediments. Sediment, nutrient, bacteria, and toxin loading must be reduced by addressing multiple sources. These include improvement and continuation of urban and agricultural BMPs, more stringent sediment controls on construction projects, and additional buffers along coastal waters.

Water column habitat is required for the survival, growth and reproduction of fish and it greatly influences all other coastal fish habitats. Therefore, efforts are needed to minimize threats and enhance water quality wherever possible, particularly within and adjacent to designated Strategic Habitat Areas.

Table 5C.3. Summary of threats and management needs for the Water Column (Street et al. 2004).

Threat	Management Need
Hydrologic modifications Flow regulation Dams/impoundments	Restoration efforts through removal or modification of dam structures that impede migration of anadromous fish should remain a high priority to continue in North Carolina, focusing on the lowermost structures in rivers or streams, and advancing upstream. In particular, the Cape Fear system (i.e., Lock and Dam #1) should be a high priority, since striped bass, shortnose sturgeon, and Atlantic sturgeon have not recovered
Hydrologic modifications Flow regulation Water withdrawals	More research is needed to assess the impact of water withdrawals on water column habitat and fish populations in the affected river basins. Assessments of groundwater water supplies in coastal counties should be made to determine what the environmental consequences will be if the increase in water withdrawals continues. Until standards are implemented and effective exclusive technology is available, withdrawals should be reduced as much as possible during and following spawning season in areas known to be used by eggs, larvae, and early juveniles. This would include NCDMF designated PNAs and anadromous fish spawning and nursery areas that are currently being mapped by NCDMF staff.
Hydrologic modifications Flow regulation Status and trends in flow regulation	New dam construction should be avoided whenever possible or designed and sited to minimize impacts to anadromous fish use and to maintain appropriate flow conditions. Flow alterations that may significantly change the temporal and spatial features of inflow and circulation that are required for successful spawning of anadromous fish should be prohibited. A process that fully evaluates cumulative impacts from water withdrawals and other hydrological modifications should be developed and implemented.
Hydrologic modifications Road fill and culverts	Through the EEP process, additional focus on restoring stream flow and fish habitat through the replacement of culverts with bridges should be accelerated. Funding should be allocated for replacing filled channels and streams with "fish friendly" culverts or bridges and upgrading existing culverts to "fish friendly" structures, prioritizing structures that are known to impede anadromous fish migration to spawning grounds or have been found to be particularly problematic to the natural hydrology of a system.
Hydrologic modifications Channelization and ditching	De-snagging of woody debris from streams for navigation or other purposes should be minimized to enhance water column habitat value. New channelization projects should not be constructed unless found to be absolutely necessary and designed to minimize or adequately mitigate any negative habitat and water quality impacts. Dechannelization of streams, particularly in areas historically utilized as fish nurseries, implementation of alternative drainage control practices, and acceleration of innovative BMP development are needed where feasible. Increased funding and educational outreach to farmers and other landowners are also needed for such projects. Additional monitoring, paid for by the party responsible for the ditching, is needed to better assess impacts where extensive areas of wetlands were drained. More NCDWQ staff are needed to inspect for compliance with the wetland draining policy.
Hydrologic modifications Dredging (navigation channels and boat basins)	New dredging in shallow, nearshore areas with fine sediment and low flushing should be discouraged. Areas where dredging could enhance habitat should be identified for habitat restoration efforts.
Hydrologic modifications Mining	Log salvage operations may also need to be restricted from anadromous fish nursery areas.
Hydrologic modifications Jetties	Construction of new or expanded jetties or groins along North Carolina's ocean shoreline should not be allowed until field research has been completed to assess the impact of jetties on successful larval passage through inlets into estuaries, particularly in Pamlico Sound where inlets are limited. Environmental outreach to the public, particularly commercial and recreational fishermen, regarding the effect of inlet stabilization on coastal fish habitat is needed to educate the public on this issue and gain support for maintaining natural barrier island processes.

Threat	Management Need
Hydrologic modifications Shoreline stabilization	The state should enforce the prohibition of hardened structures on the oceanfront. In addition, existing seawalls and hardened structures on the oceanfront should be removed if they are more than 50% damaged and if removal will be beneficial to coastal fish habitat. Where shoreline stabilization structures such as rock revetments, sills, or bulkheads are allowed adjacent to fringing wetlands, permit conditions should require openings in the structures to allow adequate fish ingress and egress and water circulation. To minimize impacts to the water column and its functions, CRC estuarine shoreline stabilization regulations should be modified.
Water quality degradation Land cover and water quality	The estuarine shoreline Areas of Environmental Concern (AEC) should be widened and extended inland beyond the Inland Water jurisdictional line to at least the upstream boundary of coastal wetlands. Establishment of development setbacks within AECs should also be considered as a tool in protecting water quality. To more effectively manage development in a manner that minimizes impacts to coastal fish habitat, a process to fully evaluate cumulative impacts of coastal development needs to be developed and implemented by the regulatory agencies. Coast-wide mapping of impervious cover is needed to evaluate watershed condition. The coast-wide mapping of impervious surfaces should be supplemented with data on local hydrology and on-site stormwater controls to more accurately reflect potential degradation of water quality. Water quality problems associated with development and excessive impervious cover will continue to worsen unless improved land-based strategies that reduce nonpoint source pollution are voluntarily utilized at a local level. Such voluntary strategies could include providing incentives for low impact development, improved BMPs and other techniques. Rule-making strategies may also be necessary to adequately retain stormwater on-site. This could be achieved through site design, construction of engineered storm water controls, or lower maximum amounts of impervious surfaces on developments choosing the low-density option for stormwater control. Phase II stormwater rules already recognize the need to limit impervious surfaces. The EMC and CRC should consider 1) modifying rules regarding limits of built-upon area (low-density option) to be consistent with the scientific literature regarding water quality protection needs, or 2) modifying stormwater rules to require adequate retention or treatment of stormwater on-site, through alternative effective techniques. Mandatory buffer zones, of scientifically based and effective widths and configurations that protect habitat and water quality, should be required along all streams draining to coastal fish habitat in North Carolina. Requiring professional foresters to be involved with the implementation of logging BMPs, even on small private forests, would enhance proper use of BMPs. In addition, notifying the Division of Forest Resources prior to initiating logging operations would facilitate BMP inspections and, hopefully, improve overall compliance. Educating owners of small non-industrial forests would also improve BMP implementation and success.
Water quality degradation Nutrients	Loading of nutrients into coastal waters from mechanical failures, spills, and inadequate treatment must be reduced. This will require additional funding to upgrade plants and infrastructure. Increased inspections of sewage treatment facilities, collection infrastructure, land disposal sites, and onsite wastewater treatment facilities is necessary to identify and prioritize sites needing upgrades. More funding is needed to buy out or relocate additional animal operations from environmentally sensitive areas. The moratorium should remain in effect until alternative waste treatment is implemented that will reduce pollutant loading to streams and nitrogen release into the air. In addition EMC should phase out use of waste lagoons or reclassify waste lagoon systems from nonpoint to point source discharges, and be permitted accordingly, as recommended in NCDENR's Neuse River Nutrient Sensitive Waters Management Strategy (NCDWQ 1997). Some environmentally superior alternatives to the current lagoon and spray field systems were identified in the Smithfield Agreement. The early implementation of these superior alternatives should be encouraged. A greater portion of agricultural conservation funds should be allocated to the buy out or relocation of animal operations from sensitive areas, and for the purchase of conservation easements. Additional measures to reduce inputs from agriculture should be considered by the CRC, EMC, MFC, and NRCS, such as removing their exclusion of agriculture from CRC and EMC regulations, expansion of funding for BMPs and cost-share programs for nonpoint pollution control.

Table 5C.3 *(continued)*. Summary of threats and management needs for the Water Column (Street et al. 2004).

Threat	Management Need
Water quality degradation Nutrients *(continued)*	The Division of Air Quality and NCDENR should implement the planned expansion of car inspections as soon as possible. In addition, North Carolina legislators, state agencies, and local governments should adopt coast-wide or state-wide "Smart Growth" policies to provide incentives and direct growth into more highly developed areas and preserve rural land uses. Additional education is needed on proper application of fertilizers to reduce runoff of nutrients into coastal waters, targeting homeowners, golf course owners, and landscape businesses. BMPs, including vegetated buffers, detention ponds, and wetland areas, should be required on all new and existing golf courses draining to coastal waters to help reduce nutrient concentrations. Areas like Futch or Pages Creek, that have relatively good water quality condition and are important nursery and shellfish producing areas, should be a high priority for water quality maintenance and protection through stormwater control BMPs, such as vegetative buffers and impervious surface limits and land conservation. Comprehensive sampling, similar to that done in the Tidal Creeks Program in New Hanover County, is needed for other tidal creeks in Brunswick, Pender and Onslow counties that are highly important nursery and shellfish areas.
Water quality degradation Oxygen depletion and fish kills	Coastal research and monitoring needs to continue to improve our understanding of the processes of hypoxia and anoxia and the effect on fish populations. Efforts to reduce nutrient loading from point and nonpoint sources in the Neuse, Tar-Pamlico, and Cape Fear river systems, where the largest number of fish kills have occurred, should continue and be increased as necessary. Implementation of mandatory riparian buffers along the Cape Fear, as well as other strategies, should be considered.
Water quality degradation Sediments	Updated and accurate coast-wide estuarine erosion rates are needed for the CRC and EMC in determining adequate development guidelines and regulations along the coast. More stringent sediment controls on construction projects are still needed to reduce sedimentation in coastal waters. Implementation of mandatory vegetated buffers along all coastal waters should be considered as a strategy for reducing sediment loading, the largest pollutant in North Carolina coastal waters. Width and configuration of the buffers should be scientifically based and may need to be larger adjacent to strategic habitat areas.
Water quality degradation Fecal coliform bacteria	Any steps taken to reduce nonpoint sources of bacteria loading will at the same time reduce loading of other pollutants into coastal waters and improve water quality and habitat conditions. The effect of shellfish filtering capacities on water quality parameters, such as bacteria, nutrients and sediments, should be determined. Additional funds and process changes are needed to allow local communities to more rapidly address repairs and upgrades to all aspects of the municipal waste systems, including collection and treatment systems. To prevent fecal coliform contamination from on-site sewage systems, periodic inspections of on-site systems should be conducted at frequencies recommended by the North Carolina Division of Environmental Health. In addition, siting of subsurface disposal systems in soils adjacent to coastal waters should be reevaluated and revised if necessary to protect water quality. Modification of local or state stormwater rules limiting built upon area for new development adjacent to all coastal waters to less than approximately 12% (for the low density option) would be a scientifically based means of preventing additional water quality degradation. Scientifically based performance standards regarding the quantity and quality of stormwater coming off a site could be established, but careful maintenance and monitoring would be necessary. Restoration efforts to reduce fecal coliform levels should target concentrated areas of shell bottom or other Strategic Habitat Area. Focusing on areas less degraded (conditionally approved areas, recently experiencing increased closures), rather than areas that have been permanently closed for many years, could also result in a greater success in habitat enhancement.

Threat	Management Need
Water quality degradation Fecal coliform bacteria (*continued*)	New or expanded stormwater outfalls to coastal shellfishing waters should be prohibited by the EMC and existing outfalls should be phased out. Coordination and enhancement of rule enforcement and compliance review capabilities within NCDENR agencies is needed to fully enforce existing statutes and rules and minimize further water quality degradation. Given the role of public infrastructure (i.e., sewage treatment capacity) in coastal development, the siting process for infrastructure should be restricted from areas that would impact sensitive fish habitats and supporting areas. Offshore wastewater discharges should be prohibited in North Carolina to minimize water quality degradation to the water column. Additional permits for stormwater outfalls on ocean beaches or nearshore waters should be prohibited by the EMC or the stormwater should be treated to acceptable water quality levels prior to discharging. Alternative stormwater management strategies should be implemented, similar to the efforts underway by Emerald Isle, to phase out existing stormwater outfalls and encourage land application. More detailed monitoring is needed to assess the extent oceanfront septic systems are causing degradation to nearshore coastal waters.
Water quality degradation Toxic chemicals	More research is needed on the subject of hormone-altering chemicals in surface waters. Because pollutants associated with roads, parking lots, and associated transportation are a significant source of toxins and other pollutants to the water column, efforts should be taken by NCDOT to minimize impacts by 1) designing roads to retain stormwater runoff in natural and vegetated upland or wetland areas; 2) designing roads and parking lots to minimize impervious surfaces; 3) improving water flow through transportation structures; 4) monitoring of BMPs; and 5) incorporating BMP design criteria to enhance control of bacteria. Determining the distribution and concentration of heavy metals and other toxins in bottom sediments throughout the coast is needed to comprehensively assess potential threat to the water column. Any new wood preservative products should be evaluated for impacts to marine benthos, including oysters. Ultimately, research is needed to determine if marina basins in freshwater and low-salinity areas actually produce enough toxic chemicals, at the right time, to impact fish populations. The impact of chronic oil pollution on nursery areas is unknown and needs future research. To protect anadromous fish spawning and nursery areas from marina impacts, dredging for new marina construction and other marina-related activities that negatively impacts these fish functions should be restricted. Waters designated as Inland PNAs by NCWRC should be considered for reclassification to HQW by EMC, as was done for MFC-designated PNAs. Formal criteria need to be developed to classifyand protect anadromous fish spawning areas that will be recognized by DWQ. Designation of specific anadromous fish spawning and nursery areas and possibly additional Inland PNAs needs to be completed along the entire coast to provide protection from marina development and other potential threats. Studies are needed to compare use of both upland and open water basins by young fish. Development of a comprehensive marina policy to address appropriate design, siting, operation and maintenance procedures, and cumulative impacts is needed to thoroughly address these and other impacts of marinas. This should consider, among other things, requiring the use of oil-absorbing materials around fuel and docking stations and shoreline habitat (i.e., wetlands, soft bottom). Support of the Clean Marinas Program through additional staff resources and incentives would benefit coastal fish habitat. The cumulative impact of clustered marinas should also be assessed. NCDENR should consider a temporary moratorium on all new small docking facilities (1-10 slips) and marinas, excluding individual private docks, until a comprehensive marina management system for all counties is developed. There is a need to study the cumulative impact of small docking facilities and associated development on toxic chemical concentrations in the water column. The study should also compare higher and lower salinity nursery areas.

Table 5C.3 *(continued)*. Summary of threats and management needs for the Water Column (Street et al. 2004).

Threat	Management Need
Water quality degradation Toxic chemicals *(continued)*	Pesticides should always be applied according to label instruction, regardless of whether a permit is required or not. Research is needed to identify those pesticides safe for spraying over open waters and, for those pesticides whose toxicity is impacted by salinity, appropriate application rates for controlling mosquitoes. Although safeguards are in place, the North Carolina Pesticide Board's policies on drift should be assessed and modified if necessary to ensure adequate protection of aquatic life and water quality.
Water quality degradation Other sources of WQ degradation	Research is needed to determine if effluent from desalination plants could create isolated pockets of higher salinity water with very low diversity of species. Basic water quality parameters (flow, temperature, pH, and DO) should be identified for permit applicants to monitor (<http://h2o.enr.state.nc.us/NPDES/documents.html>, 2004). If the data indicate the presence of pollutants in the discharge water, toxic chemical monitoring and toxicity testing should be required. Nutrients and ammonia should be monitored if a mass balance approach indicates excess nutrients. Finally, biological monitoring of the macrobenthic community should be required on facilities discharging more than 0.5 million gallons per day. Incentives are needed to encourage removal and proper disposal of derelict fishing gear. In addition, public education is needed to discourage littering from land or water based activities.
Non-native/nuisance species	Until treatment of ballast water is required and implemented, monitoring of port waters for algal blooms is recommended to minimize risks of introduction elsewhere.

Shell Bottom

Shell bottom habitat is unique because it is the only coastal fish habitat that is also a fishery species (oysters). The ecological value of shell bottom has only recently been recognized to be as or more significant than the fishery itself, since it provides numerous habitat and water quality functions that are vital for fishery and non-fishery species. The ability of shell bottom to withstand moderate turbidity levels allows oysters to clear the water column, encouraging growth of submerged aquatic vegetation (SAV) and benthic microalgae.

Oysters, SAV, and benthic microalgae quickly process dissolved and suspended material from the water column, thus facilitating the estuaries' role in storage and cycling of nutrients. This process reduces the likelihood of coastal eutrophication and its detrimental effects on fish and fisheries. Oyster beds also increase shoreline complexity, can alter circulation patterns, and enhance fish use of marsh edge habitat. Shell bottom also provides hard structure for attachment of diverse invertebrate species and protective cover for small mobile finfish and invertebrates. Gobies, blennies, hard clams, mud crabs, blue crabs, anchovies, oyster toadfish, and sheepshead are a few of the typical residents of oyster reefs. Research has shown that abundance and production of numerous fishery and prey species are enhanced more by shell bottom than by the surrounding soft bottom. Some of the important fishery species whose production is enhanced by shell bottom include hard clam, black sea bass, gag, tautog, and southern flounder. Shell bottom is federally designated as a Habitat Area of Particular Concern for estuarine dependent snapper-grouper species. The restoration of living oyster beds is therefore critical to the proper functioning and protection of surrounding coastal fish habitats and numerous fishery species.

Shell bottom habitat declined for most of the 20th century. The current distribution of shell bottom has shrunk to a mere fraction of its historical range, when oyster rocks were so abundant that they were considered a hazard to navigation. Anecdotal information suggests that oyster beds have been displaced roughly 10–15 miles (16–24 kilometers) downstream in the Pamlico and Neuse estuaries and completely covered by sediment in other areas. Furthermore, North Carolina's commercial oyster landings have declined about 90% from 1889 to today's low harvest. Most shell bottom losses have been subtidal beds in Pamlico Sound, where NCDMF has also found declines in spatfall. Although mechanical harvesting of oysters has been greatly restricted, reefs have not recovered, possibly due to stress from water quality degradation and increased occurrence of disease (Dermo, MSX). The loss of habitat could be particularly damaging to fishery stocks associated with shell bottom that are classified as Overfished by NCDMF, such as southern flounder, black sea bass south of Cape Hatteras, or the central/southern stock of striped bass.

Oyster dredging, beginning in 1889, is believed to be the major cause of the initial decline in shell bottom (*for a summary of threats and management actions, see Table 5C.4*). Today the dredge harvest has greatly diminished in North Carolina, although about 42% of shallow estuarine bottom (where oysters could live) is still open to mechanical harvest methods, all in Pamlico Sound. Dredging removes oysters and reduces the vertical profile of oyster rocks, increasing the susceptibility of remaining shell bottom at that location to low dissolved oxygen and possible mortality. Hand harvest methods for oysters and clams can also be destructive, but on a much smaller scale. Other bottom disturbing fishing gears, such as trawls, prevent the establishment of oyster reefs in areas within their historic range. Dredging for navigation channels or marina basins also impacts shell bottom. The downstream displacement of oysters in the Neuse and Pamlico rivers is probably the result of extensive drainage networks designed to increase the flow of stormwater (fresh water) into coastal waterways, decreasing salinity in the downstream portions of those rivers. While drainage for agriculture has changed little, drainage for urban/suburban development is increasing steadily. Runoff from agriculture, urban/suburban development, and transportation infrastructure carries sediment, nutrient, and toxic chemical pollutants. Sediment, the number one pollutant of waterways in the United States, clogs oyster gills and buries shells. Excess nutrients can fuel algal blooms and low dissolved oxygen events, and in turn, cause mortality of benthic organisms on deep, subtidal shell bottom. Heavy metals, petroleum products, pesticides, and other toxic chemicals in the runoff can kill sensitive oyster larvae.

To offset the decline in oyster habitat, restoration efforts were begun in 1958, and some protected areas have been established. While almost all work in the past has focused on restoring oysters for harvest, some recent efforts have been designed to restore or enhance shell bottom for habitat purposes. However, the magnitude of losses still greatly exceeds gains from restoration. Large areas of shell bottom habitat are still unprotected from direct physical removal or damage via human-related activities, as well as from indirect damage from water quality degradation. In order to restore shell bottom habitat, the destruction of oyster beds from fishing practices, channel or marina dredging, and pollutant loading must be reduced and oyster habitat restoration must increase significantly.

Submerged Aquatic Vegetation

Submerged aquatic vegetation is an extremely valuable fish habitat that occurs in North Carolina's coastal estuarine and freshwater systems. Because light is the primary limiting factor affecting its distribution, SAV is restricted to relatively shallow waters. Submerged aquatic vegetation provides ecosystem functions similar to shell bottom, such as enhancing water quality through stabilizing and trapping sediment, reducing wave energy, cycling nutrients within the system, and providing structure for invertebrate attachment and refuge from predators. Seagrasses also produce large quantities of organic matter, which supports a complex food base for coastal fishes and other organisms. This habitat is especially valuable as a nursery and refuge from larger predators for the young of many important commercial and recreational fishery species. Bay scallops, pink shrimp, hard clams, gag, black sea bass, summer flounder, and others are typically associated with high salinity SAV. Juvenile striped bass, striped mullet, brown and white shrimp, Atlantic croaker, and others frequently use low salinity grasses.

Red drum and blue crabs are among several species that rely upon both low and high salinity grasses at different stages of their life cycles. The high fisheries value of this habitat has been well established by the scientific community, and SAV is federally designated as a Habitat Area of Particular Concern for penaeid shrimp, blue crab, and red drum.

Historical accounts indicate that there have been large-scale losses of SAV in North Carolina's low salinity tributaries on the mainland side of Pamlico Sound and along much of the shoreline of western Albemarle Sound, while the high salinity grass beds to the east appear relatively stable. Loss of low salinity SAV habitat could negatively affect stocks of striped mullet, Atlantic croaker, and blue crab, which were classified as Concern by NCDMF in 2003. Impacts to high salinity SAV beds could be especially detrimental to bay scallops and black sea bass (south of Hatteras), which are currently listed as Overfished. Protection, enhancement, and restoration of this habitat are high priorities for recovery of those species and for sustained health of many others.

The major threat to SAV is large-scale nutrient enrichment and sediment loading, which increases turbidity, reduces light penetration, and subsequently impacts SAV growth, survival, and productivity (Table 5C.5). In North Carolina, most of the low salinity areas that have experienced large reductions in SAV coverage are also designated Nutrient Sensitive Waters. Major contributors of nutrients and sediments include point source discharges, nonpoint runoff (from crop agriculture, animal operations, urban and road construction, and impervious surfaces) and resuspended sediments (from bottom disturbing fishing gear and channel dredging). There are also activities that threaten the physical structure of SAV. Dredging for navigational channels, marinas, or infrastructure such as bridges or cables can result in large, direct losses of SAV. Docks constructed over SAV can cause immediate loss during construction or gradual loss due to shading effects. Boating activity in shallow vegetated waters can damage SAV from propeller damage to SAV. Bottom disturbing fishing gears used within or near SAV habitat, such as oyster and crab dredges, hydraulic clam dredges, clam trawls, and bull rakes, may cause significant damage to SAV habitat. As human population, boating activity, fishing pressure, and shoreline development increase, losses of SAV are likely to continue if steps are not actively taken to protect SAV and maintain suitable water quality conditions. State and local managers need to ensure that 1) SAV habitat is not physically impacted by water-dependent activities and 2) water quality (especially clarity) is enhanced to allow persistence of existing SAV and re-colonization of former habitat.

Table 5C.4. Summary of threats and management needs for the Shell Bottom (Street et al. 2004).

Threat	Management Need
Physical threats Mobile bottom disturbing fishing gear	Construction of oyster sanctuaries in locations of historic abundance and restriction of trawling over restored shell bottom is necessary to restore shell bottom in these northern subtidal areas. Oyster dredging in these areas should also be prohibited. Stronger penalties are needed for trawling over oyster rocks, where prohibited by the MFC. Additional marking of productive shell bottom would provide increased protection of this habitat from destructive fishing gears. However, additional law enforcement resources are necessary to mark and enforce increased closed areas.
Physical threats Hand harvest	Creation of additional Shellfish Management Areas would reduce habitat damage and enhance spatfall of oysters and clams in areas where hand-harvesting activity is intense. More enforcement would also be needed to enforce the restrictions associated with Shellfish Management Areas.
Physical threats Water-dependent development	Oyster beds in closed shellfishing waters are particularly vulnerable to loss and degradation from marina dredging. These areas should be evaluated for protection as Strategic Habitat Areas. A variety of working groups have recommended the development of a coastal marina policy that encompasses all associated regulatory activities conducted within the NCDENR. Development of this policy continues to be a management need. Evaluation of the impact of dock-associated boating on shell bottom habitat is therefore a research need. Prohibiting construction of docks or replacement of severely damaged docks (>50%) in documented shellfish beds may be required to minimize degradation and loss of habitat.
Water quality degradation Sediment	Improved voluntary and regulatory land use strategies must be implemented to reduce nonpoint source pollution in coastal waters and subsequent habitat degradation. Mitigation should be required from upstream development projects that result in habitat loss downstream.
Water quality degradation Nutrients	Nitrogen, phosphorus and sediment loading from waste treatment facilities, animal operations and other sources must be reduced upstream of shell bottom habitat to minimize mortality to shellfish and associated organisms. Construction of high profile oyster reefs in deeper waters is needed to serve as refuge areas during low oxygen events. Efforts in wetland restoration, shoreline conservation (vegetative buffers, setbacks), and stormwater management should be a priority in watersheds draining to shell bottom habitat, particularly where oxygen and nutrient problems have been documented. Nutrient loading from point sources must also be reduced through increased inspections and maintenance of sewage treatment facilities, collection infrastructure, and on-site wastewater systems. In systems with an abundance of "black waters" (or swamp water), such as the lower Cape Fear River, investigations should focus on separating nutrient impacts on DO from impacts due to inflow of low DO swamp waters.
Water quality degradation Toxic chemicals	Any new wood preservative products should be evaluated for impacts to marine benthos, including oysters.
Disease	Maintenance of high-profile oyster rocks is critical for subtidal oysters to perform their ecological functions, as well as provide resources for harvest. The relative contribution of channel deepening to saltwater intrusion and subsequent oyster mortality must be evaluated in order to determine appropriate management action. Establishment of oyster sanctuaries seeded with disease-resistant brood stock or allowed to naturally develop disease-resistant oysters would enhance the oyster's ability to survive and provide disease-resistant broodstock for repopulating highly impacted areas.
Introduced and nuisance species	The NCDMF Fishery Management Plan for Oysters recommended that testing continue on aquaculture use of non-spawning, non-native oysters before decisions are made opposing or supporting introduction. The recommendations provided by the National Research Council (2003) should be considered in developing a comprehensive oyster restoration plan.

Table 5C.5. Summary of threats and management needs for Submerged Aquatic Vegetation (Street et al. 2004).

Threat	Management Need
Physical threats Channel dredging	The NCDMF and MFC should continue to use existing permit review authorities and CRC and EMC should provide more protection to SAV within existing permitting authority to prevent or limit as much as possible direct or indirect impacts to SAV from all dredge and fill projects.
Physical threats Infrastructure	Infrastructure projects that require SAV impacts should be avoided. Where impacts are unavoidable, SAV losses should be minimized and adequately compensated through mitigation, using methods recommended by NMFS for SAV restoration or creation. Such projects should be monitored over time to determine persistence of restored SAV beds.
Physical threats Boating activity	Educational outreach is needed to increase awareness by the boating public of the ecological value of SAV and the damaging effects of boat propellers to SAV habitat. The level of damage to SAV from prop scarring should be assessed periodically. In areas where boating activity is found to cause significant SAV impacts, navigational markers should be installed to clearly delineate navigational channels to be used or SAV beds to avoid.
Physical threats Marinas and docks	Direct, indirect, and cumulative impacts to SAV and other habitats from marina and dock siting should be minimized. Development of a comprehensive state marina policy is needed to achieve this objective. Research is needed to determine if adequate light is available beneath North Carolina docks, given the current CRC dock siting criteria. These criteria should be evaluated to determine if existing requirements are adequate for SAV survival and growth and what changes would be needed to allow at least the minimum amount of light beneath docks. The permit requirements for docks and piers may need to be changed accordingly. Any research and modeling effort conducted on dock impacts should address the cumulative impact of shading, turbidity, boater access, and other impacts on the quality and quantity of SAV beds.
Physical threats Fishing gear impacts	Research is needed to determine where there is suitable potential SAV habitat along the mainland shorelines of the Albemarle-Pamlico system for the purpose of establishing defined SAV restoration goals. Once determined, oyster dredging should be prohibited from areas targeted for SAV restoration. Research should be conducted to determine whether gear impacts or other factors are causing the decline observed in bay scallop landings that was discussed in the Status and Trends section. If current bay scallop harvesting methods are found to negatively impact SAV and bay scallop populations, the NCDMF and MFC should consider rotation of fishing areas, or other fishery management techniques. Turbidity impacts to SAV at this new location and other existing mechanical harvest areas should be assessed through water quality monitoring. Field studies are needed to assess the effect of shrimp and crab trawling on SAV in North Carolina, particularly in Core and Bogue sounds. In addition, the boundaries of No Trawl Areas should be evaluated and adjusted, if necessary, to adequately protect all high salinity SAV beds and provide a buffer of unvegetated area to reduce turbidity impacts. Additional law enforcement may be needed to enforce buffers around SAV.
Water quality degradation Nutrients and sediments	Modifications may be needed to regulations and monitoring programs to improve their effectiveness for SAV protection. A review of current chlorophyll, total suspended solids, and turbidity standards should be conducted to determine if they are appropriate for the protection of SAV in North Carolina waters. NCDENR should work with NOAA Fisheries to determine what levels of total suspended solids, chlorophyll a and other parameters are needed to achieve desired water clarity. The need and feasibility (scientific defensibility and "implementability") for a water quality standard for light attenuation should be investigated to provide a pro-active target or standard for protection and restoration of SAV. Once the appropriate water quality conditions for protection of SAV are determined, NCDWQ should evaluate whether current sampling locations and methods are sufficient in estuarine waters to monitor the suitability of water quality conditions for SAV survival and growth. Monitoring should be conducted in waters with SAV habitat to ensure that the standards and conditions are being met. If additional monitoring is needed, establishment of continuous monitoring stations should be considered. In either case, priority should be given to those areas already classified Nutrient Safe Waters.

Threat	Management Need
Water quality degradation Nutrients and sediments (*continued*)	Since some SAV is present in the shallow portions of the Neuse and portions of the White Oak river basins, and water quality data indicate some level of eutrophication exists, nutrient levels may be limiting survival or expansion of SAV in these areas. These areas should be a high priority for monitoring of SAV and water clarity. To restore SAV habitat in fresh and estuarine systems where it historically occurred, management strategies should focus on water quality improvements at the edges and upstream of SAV occurrence. Nonpoint source loading of nutrients and sediment could be reduced through multiple strategies, including preservation and restoration of upland and wetland riparian habitats, modifications in land use regulations and agricultural BMPs. Conservation priorities should be set for land acquisition programs which will aid in protecting Strategic Habitat Areas. Nutrient and sediment reduction goals should be established by the EMC to achieve the minimum of 15-25% light availability at depth requirement for SAV growth. An increase in staffing to fully implement and enforce existing stormwater and other nonpoint source-related regulations is needed to achieve this goal. The New River nutrient management strategy [EMC rule 15A NCAC 02B.0223] was heavily focused on point sources and should be revisited to determine what additional controls, such as buffers, might be necessary to achieve continued water quality improvements. An approach similar to that used in Indian River Lagoon and the Chesapeake Bay, where the condition of water quality, SAV, and fish populations are linked in monitoring and management, would be useful for protection of SAV habitat in North Carolina.
Water quality degradation Toxic chemicals	Permitting for chemical removal of European watermilfoil and other non-native vegetation should be carefully restricted where native species co-occur to prevent non-target impacts. More education on the value of SAV to the health of North Carolina's estuaries and fisheries is needed to modify attitudes toward this habitat and improve individual and community stewardship of SAV.
Introduced and nuisance species	Long-term management and restoration of SAV habitat should include replacement of Eurasian watermilfoil with native species. NCDENR should coordinate with the Division of Water Resources to ensure that native species are not targeted for removal. Research is also needed to determine the relative fishery value of Eurasian watermilfoil compared to native vegetation. Non-native species may also be introduced through unintentional releases from aquaculture and live bait facilities. Policies should be developed by state agencies overseeing aquaculture and bait facilities to prevent such releases into coastal waters.
Other threats	Submerged grasses need to be monitored on a regular basis to assess the status of wasting disease and its association with human-induced stresses.

Wetlands

Wetland habitat is unique among the coastal fish habitats because it is not entirely submerged but occurs in and above the water. There are many different types of wetlands throughout the coast, many bordering the rivers and sounds, while others are hydrologically isolated. While each wetland type is unique, these different types provide similar ecological functions. Wetlands are highly effective and well recognized for their value as a natural filter, trapping and filtering pollutants from upland runoff; as well as serving to buffer the effects of floods by storing, spreading, and slowing stormwater runoff. Like SAV, wetlands are highly productive biologically, but because of their expansive coverage and biomass, produce much more organic matter, which is broken down and utilized by multiple species adjacent to wetlands and elsewhere. It has been estimated that over 95% of the United States' commercially harvested finfish and shellfish are wetland dependent. The combination of shallow water and thick vegetation provides excellent nursery habitat for juvenile fish. The majority of MFC-designated Primary Nursery Areas consists of wetlands and adjacent shallow water and soft bottom. Fish found commonly in or near freshwater marshes and swamps include bluegill, largemouth bass, river herring, and striped bass. In and adjacent to estuarine wetlands, killifish, spot, red drum, flounder, penaeid shrimp, striped mullet, pinfish, blue crab, and other species are abundant. In addition to supplying food and acting as nursery habitat for numerous species, riparian wetlands also provide a relatively safe corridor for fish moving among the other nearshore habitats.

It is estimated that as much as 40-50% of North Carolina's original wetland coverage has been lost, primarily due to ditching, channelization, and filling for agriculture and development. From the early 1800s to the early 1900s, agriculture accounted for the majority of wetland losses. From about 1950 to the 1990s, development accounted for two-thirds of wetland impacts, with forestry and agriculture associated with the remainder. Although the rate of wetland loss has slowed, losses continue to occur. Mitigation for permitted losses and voluntary restoration efforts in some areas have partially offset some recent losses, but the type of wetland gained is often not equivalent to what was lost. Degradation and loss of wetlands can impact many species, including overfished stocks of river herring and southern flounder, as well as stocks designated with the Concern status such as blue crab and striped mullet.

There are multiple threats to wetland habitat today, primarily due to physical destruction and hydrological alteration (Table 5C.6). Ditching and draining for development, construction of new dams, mining activity, and filling for new development accounted for the majority of permitted wetland losses in recent years. Construction of roads, infrastructure, and water dependent-development, including dredging for marinas and navigation channels, also results in smaller, site-specific losses and contributes to cumulatively large wetland losses. Estuarine shoreline stabilization causes gradual, long-term wetland loss by limiting sediment inputs needed for maintenance and expansion of wetlands, and by blocking landward migration as sea level rises. Because wetlands are critical to a large number of fishery species, but have been greatly reduced in spatial coverage from their original extent, ongoing initiatives such as wetland restoration, land acquisition and preservation, and agricultural cost-share BMPs need to be enhanced. There should also be additional initiatives implemented to protect and enhance wetland habitat. The many fishery and water quality functions provided by wetlands make their preservation and restoration along North Carolina's coast a high priority for protection of all coastal fish habitats.

Table 5C.6. Summary of threats and management needs for Wetlands (Street et al.2004).

Threat	Management Need
Physical threats Land use and wetland alteration	Additional monitoring is needed to better assess impacts where extensive areas of wetlands were drained. More NCDWQ staff are needed to inspect for compliance with water quality standards, including wetland draining. Any ditching activity resulting in nonpoint source pollution in North Carolina's rivers and sounds should require an NPDES permit. The EMC's constraints on discharges in SA waters could then be extended to drainage projects, in addition to traditional point source discharges (i.e., wastewater treatment plants). Eventually, the EEP should include mitigation planning for upland development and other approaches to habitat enhancement, restoration, and preservation.
Physical threats Shoreline stabilization	Better criteria to define an "erosion problem" and aid in proper utilization of erosion control structures are needed and should be developed by the NCDCM and CRC. There is a need to more accurately assess where and how much of the estuarine shoreline is hardened. With more accurate information, the level of impact to marine resources can be assessed. The methodology used for assessing shoreline hardening (examination of aerial photographs) could be used for a larger portion of the coast to spatially delineate and quantify where and how much of the shoreline is hardened. The CRC should revise estuarine shoreline management rules using best available scientific information, including the recommendations from the Estuarine Shoreline Biological and Physical Processes Work Group to minimize impacts to natural shoreline and nearshore fish habitat functions. As part of the process of modifying shoreline management rules, accurate estuarine shoreline erosion rates are needed to aid in identifying "erosion problems," determining adequate shoreline setbacks, and determining appropriate erosion control methods where necessary. Wherever possible, sections of estuarine, non-vegetated shoreline with very little hard stabilization should remain unaltered to provide "new" sediment for shallow water habitats. Some consideration should also be given to the type of material used in rock structures because oysters more readily colonize oyster cultch material or limestone marl, than granite.

Threat	Management Need
Physical threats Channelization and ditching	Dechannelization of streams, restoration of wetland hydrology, use of alternative drainage techniques, and on-site BMPs are therefore needed to maintain and restore wetlands, flows and salinity patterns in downstream areas. In addition, increased funding and educational outreach to farmers and other landowners are needed for projects that restore natural stream and wetland functions.
Physical threats Boating	There is a need to amend NCWRC no wake zone authority to include consideration for erosion in strategic wetland areas. There should also be increased public awareness of the impact of boat wakes on wetland shorelines.
Water quality degradation	The susceptibility of freshwater wetlands to sulfate pollution should be evaluated in coastal North Carolina. Results should provide the measure of iron concentrations in wetland sediment necessary to evaluate susceptibility.
Sea level rise and storm events	Buyers and owners of coastal property should be aware of sea level rise and the potential for loss of wetlands and property. Updated and accurate coast-wide estuarine erosion rates are needed for the CRC and EMC to determine adequate development guidelines and rules along the coast. Priorities for coastal wetland protection should also acknowledge sea level rise, and protect gently sloping areas upland of coastal wetlands to allow for landward migration of coastal wetlands with sea level rise. Research is needed on site-specific erosion and accretion rates and their relationship with sea level rise and storm events. Specific research is also needed to determine processes that control the upper limits of peat accumulation, which is the foundation of coastal wetland development in the Albemarle-Pamlico system.

Soft Bottom

Soft bottom habitat is the unvegetated bottom sediment in all coastal systems, and includes features such as inlets, shoals, channel bottoms, intertidal ocean beaches, and cape shoals. Soft bottom plays a key role in primary productivity in shallow estuarine and marine systems. This habitat strongly influences the water column through dynamic cycling processes, storing and releasing nutrients and chemicals over time. Other ecosystem functions of soft bottom include the reduction of physically destructive storm effects on oceanfront beaches, and providing sand sources for barrier island and inlet migration. Soft bottom habitat is particularly important as a foraging area for all size ranges of bottom feeding fish and invertebrates, such as blue crabs, shrimp, flounders, striped mullet, spot, croaker, and kingfish. Burrowing mollusks (e.g., hard clams, coquina clams), flatfishes (e.g., southern flounder, hogchoker) and baitfish (e.g., striped mullet) are highly associated with shallow soft bottom, while larger benthic feeding predators (e.g., weakfish, coastal sharks, sturgeons) typically utilize deeper soft bottom areas. Valued fishery species that depend on healthy soft bottom habitat include hard clams, shrimp, blue crabs, southern flounder, Atlantic croaker, striped mullet, kingfish, and spot. Of these, the NCDMF stock status of Atlantic and shortnose sturgeons, southern flounder, and coastal sharks was Overfished. Striped mullet and Atlantic croaker were listed as Concern. The Atlantic sturgeon, which is classified as Overfished, has been under a fishing moratorium since 1991 but has not shown signs of recovery. Coastal inlets have been federally designated as Habitat Areas of Particular Concern for blue crab, estuarine-dependent snapper and grouper, penaeid shrimp, and red drum.

Inadequate data are available to clearly indicate the current condition of soft bottom habitat. Fortunately this habitat is relatively resistant to a changing environment. This is the most abundant submerged coastal fish habitat, and estuarine acreage of soft bottom has undoubtedly increased over time as shell bottom, SAV, and wetland habitats have declined.

Threats of greatest concern include large-scale alterations such as dredging of productive shallow bottom areas, construction of marinas and docks, bottom dredge and trawl fisheries in estuarine waters, and large-scale beach nourishment (Table 5C.7). Depletion of oxygen and toxic contamination of bottom sediments are the major water quality concerns since those conditions can cause mortality or poor recruitment of benthic invertebrates, which in turn can affect food availability for numerous benthic feeding invertebrates and fish. Therefore, minimizing dredging of productive shallow bottom, properly managing beach nourishment to maintain healthy benthic communities in the surf zone, and reductions in nutrient and toxin loading in all coastal waters are the primary management needs for soft bottom.

Table 5C.7. Summary of threats and management needs for Soft Bottom (Street et al. 2004).

Threat	Management Need
Physical threats Dredging	More research is needed to assess direct and indirect dredging impacts on blue crabs and inlet spawning species. Commenting and permitting agencies should continue to use their existing authorities to a) minimize new dredging of shallow soft bottom habitat, b) prevent direct impacts from dredge and fill projects, and c) limit as much as possible indirect impacts to shallow soft bottom or other habitats.
Physical threats Dredge material disposal on subtidal bottom	A state policy on dredge material management that a) minimizes impacts to coastal fish habitat, including soft bottom habitat, and b) is consistent with federal existing guidelines, should be developed.
Physical threats Marinas and docks	Stringent efforts are needed to prevent toxic contamination of sediments from marinas to reduce impacts to soft bottom productivity. Toxic sources at marinas should also be addressed. Dock siting criteria should include a minimum water depth to prevent boats or floating docks from sitting directly on soft bottom or other benthic habitats. A comprehensive dock and marina policy is needed to address appropriate design, siting, operation, and maintenance procedure and cumulative impacts to minimize impacts to soft bottom and other fish habitats. Research on the impacts of these parameters is needed.
Physical threats Shoreline stabilization	A comprehensive examination and revision of current CRC shoreline stabilization rules using best scientific information is still needed to minimize impacts from this activity to soft bottom, particularly intertidal estuarine shorelines. Research is needed to determine if and how oyster shell could be utilized as an alternative to rock or wooden stabilization structures to create "living shorelines" that are effective in stabilizing the shoreline while also providing habitat value. Any new wood preservative products should be evaluated for toxicity to marine benthic organisms and juvenile fish. When formulating revisions to CRC's shoreline stabilization regulations and guidelines, CRC should take into account the impact of sediment contamination and potential toxicity of wood preserved bulkheads on marine organisms. Prohibition of shoreline hardening of the oceanfront should continue to be enforced for overall protection of barrier island processes, nearshore soft bottom communities, and associated fish species. The effectiveness and cumulative impact of beach bulldozing should be assessed and appropriate guidelines should be included in a coastal beach management plan. When mine areas are necessary for beach nourishment projects, guidelines should strongly encourage siting protocol that maximizes biological recovery rates and does not degrade critical fish foraging areas. More specific minimum and maximum grain size standards are needed to minimize biological impacts (re: beach renourishment). Because of the potential impact of beach nourishment and dredge disposal on soft bottom communities, there is a need for a coast-wide Beach Management Plan that carefully reviews cumulative impacts of activities and provides ecologically based guidelines, including sediment compatibility standards, to minimize cumulative impacts. The CRC's beach nourishment rules should be evaluated and modified in a comprehensive manner as needed to minimize overall impacts from this activity. Additional research is also needed to more clearly quantify the cumulative impact of nearshore dredge disposal on fish populations. Adequate monitoring of the effects of beach nourishment on the soft bottom community and associated surf fish populations is increasingly important as the number of beach nourishment projects increase and should be required for all large-scale or long-term nourishment projects. To adequately and correctly assess the direct and cumulative impacts of beach nourishment activities on fish, their habitat, and biological recovery rates, thorough monitoring must be conducted. Because the demand for beach nourishment has increased in recent years, due in part to the state's prohibition of shoreline hardening, there is a need to complete a comprehensive beach management plan to provide guidelines to minimize long-term impacts. In addition, multi-agency efforts should be made to educate local government officials and the general public (since these groups initiate and drive the demand for beach nourishment) on natural hazards and other factors associated with dynamic coastal systems.

Threat	Management Need
Physical threats Fishing gear impacts Dredging	Because less habitat damaging methods are available for harvesting crabs, MFC should prohibit crab dredging.
Physical threats Fishing gear impacts Bottom trawling	Further analysis is needed to identify the location, duration, and initiation of trawling over soft bottom habitat as well as over structured habitats, such as shell bottom and SAV. It is also important to quantify the effects of trawling on the habitat. Further analysis is needed to spatially quantify where, how often, and when trawling occurs in specific areas of soft bottom habitat. Primary nursery areas and inlets are described as "recruitment bottlenecks" for estuarine dependent species. Since larval flounder, shrimp, and Atlantic croaker must pass through inlets and recruit to shallow PNAs, trawling impacts in inlets and PNAs could be greater than trawling in ocean waters. Protection of these "recruitment bottlenecks" from trawling or other impacts is therefore very important for estuarine dependent fish and invertebrates. Shallow areas where trawling is currently allowed should be re-examined to determine if additional restrictions are necessary. Further studies are needed to more accurately assess if trawling is having a negative effect on soft bottom habitat and justify if additional closures are necessary for habitat concerns. Large-scale long-term experiments with and without fishing pressure are needed, rather than short-term small-scale studies, to examine and better quantify cumulative fishing impacts and recovery patterns in ocean waters.
Water quality degradation Toxic chemicals	More information is needed on the in situ effects of various contaminant levels, in combination with other contaminants and existing environmental stressors, to many important fish species in North Carolina. To better determine if contaminated sediment is a significant threat to coastal fish habitat, the distribution and concentration of heavy metals and other toxic contaminants in freshwater and estuarine sediments need to be adequately assessed and areas of greatest concern need to be identified. Continued minimization of point and nonpoint sources of toxic contaminants is vital for protecting not only soft bottom but also the other fisheries habitat.
Water quality degradation Nutrients	Long-term monitoring is required, in combination with management actions that reduce discharge concentrations, to determine effectiveness and future management needs.
Water quality degradation Oxygen depleted sediment	More information is needed to understand the consequences on the estuarine food web and to what extent anoxia is impacting the soft bottom community. Efforts are needed to reduce anthropogenic nutrient loading, particularly in systems that have a history of hypoxia and anoxia.

Hard Bottom

Hard bottom is valuable to fish because it provides structural complexity for foraging and refuge in marine waters. The presence of ocean hard bottom, along with appropriate water temperatures, allows for the existence of a temperate-to-subtropical reef fish community and a snapper-grouper fishery in North Carolina. Many economically important species and many non-fishery species spawn on nearshore hard bottoms, including black sea bass, Atlantic spadefish, sheepshead, tomtate, white grunt, pinfish, pigfish, damselfish, blennies, sand perch, and inshore lizardfish. Nearshore hard bottoms within North Carolina's ocean waters also serve as important nursery areas for these species as well as provide important secondary nursery habitat for estuarine-dependent fish, such as gag, and black sea bass, as the fish move between estuarine areas and offshore reef areas. All nearshore hard bottoms have been federally designated as Habitat Areas of Particular Concern for the snapper-grouper complex.

Although the current distribution of hard bottom habitat has been mapped, little is known about the biological condition of specific hard bottom sites or how it is changed over time. Wrecks and artificial reefs are beneficial since they add to the total amount of hard structure available to marine organisms and may reduce fishing pressure on natural reefs.

Because of the lack of baseline information on the biological functioning of nearshore hard bottom, the primary management needs for this habitat are continued research and monitoring to determine specific functional importance, determination of status and trends, and protection of existing hard bottom habitats from degradation or destruction. Threats to nearshore hard bottom in North Carolina include beach nourishment, channel dredging, bottom-disturbing fishing gear, and water quality degradation (Table 5C.8). Channel dredging can directly remove hard bottom habitat or increase turbidity to damaging levels. Sand transported from nourished beaches can cover up hard bottom structure. Bottom-disturbing fishing gear and related equipment, such as bottom trawls and boat anchors, can uproot coral and damage the structure of hard bottom. Excess nutrients, sediments, or toxins can impact growth or survival of the invertebrates living on hard bottom structure. Water quality degradation to hard bottom originates from nonpoint sources, such as oil and gas from boating activity, oil spills, and nutrient, sediment, or toxin loading from estuarine and riverine discharges. The quality of estuarine waters discharging into marine waters may have the largest overall effect on hard bottom, and can be addressed through the management needs discussed in the other estuarine habitat sections.

Table 5C.8. Summary of threats and management needs for Hard Bottom (Street et al. 2004).

Threat	Management Need
Dredging and beach renourishment	The transport of sand from nourished beaches over time should be monitored. Future research should attempt to determine if the probability or extent of burial are affected by sand volume, type, or grain size, by the time-of-year of project initiation, or by the distance between nourished beach and hard bottom. A NCDENR Beach Management Plan should be developed and implemented which includes specific guidelines to minimize impacts to hard bottom from nourishment projects.
Fishing and diving Commercial fishing	While there is potential for damage, research is needed to determine if and to what extent hard bottom is being damaged by trawling activity in North Carolina, particularly shrimp trawls in the southern portion of the coast. The specific locations of trawl trips should be mapped. To assess potential effects of trawling, experimental trawls of predetermined duration, magnitude and frequency should be conducted in a previously untrawled hard bottom location. The MFC should consider designating nearshore ocean hard bottoms as Strategic Habitat Areas due to their importance as secondary nursery habitat and corridors for gag, black sea bass, and other fisheries resources.
Fishing and diving Recreational fishing	Monitoring of hard bottom is needed to assess the level of impact from hook and line fishing. Educating anglers on the impacts of anchor damage, lost fishing gear and discarded litter to hard bottom habitat and associated species would be helpful in reducing those impacts.
Infrastructure	North Carolina should coordinate with ASMFC, other states, and thecommunications companies to manage the placement of fiber optic cables in North Carolina offshore waters in a manner that minimizes impact to hard bottom and minimizes conflicts with existing activities.
Water quality degradation	It would be beneficial for the state to develop and implement a policy to prohibit oil and gas drilling in North Carolina's coastal waters, to ensure protection of hard bottom and water column habitats. Adequate monitoring should be conducted prior to creation and during use of the Ocean Dredge Material Disposal Site (off the mouth of the Cape Fear River) to determine its effect on hard bottom habitat. Current state (EMC) policies prevent wastewater discharge into the Atlantic Ocean. The only exception to this restriction is the discharge off Oak Island of heated flow-through, non-contact cooling water from a nuclear power plant. Because nearshore hard bottoms are so vulnerable to damage from physical and water quality changes, this policy should be maintained. Monitoring of hard bottom should be initiated and coordinated with UNC-W or other ocean water quality monitoring programs to determine the effects of estuarine water quality, particularly nutrient and sediment loading, on hard bottom. Additional water and tissue sampling at hard bottom sites are needed to determine if the benthos of the hard bottom community or the surrounding waters exhibit levels that exceed designated levels of concern.

Management Recommendations[12]

The discussions of the six major habitat types demonstrate the importance of coastal fish habitats, threats to those habitats, and the need to take actions to achieve the stated goal of the CHPP as provided by the North Carolina General Assembly: "long-term enhancement of coastal fisheries associated with each coastal habitat." Management recommendations are based on scientific studies cited in CHPP chapters 2–7, deliberations of the Environmental Management, Coastal Resources, and Marine Fisheries commissions, and citizen input (verbal comments received in person or by telephone; written comments received in person or via mail and e-mail) from two series of well-attended public meetings (20 in all) held during the summers of 2003 and 2004, as well as additional comments obtained during the CHPP process.

The public cited coastal development as the issue most needing immediate attention, followed by enforcement of existing statutes, rules, and permit conditions, and then environmental education and research. Threats associated with development included polluted stormwater runoff, wastewater discharges, and wetland filling. Meeting attendees agreed that existing laws and rules might be sufficient for habitat protection, but that they are not adequately enforced largely due to insufficient staffing and resources. Educating the public about the importance of coastal habitats and the threats they face was repeatedly mentioned as being critical for successful habitat protection and enhancement.

Threats

The CHPP law specifically requires identification of "existing and potential threats to the habitats" and "actions to protect and restore the habitats" (G.S. 143B-279.8). Threats to coastal fish habitat come from many sources and usually affect more than one habitat. Table 5C.9 (reproduced from Table 9.1, Ch. 9, Street et al. 2004) provides a listing and evaluation of the principal threats to the six types of coastal fish habitats identified previously in (the CHPP report). The water column and shell bottom are the most threatened habitats (shell bottom because there is so little of it, and the water column because there are so many pollution sources). All habitats are subject to multiple threats.

Recommendations

The CHPP development process identified hundreds of management needs (summarized in Tables 5C.3–5C.8 above). The members of the three Commissions reviewed the issues, along with suggested management actions to address those needs. The Commissions selected four general goals and a series of recommended actions to reach each goal, as shown below (and in Table 9.2, Ch. 9, Street et al. 2004). The goals and recommendations shown below are not listed in any kind of priority order. Implementation of any of the recommendations below through specific rules or policies may involve further discussion with stakeholders and, in some cases, the balancing of competing ecological and economic values.

GOAL 1. Improve Effectiveness of Existing Rules and Programs Protecting Coastal Fish Habitats

Every year, an average of more than 100 acres of Outstanding Resource Waters (the highest quality waters in North Carolina) are closed permanently to shellfish harvest, and miles of previously unaltered estuarine shoreline are artificially hardened with vertical shoreline stabilization structures. Thousands of acres of farmland and forests are uprooted, developed, and paved annually, and nutrient-contaminated Public Trust waters suffer from low oxygen events and fish kills. Existing rules and programs have had only limited success in protecting and enhancing coastal fish habitats and fisheries resources. The following non-regulatory actions must be taken for existing management strategies to be effective:

- Enhance enforcement of, and compliance with, Coastal Resources Commission, Environmental Management Commission, and Marine Fisheries Commission rules and permit conditions.
- Coordinate and enhance water quality, physical habitat, and fisheries resource monitoring (including data management) from headwaters to the nearshore ocean.

[12]Text taken directly from Ch. 9, Street et al. 2004.

Table 5C.9. Evaluation of specific threats to coastal fish habitats based on hydrologic, physical, and water quality alterations. Darker shading indicates greater impact[13](Street et al. 2004).

Activity Type	Threat/Activity	Coastal Fish Habitats					
		Water Column	Shell Bottom	SAV	Wetlands	Soft Bottom	Hard Bottom
Agriculture/ Aquaculture related	Animal operations						
	Aquaculture (incl. discharges, exotic species)						
	Cropland						
	Forestry						
Water control	Dams						
	Water withdrawal						
Development related	Urban/suburban construction activities						
	Urban stormwater runoff (impervious surface)						
	On-site wastewater disposal						
	Permitted industrial wastewater discharges						
	Permitted domestic wastewater discharges						
	Waste disposal (landfills, ocean dumping)						
	Fiber optic cables/utility pipelines						
	Estuarine shoreline stabilization						
	Ocean shoreline hardening						
	Ocean beach renourishment						
Transportation related	Impervious roadways						
	Culverts, bridges, and fill (physical blockages)						
Fishing related	Bottom trawl						
	Clam trawl (clam kicking)						
	Toothless dredge (bay scallop)						
	Toothed dredge (crab and oyster)						
	Long haul seines						
	Pots (crab)						
	Rakes, tongs						
	Rod and reel						
Navigation related	Marinas and docks (construction, assoc. NPS)						
	Ports (incl. exotic species via ballast water)						
	Boating activity						
	Channel and inlet dredging						
	Dredge material disposal (on submerged land)						
Mining related	Phosphate and other minerals						
	Log salvage						
	Oil and gas exploration/drilling						
Other	Sea level rise						
	Storm events						
	Disease						
	Introduced or nuisance species						
	Marine debris/litter						

[13]Impact rating: Dark green – severe; Medium green – moderate; Light green – minor; White – none, unknown or potential

- Enhance and expand educational outreach on the value of fish habitat, threats from human activities, effects of non-native species, and reasons for management measures.
- Coordinate rulemaking and enforcement among regulatory commissions and agencies.

GOAL 2. Identify, Designate, and Protect Strategic Habitat Areas

Growing resident and visitor populations in coastal North Carolina will further stress productive coastal habitats and fisheries resources through expansion of support services and infrastructure. Inland development degrades the water quantity and quality of streams that flow to the coastal sounds, as do increased boating and some fishing activities. Certain areas are especially important to fish production, and others are particularly vulnerable to these threats. Greater protection for these "Strategic Habitat Areas" must be a high priority in order to maintain a healthy coastal ecosystem. The following regulatory and non-regulatory management actions should be implemented:

- Evaluate potential Strategic Habitat Areas by:
  a) Coordinating, completing, and maintaining baseline habitat mapping (including seagrass, shell bottom, and other bottom types) using the most appropriate technology.
  b) Selective monitoring of the status of those habitats.
  c) Assessing effects of land use and human activities on those habitats.
- Identify and designate Strategic Habitat Areas using ecologically based criteria.
- Analyze existing rules and enact measures needed to protect Strategic Habitat Areas.
- Improve programs for conservation (including voluntary actions) and acquisition of areas supporting Strategic Habitat Areas.

GOAL 3. Enhance Habitat and Protect It from Physical Impacts

Studies estimate that up to 50% of North Carolina's original wetlands have been destroyed since colonial times. Development continues to cause degradation and permanent loss of coastal and non-coastal wetlands. Significant negative impacts to wetlands may occur through a combination of larger projects that require state and federal permits and numerous small, unrecorded actions. Regardless of magnitude, each impact contributes to the cumulative loss of habitat functions and biological productivity. Shell bottoms (oyster reefs) in coastal North Carolina were decimated by uncontrolled fishing methods more than a century ago, and later by construction of the Atlantic Intracoastal Waterway in the 1930s. Since that time, hurricanes, mechanical harvest methods, small scale dredging and filling projects, and diseases and parasites have continued to reduce remaining shellfish bottoms, particularly subtidal oyster beds in the Pamlico Sound system, and impede establishment of new shell bottoms. Submerged aquatic vegetation (SAV, seagrass) in low salinity areas, such as Albemarle Sound and western Pamlico Sound, has all but disappeared. Submerged aquatic vegetation is highly vulnerable to physical disturbances, as well as to water quality degradation, especially turbidity. Strong management actions are necessary to reverse historic and current habitat losses and restore wetlands, shellfish beds, and SAV. The following regulatory and non-regulatory measures are recommended:

- Greatly expand habitat restoration, including:
  a) Creation of subtidal oyster reef no-take sanctuaries.
  b) Re-establishment of riparian wetlands and stream hydrology.
- Prepare and implement a comprehensive beach and inlet management plan that addresses ecologically based guidelines, socio-economic concerns, and fish habitat.
- Protect Submerged Aquatic Vegetation, shell bottom, and hard bottom areas from fishing gear effects through improved enforcement, establishment of protective buffers around habitats, and further restriction of mechanical shellfish harvesting.
- Protect fish habitat by revising estuarine and public trust shoreline stabilization rules using best available information, considering estuarine erosion rates, and the development and promotion of incentives for use of alternatives to vertical shoreline stabilization measures.

- Protect and enhance habitat for anadromous fishes by:
  a) Incorporating the water quality and quantity needs of fish in surface water use planning and rule making.
  b) Eliminating obstructions to fish movements, such as dams, locks, and road fills.

GOAL 4. Enhance and Protect Water Quality

Because all fish habitats are connected through the water column, maintaining and restoring water quality is the basic component of habitat protection and enhancement. Runoff from developed lands (structures, parking lots, roads, residential yards), agricultural fields and facilities, and some intensively managed forests carries excess nutrients into surface waters, which can lead to algal blooms that reduce water clarity and lower dissolved oxygen in the water column. Turbidity from runoff can suppress SAV growth, cause low oxygen events leading to fish kills, and cause mortality of organisms in the bottom community, including oysters. Excess sediment clouds the water, reduces SAV growth and survival, fills in creeks and small water bodies with silt, and degrades spawning and nursery habitats. Heavy metals and pesticides transported into the water with storm water can accumulate in the bottom sediments and organisms. Through the food chain, such pollutants may contaminate fish, affecting their survival and growth, and making them unsafe for human consumption. Runoff also carries fecal material to surface waters after rain events, requiring closure of tens of thousands of acres of shellfishing waters to harvest in order to protect human health.

Spills and other failures of municipal and on-site wastewater treatment facilities and infrastructure often send sewage pollution downstream, contributing to algal blooms, and causing shellfishing closures and restrictions on swimming in public waters. Some coastal towns dispose of stormwater on the ocean beaches, while others drain it to the ocean or estuaries. These discharges degrade water quality, leading to shellfishing closures and notifications warning of possible public health dangers from contact with contaminated water. These warnings have a detrimental effect on tourism. Marinas also degrade water quality and restrict use of Public Trust waters via mandatory shellfish harvest closures. Large-scale animal farming expanded rapidly in eastern North Carolina in the 1990s, and management of hog waste became a major environmental problem. Current methods generally used for hog waste management can greatly increase nutrient loading to adjacent waters through excessive spraying on fields, aerial deposition, and spills. The following regulatory and non-regulatory management measures are necessary to address a diversity of point and non-point pollution sources:

Point Sources

- Reduce point source pollution from wastewater by:
  a) Increasing inspections of wastewater treatment facilities, collection infrastructure, and land disposal sites.
  b) Providing incentives for upgrading all types of wastewater treatment systems.
- Adopt or modify rules or statutes to prohibit ocean wastewater discharges.
- Prohibit new or expanded stormwater outfalls to coastal beaches and to coastal shellfishing waters (EMC surface water classifications SA and SB) except during times of emergency (as defined by the Division of Water Quality's Stormwater Flooding Relief Discharge Policy) when public safety and health are threatened, and continue to phase-out existing outfalls by implementing alternative stormwater management strategies.

Non-point Sources

- Enhance coordination with, and financial/technical support for, local government actions to better manage stormwater and wastewater.
- Improve land-based strategies throughout the river basins to reduce non-point pollution and minimize cumulative losses to wetlands and streams through voluntary actions, assistance, and incentives, including:
  a) Improved methods to reduce sediment pollution from construction sites, agriculture, and forestry.
  b) Increased on-site infiltration of stormwater.
  c) Documentation and monitoring of small but cumulative impacts to wetlands and streams from approved, un-mitigated activities.
  d) Incentives for low impact development.
  e) Increased inspections of onsite wastewater treatment facilities.
  f) Increased water re-use and recycling.
- Improve land-based strategies throughout the river basins to reduce non-point pollution and minimize cumulative losses to wetlands and streams through rule making, including:
  a) Increased use of effective vegetated buffers.
  b) Reduction of impervious surfaces where feasible and reduction of the level of impervious surface allowable in the absence of engineered stormwater controls.
  c) Expansion of CAMA Areas of Environmental Concern upstream and landward.
  d) Consideration of erosion rates as an additional factor in the siting of structures along estuarine and public trust shorelines.
- Develop and implement a comprehensive coastal marina and dock management plan and policy for the protection of shellfish harvest waters and fish habitat.
- Reduce non-point source pollution from large-scale animal operations by the following actions:
  a) Support early implementation of environmentally superior alternatives to the current lagoon and spray field systems as identified under the Smithfield Agreement and continue the moratorium on new/expanded swine operations until alternative waste treatment technology is implemented.
  b) Seek additional funding to phase-out large-scale animal operations in sensitive areas and relocate operations from sensitive areas.
  c) Use improved siting criteria to protect fish habitat.

(Also see Table 9.2 in Street et al. 2004).

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