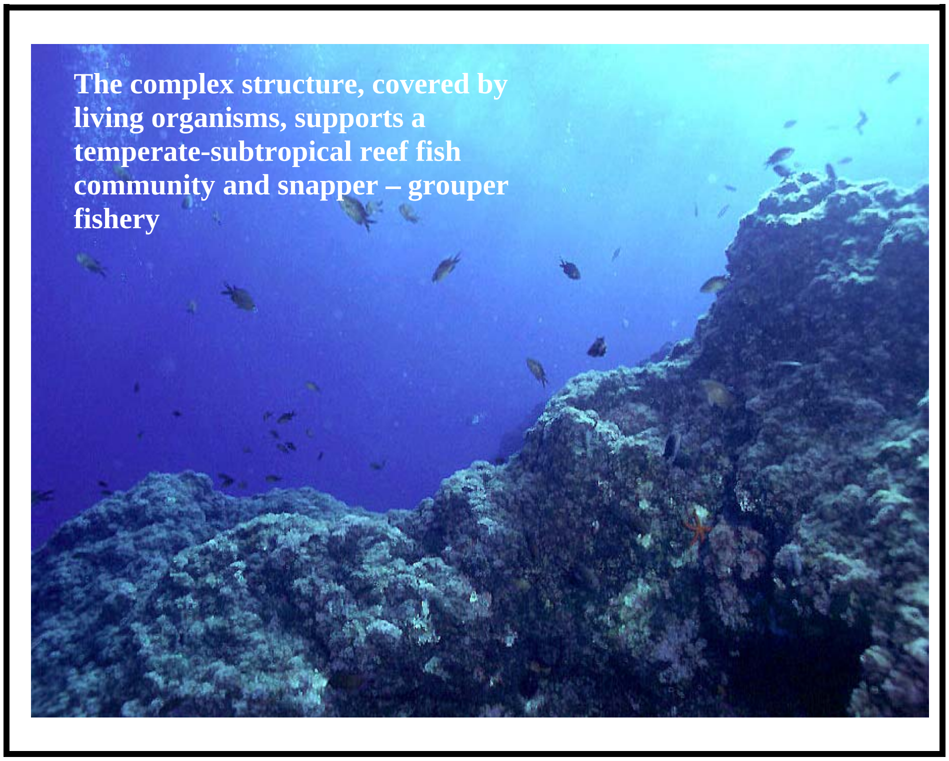
CHAPTER 7. HARD BOTTOM

7.1. DESCRIPTION AND DISTRIBUTION

Definition

Hard bottom refers to a classification of coral communities that occur in temperate, subtropical, and tropical regions that lack the coral diversity, density, and reef development of other types of coral communities (SAFMC 1998a). For the purposes of the CHPP, hard bottom habitat is defined as "exposed areas of rock or consolidated sediments, distinguished from surrounding unconsolidated sediments, which may or may not be characterized by a thin veneer of live or dead biota, generally located in the ocean rather than in the estuarine system."

Man-made structures, such as artificial reefs, wrecks, and jetties, provide additional suitable substrate for development of hard bottom communities. Artificial reefs are structures constructed or placed in waters for the purpose of enhancing fishery resources and providing opportunities for commercial and recreational fisheries. Although the purpose of artificial reef placement is primarily fishery enhancement, colonization of the structures by marine life results in establishment of hard bottom habitat. Vessels that have run aground or sunk and remain on the seafloor can also provide a base for hard bottom communities. These sites are separate from the DMF-managed artificial reef sites.



Description

Natural hard bottom varies in topographic relief from a relatively flat, smooth surface to a scarped ledge having up to 10 m of vertical, sloped, or stepped relief. The exposed areas of rock outcrop or relic reef are colonized to a varying extent by algae, sponges, soft coral, hard coral, bryozoans, polychaete worms, and tunicates, which in turn support a large diversity of fish (SAFMC 1998a). Hard bottom is also referred to as "live rock" or "live bottom" because of the abundance of live plants and invertebrates that typically attach to or bore into hard substrate. Erosion of the hard substrate through the long-term actions of colonizing organisms results in overhanging hard bottom ledges and undercut sloped scarps (Riggs et al. 1995). Rock outcrops, particularly those with low relief, can become buried and unburied by the natural processes of sand movement across the seafloor (SEAMAP-SA 2001). When hard substrate is exposed, a live bottom community may develop on the hard surfaces and persist for many years, later becoming covered by varying thicknesses of sand (SEAMAP-SA 2001). Areas of compacted or sheered mud and sediment also function as consolidated hard bottom (Riggs et al. 1995).

Artificial reefs can be constructed of many different materials. In North Carolina, surplus vessels, steel boxcars, concrete pipe, concrete rubble, boat molds, tires, and surplus military aircraft have been used for artificial reefs. In addition, concrete structures specifically designed and constructed to provide complex habitat (domes, igloos) are used by DMF. In total, artificial reefs provide roughly 2.75 million ft^2 (47 acres) of hard surface area (DMF 1995). This area is equivalent to approximately 2% of the natural hard bottom occurring in Raleigh and Onslow bays. The DMF Artificial Reef Program is responsible for deployment and maintenance of the sites, following the guidelines of the DMF Artificial Reef Master Plan (DMF 1988). In addition to the DMF's artificial reefs, the U.S. Army Corps of Engineers (COE) constructed a large artificial reef off the Cape Fear River, known as the Wilmington Offshore Fishery Enhancement Structure, using rock dredged during deepening of the Cape Fear River shipping channel. Comprised of approximately 800 barge-loads of rock and rubble piled in rows, this structure is currently being disrupted by relocation of the Cape Fear River shipping channel. The North Carolina Department of Cultural Resources, Underwater Archeology Unit, estimates there are more than 1,000 sunken vessels along the North Carolina coast dating from the days of the earliest European explorers to the present (<http://www.arch.dcr.state.nc.us/UW-LIGIT.HTM>, 2003). Documented wrecks include World War II German U-boats, gunboats, tankers, freighters, barges, and wooden and iron-hulled steamers. The abundance of shipwrecks off the North Carolina coast provides additional structure available as hard bottom habitat.

Jetties are man-made structures consisting of large boulders placed perpendicular to the shoreline, usually near inlets, for the primary purpose of stabilizing navigational channels. Because jetties emerge above the water line, they support both intertidal and subtidal hard bottom communities. Groins are similar to jetties, but are generally smaller. They may be constructed to stabilize a marina entrance or navigational channel or used as an erosion control device to trap sand and stabilize the shoreline. Community composition and fish utilization of jetties were described in Hay and Sutherland (1988) and are discussed in section 7.2, Ecological role and functions.

Habitat requirements

The primary requirement for this habitat is exposed hard substrate. Bottom water temperatures at hard bottom habitats in the ocean off North Carolina range from approximately 11 to 27º C. Salinity is generally around 35 ppt with little fluctuation. The composition of invertebrate, algal, and fish communities varies with temperature and depth. Although hard bottom is similar to other coral reef communities, the hard bottom community in warm-temperate regions such as North Carolina is physically stressed by changes in water masses and seasonal fluctuations in water temperature and light penetration (Kirby-Smith 1989). Because of this stress, hard coral and reef fish abundance and diversity in temperate hard bottom are limited and often vary by season.

Distribution

Hard bottom is the most widely distributed coral community in the South Atlantic Bight. It occurs in both warm-temperate and tropical areas, although it is less extensive in the northern end of its range (North Carolina). Along the south Atlantic states, hard bottom ranges from the shoreline and nearshore (within the state’s three-mile jurisdictional limit) to beyond the continental shelf edge (>200 m deep). It tends to occur in clusters across the shelf in specific areas (SEAMAP-SA 2001). Estimates of the percent cover of hard bottom vary greatly along the south Atlantic coast between Cape Canaveral and Cape Hatteras.

From Cape Hatteras to Cape Fear, it was estimated that approximately 14% (roughly 504,095 acres) of the bottom between 27 and 101 m water depth consisted of hard bottom; between Cape Fear and Cape Canaveral, 30% (roughly 1,829,321 acres) of the seafloor was hard bottom (Parker et al. 1983). Approximately 7–10% of the hard bottom habitat is estimated to be one meter or more in relief (Parker et al. 1983).

Hard bottom mapping

In 1985, the Southeast Area Monitoring and Assessment Program—South Atlantic (SEAMAP-SA) began a large-scale initiative to identify and map all known hard bottom and coral reef areas in the South Atlantic Bight. A final report and ArcView GIS CD were completed in 1998 and updated in 2001 (SEAMAP-SA 2001). The majority of the data used to identify hard bottom was based upon the relative presence of indicator species in traps or trawls or on sidescan sonar records (73%). The SEAMAP Bottom Mapping Workgroup identified 177 South Atlantic Bight reef species that indicate reef habitat. The remaining data came from video and diver observations. The majority of identified sites was located in federal waters off North Carolina (> three nautical miles (nm) from shore). Because of the ephemeral nature of low-relief hard bottoms (uncovered and covered by storm-induced shifting sands) and the difficulty of distinguishing soft bottom from low-relief hard bottom using seismic data, the amount of hard bottom habitat identified in this program was most likely an underestimate (SEAMAP-SA 2001).

Hard bottom and artificial reef sites identified by SEAMAP in both state and federal waters are shown in Map 7.1, along with some of the known wrecks. Hard bottom outcrops are most concentrated in Onslow and Long bays. In federal waters, concentrations occur offshore between Shallotte Inlet and the Cape Fear River. In Onslow Bay, hard bottom is most concentrated from Frying Pan Shoals north to Masonboro Inlet, from New Topsail Inlet to Brown's Inlet, and from Bogue Inlet east to Cape Lookout Shoals. In Raleigh Bay, there are two concentrations of hard bottom - one east of Lookout Shoals and another south of Diamond Shoals. Within North Carolina state territorial waters, using point data, the SEAMAP database identified 19 natural hard bottom sites and 16 possible hard bottom sites. In addition, line data from trawls identified 29 hard bottom sites and 59 possible sites.[79]

A follow-up study compiling hard bottom locations in the nearshore ocean waters of North Carolina identified additional sites not included in the SEAMAP-SA database (Map 7.1, Table 7.1) (Moser and Taylor 1995). The study relied on surveys of researchers, dive professionals, and fishermen. Some of these sites may be duplicates of those identified by SEAMAP-SA, due to different sources and slightly different coordinates. A total of 198 hard bottom positions was identified; some were point data, while others represented transects or areas. Over 92% of the identified hard bottom in North Carolina waters are south of Cape Lookout, particularly in the southern half of Onslow Bay and in northern Long Bay. Concentrations of hard bottom occur seaward of inlets, including Shallotte, Lockwood's Folly, New, Carolina Beach, Masonboro, New Topsail, New River, and Bogue inlets. There are outcrops of moderate-to-high relief in shallow water near the shoals of Cape Fear and Cape Lookout. Moser and Taylor (1995) estimated that the majority of the bottom in state territorial waters from 1) mid-Onslow Beach to south of New Inlet and 2) the area from Yaupon Beach west to Tubbs Inlet is comprised of hard bottom that is covered with a thin layer of sand.

[79] The lengths of the trawl lines vary, and some lines may actually represent several transects of one area. Similarly, some hard bottom lines may overlap with hard bottom points.

Table 7.1 Hard bottom and possible hard bottom locations in North Carolina by coastal bay. [Source: Point and line data identified by SEAMAP-SA (2001). Results from Moser and Taylor (1995) in parentheses.]

Bottom Type	Long Bay	Onslow Bay	Raleigh Bay	North of Hatteras	Total
Hard bottom (point)	2 (19)	14 (58)	1 (4)	2 (3)	19 (86)
Hard bottom (line)	3 (6)	25 (39)	1 (2)	0 (2)	29 (49)
Possible hard bottom (point)	1	8	3	4	16
Possible hard bottom (line)	5	37	12	5	59
Total	11 (25)	84 (97)	17 (6)	11 (5)	123 (135)

Twenty sites were reported as high-profile relief, defined by Moser and Taylor (1995) as vertical relief greater than two meters. Two of these sites, one off Carolina Beach and one off New River, are extensive in both area and topographic relief; these areas are particularly close to shore, making them more vulnerable to land-based, fishing, and boating-related impacts. A unique intertidal and subtidal coquina rock outcrop extends from the beach into the surf zone at Fort Fisher. This unique habitat supports a diversity of organisms such as starfish, anemones, sea urchins, crabs, octopi, and numerous fish species.

Distribution of man-made hard bottom

There are 11 artificial reefs of varying construction located in North Carolina State ocean waters, 28 in federal ocean waters (Map 7.1), and seven in estuarine waters. The estuarine artificial reefs are located in Pamlico Sound, Albemarle Sound, Neuse River, and Pamlico River. The artificial reef program periodically adds material to the 39 existing ocean sites, rather than creating new reefs. Gentile (1992) listed 46 documented wrecks in North Carolina waters south of Hatteras Inlet. The majority of the wrecks is located northeast and west of the mouth of the Cape Fear River (Map 7.1). There are many more wrecks in federal waters, with concentrations around the three cape shoals. There are also two jetty systems and three groin systems along the ocean shoreline. The groins are located on the south side of Oregon Inlet, off the former site of the Cape Hatteras Lighthouse, and at the west side of Beaufort Inlet. There is a single jetty at the west side of Cape Lookout; Masonboro Inlet has jetties on both sides–one attached to Wrightsville Beach and the other attached to Masonboro Island. The Little River Inlet, which is the state boundary between North and South Carolina, also has a dual jetty system, but both structures are located in South Carolina. There are also numerous small groins and jetty systems in estuarine waters, but these features have not been mapped.

For the purposes of this document, estuarine shell bottom (e.g., oyster reefs, beds, bars) is not categorized as hard bottom habitat. Although technically a "hard" substrate that shares some characteristics with hard bottom (e.g., three-dimensional structure), shell bottom differs in its formation, spatial distribution, function, and species composition from those of oceanic hard bottom; it is classified as a distinct habitat type[80]. In addition, shell bottom can be either inter- or subtidal, whereas hard bottom is typically subtidal (with the single exception of the exposed coquina outcrops near Fort Fisher).

7.2. ECOLOGICAL ROLE AND FUNCTIONS

Productivity

Exposed hard substrate (whether rock outcrops, jetties, artificial materials, or semi-compacted sediments) provides surface area for colonization by invertebrates and algae. Hard substrate with vertical relief or irregular surface areas provides more complex habitat, allowing a greater variety of species to coexist (Wenner et al. 1984). This "live bottom" structure, in turn, provides a source of abundant food and

[80] Refer to the Shell Bottom chapter (Chapter 3) .

protective cover for numerous fishes. These areas may be quite small and isolated and have been considered oases of productivity surrounded by less productive unconsolidated ocean bottom (SAFMC 1998a). The extent and diversity of colonization vary among sites due to topography, habitat diversity, currents, light availability, and location on the shelf. Studies that have documented the composition and diversity of the communities on hard bottom in North Carolina include MacIntyre and Pilkey (1969), Schneider (1976), Peckol and Searles (1984), Kirby-Smith (1989), and COE (1992). Most of the locations examined in these studies were located beyond the three-mile state boundary.

The dominant colonizing organisms on hard bottom in North Carolina are macroalgae (Peckol and Searles 1984), ranging from 10 to 70% of the biotic cover, and varying among seasons and years. Perennial and crustose brown and red algae were the dominant algal forms, including *Lobophora variegata*, *Lithophyllum subtenellum*, *Zonaria tournefortii*, and *Gracilaria mammillaris*. In nearshore waters (< one nm from shore), between Rich Inlet and Brown's Inlet, large amounts of seaweed grow on and between hard bottom areas during the summer. The algae consist of several types and species, including the brown algae, *Sargassum filipendula* and *Dictyopteris membranacea,* and the red algae, *Halymenia* sp. and *Gracilaria* sp. (DMF 2001d). Sargassum (*S. filipendula*) is common in nearshore and offshore waters, and on jetties. Hay and Sutherland (1988) documented several other species on jetties. Roughly 150 species of macroalgae were identified on hard bottom in North Carolina; the majority was red algae (Rhodophyta) (Schneider 1976). Onslow Bay had a higher diversity of species, which was attributed to more available hard substrate (Schneider 1976). The shallow inshore flora consisted of a large component of northern-distributed species, while offshore areas supported more tropical flora. Offshore areas had the greatest abundance of macroalgae, due to the high proportion of suitable substrate, greater relief on the shelf break, and mild water temperatures throughout the year. Of the offshore species, 66% were at their northern limit of distribution in Onslow Bay, and 2% were at their known southern distributional limit (Schneider 1976). The latter include *Arthrocladia villosa*, *Gigartina stellata*, and *Polysiphonia harveyi*. The presence of macroalgae from the shoreline to beyond the shelf break indicates that light and nutrient availability do not limit primary production on hard bottom off North Carolina (Cahoon and Cooke 1992).

Community structure

Non-mobile, attached invertebrates accounted for 10% or less of the biotic cover on hard bottom off North Carolina (Peckol and Searles 1984). The most abundant non-mobile invertebrates were the soft corals, *Titandeum frauenfeldii* and *Telesto fructiculosa,* and the hard coral, *Oculina arbuscula*. Sea urchins (*Arbacia punctulata* and *Lytechinus variegatus*) were the most common mobile invertebrates. Species composition of invertebrates occurring at hard bottom sites in South Carolina and Georgia were studied by Wenner et al. (1984). Study results using dredge and trawl samples showed that sponges, bryozoans, corals, and anemones[81] dominated the large macroinvertebrate collection in terms of numbers and species diversity during all seasons. Sponges were the most important invertebrate group overall on the inner shelf, comprising 60–78% of the total biomass. Tunicates, anthozoans, and mollusks also contributed substantially (Wenner et al. 1984). Species characteristic of the inner shelf sites included the sponges, *Homaxinella waltonsmithi, Spheciospongia vesparium, Cliona caribbaea*, and *Halichondria bowerbanki*; the echinoderms, variegated urchin (*Lytechinus variegatus*), purple sea urchin (*Arbacia punctuata*), *Encope michelini*, and *Ocnus pygmaeus*; the bryozoan, *Membranipora tenuis*; and the decapod crustacean, *Synalpheus minus*. Grab samples of small invertebrates showed that polychaetes were the most diverse and abundant group, followed by mollusks, and amphipods[82] (Wenner et al. 1984).

Kirby-Smith (1989) studied hard bottom communities at nearshore and offshore reefs in North Carolina. Community structure varied with season, depth, and distance from the shelf edge. Diversity and

[81] sponges (89 Porifera taxa); bryozoans (91 Bryozoa taxa); and corals and anemones (70 Cnidaria taxa)
[82] polychaetes (285 species, 72% of total individuals); mollusks (251 species, 4.3% of total individuals); and amphipods (100 species, 13% of total individuals)

abundance of invertebrates were greater in the spring and fall than in winter and summer, attributed to spring and fall plankton blooms. The inner shelf sites, in approximately 16–27 m water depths, had somewhat lower diversity than mid- or outer shelf sites. Mollusks, followed by polychaetes, and then amphipods were dominant in the number of observed species.

Due to cooler water temperatures and greater temperature fluctuations, the species composition of hard bottom communities in nearshore waters is less tropical in nature compared to that farther offshore or south of North Carolina (Kirby-Smith 1989). Furthermore, at natural and artificial reefs in Onslow Bay, seaweed species outcompeted a hard coral (*Oculina arbuscula*), limiting its growth and recruitment and largely restricting its distribution to deeper, poorly lit habitats via competitive exclusion (Miller and Hay 1996). Because of these conditions, hard bottom in North Carolina's state territorial sea is colonized by hard and soft corals to a lesser extent than offshore or more southern areas. Two species of reef building corals that have been documented on North Carolina hard bottom are *Solenastrea hyades* and *Siderastrea siderea*. These species occurred on rock outcrops at depths of 20 to 26 m in Onslow Bay approximately 32 km offshore (MacIntyre and Pilkey 1969). Other species of coral reported for North and South Carolina include the hard corals, ivory bush coral (*Oculina arbuscula*), *Oculina varicosa*, *Astrangia danae*, *Phyllangia americana*, *Balanophyllia floridana*, and the soft corals, sea whip (*Leptogorgia virgulata*), *Telesto* spp., *Lophogorgia* spp., *Titanideum frauenfeldii*, and *Muricea pendula* (Wenner et al. 1984; Hay and Sutherland 1988).

Ecosystem enhancement

In addition to providing habitat for an abundance of reef organisms and fish, hard bottoms, through bioerosion, are a source of sand production for sediment-starved sections of the continental shelf, such as Onslow and Long bays. Riggs et al. (1995) described three primary groups of bioeroders: rock boring bivalves, burrowing shrimp, and macroalgae. These animals and plants tend to occur in or on hard bottom of different hardnesses and slopes. Some species, like the rock boring bivalve *Jouanettia quillingi* and burrowing shrimp *Upogebia* sp., occur on muddy sandstones, while macroalgae tend to colonize Pleistocene limestone. The larvae of rock boring bivalves erode rock by excavating a hole chemically (through secretion of acid) or mechanically (through abrasion from their hard shell). Over time, multiple tunnels from clams eventually weaken the rock until chunks break off, leaving a fresh rock surface for more clam larvae to settle on and bore into. Macroalgae erode rock when their roots (holdfasts) are torn off the rock surface by storms and strong water currents, carrying away small pieces of rock. The decomposition of calcareous macroalgae plant material also produces sediment. Rates of sediment production from bioerosion increase with increasing softness of rock substrate, varying from 5.5 $kg/m^2/yr$ on vertical and sloped Miocene mudstone hard bottom, to 0.4 $kg/m^2/yr$ on vertical and sloped Pleistocene limestone, and 0.03 $kg/m^2/yr$ on flat Plio-Pleistocene limestone. These processes also enhance the structural complexity of the hard bottom outcrops, which promotes diversity of fish habitat within the reef (Riggs et al. 1995).

Fish utilization of natural hard bottom

Because of their structural complexity, more permanent nature, and high functional diversity, hard bottom areas of relatively high relief are particularly important to a variety of fish and invertebrate species. Fish comprise a major portion of the animal biomass on hard bottom, and they are an important component of the overall trophic structure (Jaap 1984). Numerous studies have examined fish assemblages on natural and artificial reef habitats in North Carolina (Huntsman and Manooch 1978; Miller and Richards 1980; Grimes et al. 1982; Lindquist et al. 1989; Potts and Hulbert 1994; Parker and Dixon 1998). With the exception of Hay and Sutherland (1988), who described fish utilization at jetties in North Carolina, all of these studies, including those at the inner shelf, were conducted seaward of state territorial waters. *Fish studies specific to nearshore hard bottom (within state territorial waters) are needed to better understand the dependence of fish species on this habitat.*

Natural hard bottoms off the Carolina coasts support large populations of offshore reef fish, temperate, and coastal pelagic species. In one study along the North and South Carolina coasts, 47 tropical and subtropical resident reef fish species were found on inshore hard bottom (<18 m water depth), and almost twice as many occurred farther offshore (18–110 m water depth). The fauna of hard bottom is characterized by wrasses, damselfish, snappers, grunts, parrotfish, and sea basses. Inshore hard bottom communities support large numbers of more temperate fish species, such as black sea bass (*Centropristis striata*), spottail pinfish (*Diplodus holbrookii*), and estuarine-dependent migratory species (Huntsman and Manooch 1978). A list of species reported for North and South Carolina inshore hard bottom is provided in Table 7.2.

Water temperature and topography are the most important factors in determining use of habitat by warm-temperate and tropical hard bottom species (Wenner et al. 1984; SAFMC 1998a). Temperatures less than 12º C may result in the death of some tropical fish and invertebrate species. Lindquist et al. (1989) reported 32 species at inner shelf hard bottom sites in North Carolina, approximately five miles from shore. Commonly occurring and numerically abundant species for both natural and artificial reefs were, in order of decreasing abundance:

- round scad (*Decapterus punctatus*)
- tomtate (*Haemulon aurolineatum*)
- spottail pinfish (*Diplodus holbrookii*)
- black sea bass (*Centropristis striata*)
- slippery dick (*Halichoeres bivittatus*)

Other common species included scup (*Stenotomus chrysops*), juvenile grunts, pigfish (*Orthopristis chrysoptera*), cubbyu (*Equetus umbrosus*), and belted sandfish (*Serranus sublgiarius*). Fish composition varied due to seasonal inshore migrations of tropical and subtropical species, fishing pressure, and microhabitat differences.

In general, most reef fish are carnivores (Jaap 1984). Benthic invertebrates are therefore very important as energy assimilators and food sources for reef fish (Jaap 1984). A partial list of the most important fish species that utilize hard bottom in North Carolina's state territorial waters and the function the habitat provides is given in Table 7.3.

Table 7.2. Fishes occurring at inshore hard bottom in North Carolina and South Carolina coastal waters. [Sources: Grimes et al. 1982; Powell and Robins 1998; DMF, unpub. data]

Family	**Scientific name**	**Common name**
Carcharhinidae	*Carcharhinus falciformis*	Silky shark
Muraenidae	*Gymnothorax nigromarginatus*	Blackedge moray
Ophichthidae	*Ophichthus ocellatus*	Palespotted eel
Engraulidae	*Anchoa* sp.	Anchovy
Synodontidae	*Synodus foetens*	Inshore lizardfish
	Trachinocephalus myops	Snakefish
Batrachoididae	*Opsanus pardus*	Leopard toadfish
Antennaridae	*Antennarius ocellatus*	Ocellated frogfish
Gadidae	*Urophycis earlii*	Carolina hake
Ophidiidae	*Rissola marginata*	Striped cusk-eel
Sygnathidae	*Hippocampus erectus*	Lined seahorse
	Sygnathus sp.	Pipefish
Serranidae	*Centropristis ocyurus*	Bank sea bass
	C. striata	Black sea bass
	Dermatolepis inermis	Marbled grouper
	Diplectrum formosum	Sand perch
	Epinephelus adscensionis	Rock hind
	E. drummondhayi	Speckled hind
	E. morio	Red grouper
	E. fulva	Coney
	E. guttatus	Red hind
	Mycteroperca microlepis	Gag
	M. phenax	Scamp
	M. venenosa	Yellowfin grouper
	Petrometopon cruenatatum	Graysby
	Serranus subligarius	Belted sandfish
Priacanthidae	*Pristigenys alta*	Short bigeye
	Priacanthus creuntatus	Glasseye snapper
Apogonidae	*Apogon pseudomaculatus*	Twospot cardinalfish
Pomatomidae	*Pomatomus saltatrix*	Bluefish
Carangidae	*Alectis crinitus*	African pompano
	Caranx ruber	Bar jack
Lutijanidae	*Lutjanus analis*	Mutton snapper
	L. campechanus	Red snapper
	L. griseus	Gray snapper
	Decapterus punctatus	Round scad
Pomadasyidae	*Haemulon aurolinearum*	Tomtate
	H. plumieri	White grunt
	Orthpristis chrysoptera	Pigfish
Sparidae	*Diplodus holbrookii*	Spottail pinfish
	Archosargus probatocephalus	Sheepshead
	Calamus leucosteus	Whitebone porgy
	Stenotomus chrysops	Scup
Sciaenidae	*Equetus umbrosus*	Cubbyu
	Cynoscion regalis	Weakfish
Labridae	*Haliochores bivittatus*	Slippery dick
Ephippidae	*Chaetodipterus faber*	Atlantic spadefish
Clinidae	*Paraclinus* sp.	Blennies
Gobiidae	*Ioglossus calliurus*	Blue goby
Bothidae	*Paralichthys dentatus*	Summer flounder
	Paralichthys lethostigma	Southern flounder

Table 7.3. Habitat utilization, stock status, and use of important fish species that occupy hard bottom areas in North Carolina's nearshore ocean waters.

Species*	Hard bottom Functions [1]					Fishery [2]	Stock status [3]
	Refuge	Spawning	Nursery	Foraging	Corridor		
MARINE SPAWNING, LOW - HIGH SALINITY NURSERY							
Atlantic croaker	X			X		X	C
Inshore lizardfish	X	X	X	X		X	
Southern kingfish	X			X		X	U
Spot	X			X		X	V
Striped mullet	X		X	X		X	C
Weakfish	X			X		X	V
MARINE SPAWNING, HIGH SALINITY NURSERY							
Black sea bass [4]	**X**	**X**	**X**	**X**	**X**	**X**	**O- south of Hatteras, V- north of Hatteras**
Bluefish	X			X		X	R
Damselfish (mult. spp.)	**X**	**X**	**X**	**X**			
Florida pompano	X			X		X	
Gag [4]	**X**		**X**	**X**	**X**	**X**	**V**
Gobies (multiple spp.)	**X**	**X**	**X**	**X**			
Gulf kingfish	X			X		X	U
King mackerel	X			X		X	V
Pigfish	**X**	**X**	**X**	**X**		**X**	
Planehead filefish	**X**	**X**	**X**	**X**			
Sand perch	X	X	X	X		X	
Scup [4]	**X**	**X**	**X**	**X**		**X**	**R**
Smooth dogfish	X			X		X	U
Spiny dogfish	X			X		X	O
Spottail pinfish	**X**	**X**	**X**	**X**		**X**	
Summer flounder	X			X		X	R
Tautog [4]	**X**		**X**	**X**	**X**	**X**	**O**
Wrasses (several species)	**X**	**X**	**X**	**X**			
MARINE REEF FISH COMPLEX							
Atlantic spadefish	**X**	**X**	**X**	**X**		**X**	C- reef fish complex as a whole in NC. Individual species have not been evaluated in NC.
Greater amberjack	X			X		X	
Round scad	**X**		**X**	**X**			
Sheepshead	**X**	**X**	**X**	**X**		**X**	
Tomtate	**X**	**X**	**X**	**X**		**X**	
White grunt	**X**	**X**	**X**	**X**		**X**	
Whitebone porgy	**X**		**X**	**X**		**X**	

* Scientific names listed in Appendix I. Names in **bold** font are species whose relative abundances have been reported in the literature as being generally higher in hard bottom than in other habitats. Note that lack of bolding does not imply non-selective use of the habitat, just a lack of information.

[1] Powell and Robins 1998; Grimes et al. 1982; F. Rohde, DMF pers. com. 2003

[2] Commercially or recreationally caught species. Other species are important to the ecosystem as prey

[3] V = Viable, R = Recovering, C = Concern, O = Overfished, U = Unknown (DMF 2003).

[4] Part of the reef fish complex but evaluated separately by DMF for stock status

Refuge and foraging

Hard bottom provides protective cover and foraging areas for an abundance of organisms, supporting high fish productivity. Nearshore hard bottom habitats can support over thirty times as many individuals per transect as natural sand habitats (Lindeman 1997). Consequently, natural reefs can sustain greater fish stocks (270 to 5,279 kg/ha) compared to non-reef open shelf bottom (6.3 to 46.3 kg/ha) (Huntsman 1979). In general, natural and artificial reefs support similar fish species assemblages (Ambrose and Swarbrick 1989). The abundance of fish on hard bottom and artificial reefs is related to the amount and type of structural complexity of the reef (Potts and Hulbert 1994; Carr and Hixon 1997). Rocky structures that have more available complex space resources consistently supported a more abundant and diverse resident fish community than less complex structures. In addition, multiple small hard bottom areas surrounded by sand habitat supported greater fish abundance and diversity than one large area of equal material, suggesting the importance of habitat variety to overall ecosystem quality (Bohnsack et al. 1994; Auster and Langton 1999). This research suggests that artificial refugia would be beneficial for enhancement of fish productivity and ecosystem value. An artificial refugia site is an artificial reef that is designated as a no-take area, to provide unfished habitat to aid in stock recovery, conduct research, and test effectiveness of enforcement. *Construction of artificial refugia (no-take artificial reefs) or designation of existing artificial reefs as refugia (no-take, Marine Protected Areas) should be considered to enhance fisheries productivity.*

Spawning

Hard bottom provides not only refuge and foraging areas, but also spawning areas. Most reef fish spawn in aggregations in the water column above the reef, and the eggs remain planktonic during development (Jaap 1984). The timing of egg release is often triggered by dusk, night, or the tides, probably to reduce risk from predation. Nearshore hard bottom has been identified as a spawning site for some reef species. Species known to spawn on nearshore hard bottom include black sea bass (*Centropristis striata*) and sand perch (*Diplectrum formosum*) between January and June (Powell and Robins 1998). Sheepshead (*Archosargus probatocephalus*), Atlantic spadefish (*Chaetodipterus faber*), seaweed blenny (*Parablennius marmoreus*), inshore lizardfish (*Synodus foetens*), and several species of damselfish, wrasses, and gobies (*Ioglossus calliurus* and others) are also thought to spawn on inshore hard bottom (F. Rohde, DMF, pers. com., 2001). *More research is needed concerning spawning on, and recruitment to, nearshore hard bottom to understand the importance of this habitat and document trends in fish utilization.*

Nursery

Nearshore and inner shelf hard bottom areas serve as important settlement and nursery habitat for immigrating larvae of many important fisheries species. Powell and Robbins (1998) collected larvae from 22 reef-associated families adjacent to hard bottom habitat in Onslow Bay. Planehead filefish, *Monacanthus hispidus*; the blenny, *Parablennius marmoreus*; the goby, *Loglossus calliurus*; tomtate; white grunt; snappers including vermilion snapper, *Rhomboplites aurorubens*; black sea bass; bank sea bass; sand perch; spottail pinfish; and whitebone porgy were commonly collected. These species are thought to have been spawned in Onslow Bay in somewhat deeper water and recruited locally to nearshore hard bottom (Powell and Robins 1998). Additional species that are not generally reef-associated were also collected adjacent to hard bottom, including estuarine-dependent and oceanic species. It is unclear how planktonic larvae recruit to hard bottom habitat, except that recruitment is dependent on water circulation patterns transporting larvae to suitable habitat (Jaap 1984). Hard bottom habitat with vertical relief provides a variety of microhabitats, allowing a diversity of fish to recruit to the structure. Higher food availability in structure-rich hard bottoms, as well as properly managed artificial reefs, may result in increased growth rates, as well as increased survival.

Nearshore hard bottom also serves as intermediate nursery habitat for late juveniles emigrating out of the estuaries (Lindeman and Snyder 1999). In North Carolina, this group of fishes includes black sea bass, gag, red grouper, sheepshead, Atlantic spadefish, bank sea bass, and gray snapper, which are estuarine-dependent as early juveniles, moving offshore to hard bottom habitat as older juveniles. Juvenile red snapper and mutton snapper have also been documented in North Carolina's estuaries to a lesser extent (DMF, unpub. data). Species migrating offshore benefit from structure-rich hard bottom by using it for refuge from predators and foraging on the high abundance of invertebrates and macroalgae. Lindeman and Snyder (1999) found that over 80% of the individual fish at hard bottom sites on the southeast coast of Florida were early life stages. The study documented more than 20 species of newly settled stages, including several species of grunts and snappers. In North Carolina, the patchy distribution and limited extent of hard bottom suggest that habitat availability may limit survival of early stages of reef fish, giving available hard bottom habitat particularly high value (P. Parker, NMFS, pers. com., 2002).

Fish utilization of man-made structures

The composition and density of fish at artificial reefs tend to be similar to those at natural hard bottom sites when occurring in similar environmental conditions (Huntsman and Manooch 1978; Miller and Richards 1980; Bohnsack et al. 1994; Potts and Hulbert 1994). Studies comparing fish utilization of shipwrecks and artificial reefs of various designs found that all structures supported similar species composition (Stephan and Lindquist 1989). Species composition, relative abundance, and catch-per-unit-effort (CPUE) on artificial reef sites are documented periodically by DMF (DMF 1998; DMF 2002). In 1997, an assessment of the effectiveness of differently constructed artificial reefs found species assemblages to be similar on reefs composed of concrete pipes, cans, or domes. However, the assessment also found that CPUE was 71 – 85% greater on natural reefs than nearby artificial reefs (DMF 1998), possibly because natural hard bottom habitat is inherently more complex than artificial structures.

DEMERSAL SPECIES

<u>Inshore reefs (< 30 m depth)</u>

Pinfish
Pigfish
Black sea bass
Longspine porgy
Whitebone porgy
Tomtate
Tautog
Atlantic spadefish
Sheepshead
Weakfish
Flounders
Spot
Atlantic croaker
Kingfish
White grunt

<u>Offshore reefs (> 30 m depth)</u>

Groupers
Porgies
Triggerfish
Snappers

PELAGIC SPECIES

<u>Inshore reefs (< 30 m depth)</u>

Amberjacks
Barracuda
Bluefish
Bonito
Cobia
King mackerel

<u>Offshore reefs (> 30 m depth)</u>

Dolphin
Sailfish
Wahoo
Yellowfin tuna

Jetties offer some of the same habitat functions for fishery resources that natural hard bottoms and artificial reefs provide. The hard surface and irregular relief of the rocks provide shelter and food for the colonized plants and animals, which, in turn, serve as prey for higher order invertebrates and fishes. Hay and Sutherland (1988) described fish composition at jetties in North Carolina and South Carolina as a subset of those fish found on offshore hard bottoms and estuarine oyster reefs. The majority of fish moved to deeper water in the winter, gradually returning to inshore habitats as waters warmed in spring. The abundance of *Sparidae* species, such as pinfish, spottail pinfish, and sheepshead, was positively correlated with vegetative cover on the hard bottom. Hay and Sutherland (1988) categorized five general fish groups:

- Small cryptic resident fish, such as blennies and gobies;
- Numerically dominant species that migrate offshore in colder months, such as pinfish, spottail pinfish, black sea bass, and pigfish;
- Predatory pelagic species, such as bluefish, and Spanish and king mackerels;
- Fish attracted to jetties during their northerly migration in spring or southerly migration in fall, such as smooth dogfish (*Mustelus canis*); and
- Tropical species that occur as strays during warmer months, such as butterflyfishes (Chaetodontidae) and sergeant majors (*Abudefduf saxatilis*).

Although jetties provide habitat for some fish, the species that utilize them do not require jetties for survival since they are attracted from other existing natural habitats, such as hard bottom and estuarine oyster reefs. Because of impacts of these artificial structures on intertidal beach and water column functions[83], oceanfront jetties should not be considered as a habitat enhancement tool.

7.3. STATUS AND TRENDS

Status of hard bottom habitat

The condition of this habitat is of particular importance to estuarine-dependent snapper-grouper species that utilize North Carolina's shallow hard bottom habitat as "way stations" or protective stopping points as they emigrate offshore to deeper hard bottom. Protection of the shallow hard bottom habitat in state territorial waters is essential for successful protection of the estuarine-dependent snapper-grouper species and the associated fisheries that primarily occur on hard bottom in federal waters. The offshore snapper-grouper fishery is of great importance to North Carolina's commercial and recreational fisheries because of the market value of the fish, the number of recreational participants, and the associated businesses it supports. The snapper-grouper fishery had an annual market value of $3.6 million between 1992 and 2001 (DMF, unpub. data). For the years 1997–2001, DMF and NMFS records show 10,817 trips annually by private and charter boats and another 1,049 by headboats.

Nearshore reefs, although adversely impacted to various degrees by man, are in good condition overall (SAFMC 1998b). Good information exists on the distribution of hard bottom (Moser and Taylor 1995; SEAMAP-SA 2001). However, there is very little information available to evaluate the status and trends of hard bottom habitat in North Carolina state territorial waters. Anecdotal information from fishermen and local residents in New Hanover County suggests that nearshore hard bottom sites in the 1960s and earlier are now completely covered in sand, and that the abundance of fish along the shore and nearshore areas is much reduced.

Status of associated fishery stocks

Reef fish harvested commercially or recreationally are managed collectively as the reef fish complex or Snapper-Grouper management unit. There are 73 species in this complex, including snappers, groupers, sea bass, porgies, triggerfishes, grunts, jacks, and others. Only some of these species are found on North Carolina's nearshore hard bottoms. Information is available on the status of many reef fish species through federal, state, and interstate stock assessments. Fishery-dependent data are collected on reef fish by DMF's Offshore Live Bottom Fishery Program (DMF biological database program 438/448). Fishery-independent status and trends data on reef fish are also available for a portion of North Carolina from the

[83] see Water Column (2.0) and Soft Bottom (6.0) chapters

Marine Resources Monitoring, Assessment, and Prediction Program (MARMAP) conducted by the South Carolina Department of Natural Resources (SCDNR). This program has conducted standardized groundfish (bottom fish) surveys since 1973 utilizing a variety of fishing gears. Since 1983, surveys have been conducted using fish traps and long lines from Cape Lookout south to Ft. Pierce, Florida. Sampling occurs on mid-shelf live bottom and shelf-edge reef habitats in water from 16 m to more than 92 m deep. Species composition, fish length, and fish weight are recorded to determine community structure, biomass estimates, distribution, and relative abundance of the more abundant species. In addition, CPUE is calculated for vermilion snapper, red porgy, white grunt, gray triggerfish, and black sea bass (SCDNR, unpub. data). Although sampling occurs seaward of state waters, this program provides valuable information for state and federal stock assessments of reef fish, including species that utilize nearshore hard bottom and estuarine waters in North Carolina.

Most major South Atlantic reef fish stocks are considered fully utilized or over-utilized (NMFS 2002). Of 73 managed species in the South Atlantic Snapper-Grouper management unit, including black sea bass, 14 species were classified as Overfished in 2001 by the NMFS, nine were not Overfished, and 50 were Unknown (NMFS 2002).[84] Red porgy, speckled hind, red snapper, and snowy grouper are a few of the reef species classified as Overfished that occur in North Carolina.

In North Carolina, the reef fish complex as a whole was classified as Concern by DMF in 2002 (DMF 2003a). For stock status of individual reef species, DMF defers to SAFMC. Of the twelve fishery stocks listed in Table 7.3 that are highly associated with inshore hard bottom in North Carolina, six stocks have been evaluated by DMF. Two stocks were reported as Overfished (tautog and black sea bass south of Hatteras), one was Recovering (scup), two were Viable (gag and black sea bass north of Hatteras) and the reef fish complex was reported as Concern (Figure 7.1). The reef fish complex includes numerous individual species, of which at least ten species are common in North Carolina. SAFMC evaluates many of the species within the complex individually, and has reported some as overfished and others as viable. However, DMF has reported the complex as a whole to be of Concern, unless individually evaluated. Gag was upgraded by DMF in 2002 from the Overfished category to Viable. Black sea bass north of Cape Hatteras was upgraded from Overfished to Viable, based on the Northeast Fishery Science Center spring survey. Black sea bass south of Cape Hatteras was downgraded to Overfished based on the SAFMC stock assessment, which indicated low spawning stock biomass and heavy fishing exploitation. Approximately 74% of black sea bass landed in North Carolina are caught south of Hatteras.

[84] Overfished is defined as “a stock size was below a prescribed biomass threshold” (NMFS 2002) and Unknown is defined as “no recent assessment was conducted or insufficient information about this stock exists to make a determination” (NMFS 2003).

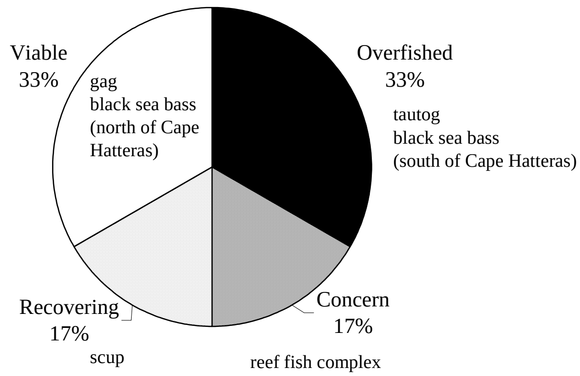


Figure 7.1. Percent of hard bottom associated fish stocks classified as Overfished, Concern, Recovering, or Viable in the 2003 DMF Stock Status Report. Individual species in the reef fish complex and common to North Carolina are listed in Table 7.3.

Although most of the overfished species are caught primarily in federal waters, many are highly dependent on the shallow hard bottom habitat in state waters as primary and secondary nursery areas. The status of gag and black sea bass is particularly important because they are highly dependent on nearshore hard bottom and estuarine habitats as primary and secondary nursery areas and for providing migratory corridors as species move offshore as individuals age. The apparent vulnerability of reef species to overfishing is attributed to their long lives, slow growth, ease of capture, large size, and delayed sexual maturity. *The MFC should consider designating inshore hard bottoms (within State Territorial Seas) as Strategic Habitat Areas because of their importance as secondary nursery habitats and migratory corridors for black sea bass, gag, and other reef fish species.*

Because of concern for the overfished status of major stocks of the snapper-grouper complex and failure of those stocks to adequately recover despite extensive changes in fishing regulations, the SAFMC is considering establishment of Marine Protected Areas (MPAs) in the south Atlantic area. The primary purposes for MPA designation by the Council would be to protect important known grouper spawning aggregations and prevent overfishing, particularly for deepwater species. One deepwater site is currently being considered in federal waters off North Carolina in Onslow Bay, east of Cape Fear. A shallow water site near Cape Lookout has been proposed as an artificial refugia location. An artificial refugia site is an artificial reef that is designated as a no-take area, to provide unfished habitat to aid in stock recovery, to conduct research, and to test effectiveness of enforcement. *Within this area, program sponsors should construct numerous small complex sites surrounded by open areas to mimic natural nearshore hard bottoms and maximize habitat utilization.*

Overfished stocks can be particularly vulnerable to changes in the quantity or quality of habitat. While some research in Florida has indicated that habitat is not limiting and reef fish population is controlled primarily by recruitment success (Bohnsack 1996; Grossman et al. 1997), these studies may not be applicable to North Carolina, where hard bottom is much less abundant. In North Carolina, there appears to be a direct relationship between the amount of hard bottom and the number of reef fish. Of the three bays in North Carolina, Onslow Bay has more hard bottom than Long Bay or Raleigh Bay and also has the greatest amount of reef fish (P. Parker, NMFS, pers. com., 2002). This relationship implies that increased habitat quantity would result in more or larger populations of reef fish. *Field experiments using* *a Before-After-Control-Impact Paired Series (BACIPS) design may be able to compare differences in fish abundance between undisturbed reefs (control sites) and areas with recently-added artificial structure (experimental sites) (Osenberg et al. 2002).*

Hard bottom restoration

Artificial reefs can potentially enhance fish production by increasing foraging, spawning, and refuge habitat (Grossman et al. 1997). However, there is some concern among fishery scientists that the structures may only concentrate available biomass rather than increase regional productivity (Carr and Hixon 1997). Artificial reefs are most effective at increasing production where reef habitat is limiting, when fishing effort is low, and when a large stock reservoir exists (Bohnsack 1996; Grossman et al. 1997). However, the results of studies attempting to determine if habitat is limiting are mixed. Although coral-eating fishes have been shown to decrease in abundance with decreasing live coral coverage, a similar relationship with fish-eating fishes, such as snappers and groupers, has not been observed (Grossman et al. 1997). The latter group is the more common type of reef fish in North Carolina and the primary target of anglers.

Artificial reefs must be properly designed, sited, and managed to successfully increase production of benthic (bottom-dwelling organisms) biomass and fish populations (DMF 1988). If habitat is limiting, artificial reefs that are not marked for fishing exploitation could serve as artificial refugia, providing beneficial habitat functions that could enhance local populations of reef fishes. Also, small complex structures that mimic natural hard bottom may be better for overall recruitment and enhance juvenile habitat and survival, while larger structures may be better for attracting large predators and enhancing fishing (Bohnsack et al. 1994). One ongoing problem that the DMF has experienced with artificial reefs is the failure of some designs to remain assembled and in position. Early reefs composed of tires have broken apart during storms, and the tires have washed up on beaches and obstructed commercial fishing trawls. More recent artificial reefs constructed of concrete and pipes appear to remain in position as designed (DMF 1995). The DMF Artificial Reef Master Plan provides recommendations for design and siting of artificial reefs (DMF 1988). Some of the recommendations that pertain to habitat enhancement include:

- Materials used should not be toxic to the environment;
- Materials used must be stable and durable;
- Materials used should provide the degree of habitat complexity and profile appropriate for the targeted reef species;
- Artificial reefs should be designed to increase surface area and interstitial space by addition of rock, concrete, or other suitable materials to barges and stripped vessels that lack structural complexity;
- Trolling alleys, reef clusters, and reef sanctuaries should be incorporated into reef complex designs;
- Artificial reefs should not be sited where natural hard bottom exists, in high-energy environments, or where traditional commercial fishing activities occur;
- Enhancement of existing artificial reef sites should be a higher priority than construction of new artificial reef sites;
- If artificial reefs are used to replace natural reef habitat that has been damaged or destroyed, they should be designed and constructed to provide proven biologically productive habitat.

High numerical abundance of fish may not necessarily be associated with increased production, survivorship, or species richness. The attraction-production debate regarding artificial reef fish assemblages is not yet resolved (Bohnsack 1989; Pickering and Whitmarsh 1996; Carr and Hixon 1997; Rilov and Benayahu 2000). *Additional research is needed to determine if and to what extent artificial reefs in North Carolina simply concentrate available fish or effectively increase fish biomass.*

7.4. THREATS AND MANAGEMENT NEEDS

Dredging and beach nourishment

In evaluating habitat condition for the snapper-grouper fishery, SAFMC concluded that dredging near or on hard bottom is potentially the most damaging physical human activity to this habitat (SAFMC 1998b). Dredging can be associated with creation or modification to navigational channels, or removal of sediment for beach nourishment projects. Dredging impacts to hard bottom habitat include the following (SAFMC 1998b):

- Dislocation of corals or colonized rock (live rock) and cuts through live tissue that lead to infection or mortality;
- Sedimentation that stresses corals and other sessile invertebrates, causing mortality if the deposited sediment can not be displaced, which in turn may also displace reef fishes;
- Elevated turbidity for extended periods may continue to stress hard bottom organisms, potentially decreasing survival over time;
- Movement of fill material from beaches by waves and currents can result in increased turbidity at and sedimentation on nearby hard bottom sites.

At beach nourishment projects in Florida, added sand was transported offshore from the beach by cross-shelf currents, covering hard bottom habitat (Marsh and Turbeville 1981; Lindeman and Snyder 1999). Studies off Wrightsville Beach and Atlantic Beach demonstrated how sediment was transported from the nourished beaches across the shoreface in southeastern and central North Carolina waters (Thieler et al. 1995; Thieler et al. 1998; Reed and Wells 2000). Hard bottom was observed to be buried by nourishment sands in the Wrightsville Beach area (R. Thieler, USGS, pers. com., 2001). Commercial fishermen in the Wrightsville Beach area, where beach nourishment has been conducted regularly since the 1960s, reported that nearshore hard bottom areas that were once productive fishing areas are now covered in sand (public comment at SAFMC public meeting on MPAs, Wrightsville Beach, 2001; B. Cleary, UNC-W, pers. com., 2001). These areas are no longer fished due to poor yield. In Florida, Lindeman and Snyder (1999) observed dramatic decreases in numerical abundance of fish species and individuals following the burial of hard bottom habitat via sand transported from an augmented beach. The cumulative number of species detected 12 months prior to and 15 months after site burial decreased by nearly one order of magnitude, from 54 to eight species, respectively (Lindeman and Snyder 1999). The average number of individual fish recorded per transect also declined, from 38 (pre-burial) to less than one (post-burial) (Lindeman and Snyder 1999). Side-scan monitoring was conducted off South Carolina to look at the effect of Myrtle Beach nourishment projects on nearshore hard bottom. Little to moderate change in percent of seafloor with exposed hard bottom or rocky substrate was observed at most sites within two years of the project's completion (Ojeda et al. 2001). Two areas immediately seaward of the nourished beach showed a 20% net loss of hard bottom. This loss was offset by a net gain in hard bottom habitat of about 10% in another area, due to local redistribution of sand. Available data from the study indicated that the nearshore loss of hard bottom seaward of the project was due to localized introduction of new sand from beach fill, but was only somewhat greater than the natural variability occurring from shifting sands (Ojeda et al. 2001).

Dredging large navigation channels through ocean bottom is limited to the entrance channels leading to North Carolina's state ports in Wilmington on the Cape Fear River and in Morehead City on the Morehead City channel. The dredged channels in the ocean lead into the Cape Fear and Beaufort inlets, respectively. Hard bottom is located in close proximity to the Wilmington channel. In 2002, the navigation channel was rerouted as part of a project to deepen the river channel and port and create a new offshore dredge material disposal site. The proposed route was altered to avoid dredging through hard bottom (F. Rohde, DMF, pers. com., 2002). Dredging and stabilization of other inlets can also potentially impact hard bottom when these activities occur close to shore, such as at New River, Masonboro, or Shallotte inlets. Turbidity and sedimentation associated with dredging may also have indirect effects on hard bottom in the vicinity of dredge sites.

In North Carolina, the frequency and magnitude of beach nourishment have increased over time.[85] If all requested and proposed projects are eventually authorized and conducted, a maximum of 155 miles (48% of ocean shoreline) could be affected and potentially degraded, excluding the beaches nourished periodically from channel and inlet dredging. All of the existing projects and the majority of the newly authorized projects are located south of Cape Lookout where hard bottom is most abundant, especially in the nearshore area. *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 DENR Beach Management Plan should be developed and implemented which includes specific guidelines to minimize impacts to hard bottom from nourishment projects.*

Fishing and diving

<u>Commercial fishing</u>

Bottom longlines, dredges, fish traps, and bottom trawls can cause rapid and extensive physical damage to living and non-living components of hard bottom (SAFMC 1998b). In a comparative analysis of benthic fishing activities, the largest relative declines in benthic species richness and total numbers of individuals were associated with intertidal dredging (Collie et al. 2000). Fishing gear dragged across the bottom causes direct damage and mortality by breaking attached benthic organisms, such as sponges, anemones, and corals, or outcrop structures from the seafloor. Damage is especially extensive where the bottom is uneven and there is a concentration of coral and other invertebrates. The removal of structure and attached benthic organisms decreases species diversity and reduces structural complexity of hard bottom (Watling and Norse 1998). Dragged gear also indirectly damages bottom habitat by increasing the vulnerability of injured organisms to subsequent diseases and predation, smothering invertebrates with sediment (Auster and Langton 1999), and partially or completely destroying burrows and tubes constructed by invertebrates (Watling and Norse 1998). Trawling also results in an immediate reduction of mobile benthic invertebrates (e.g., crabs and polychaete worms) on and adjacent to hard bottom, reducing food resources available to other reef organisms.[86]

Roller-rigged trawls are a specific type of trawl with large rubber discs that is designed to roll over hard bottom habitat without becoming entangled. A study in South Carolina on the effects of roller-rigged trawls found that 32% of the sponges, 30% of the hard corals, and 4% of the soft corals at a hard bottom site were damaged by a single tow (Van Dolah et al. 1987). Damaged individuals require years to completely regenerate to their initial, pre-disturbance sizes, due to the organisms' slow growth rates (Van Dolah et al. 1987). Another study evaluated impacts from a roller-framed shrimp trawl and found that 50% of the sponges, 80% of the hard corals, and 40% of the soft corals were damaged (Tilmant 1979). In addition, catch rates of all animal groups declined over a five-year period; fewer animals may have been available to be caught due to past trawling effort.

Of the fishing gears that can potentially damage hard bottom, longlines, dredges, and fish traps are of minimal concern because they are used little or not at all in North Carolina state waters. There is currently no active dredge fishery in North Carolina's intertidal or subtidal ocean waters. Use of bottom longlines was prohibited by federal regulations in depths of less than 50 fathoms (300 ft) throughout the South Atlantic area as part of Amendment 4 of the Snapper Grouper Fishery Management Plan in 1991 to reduce fishing mortality and habitat damage. Fish traps can cause significant damage if placed on or dragged through hard bottom. However, federal regulations (Amendment 4, Snapper-Grouper Fishery Management Plan) prohibited the use of large fish traps in 1991. Smaller sea bass pots are allowed if equipped with escape vents and biodegradable panels to release undersize fish and eliminate waste from

[85] Refer to the soft bottom threats section for status, trends, and location of beach nourishment activity, Map 6.2.
[86] Refer to Appendix L for a list of the fishing gears used in North Carolina waters and their probable habitat impacts.

lost pots ("ghost fishing"). Only a relatively small number of black sea bass pots are placed in state territorial waters. Between 1994 and 2000, the total number of fish pot trips in state territorial waters ranged from 40 to 94 (DMF, unpub. data). Fish pots are more commonly used in federal waters and may have a greater impact to hard bottom in those areas.

Bottom trawling is conducted in North Carolina state ocean waters extensively for shrimp and to a lesser extent for flounder. Shrimp trawl effort in the ocean is most concentrated in the southern district of North Carolina (Onslow, Pender, New Hanover, and Brunswick counties), where hard bottom is most abundant (Figure 7.2). Flounder trawling in the ocean occurs in the northern (Currituck, Dare, Hyde counties) and central (Carteret County) districts, primarily north of Cape Hatteras. The number of flounder trawl trips during 1994–2000 has ranged from 49 to 204 trips/year, while the number of shrimp trawl trips has ranged from 2,500 to 3,500 trips/year (DMF, unpub. data). The extent that trawls contact and damage hard bottom in North Carolina is not known. Because the irregular hard surfaces of hard bottom can tear nets and damage expensive gear, fishermen generally try to avoid those areas. Roller-rigged trawls have been prohibited by federal regulations for targeting snapper-grouper since 1989. In addition, ocean trawling is prohibited within one-half mile of the ocean shoreline from Oregon Inlet north to the Virginia border [MFC rule 15A NCAC 3J.0202]. Trawling is also restricted in many other areas, as provided by MFC rules (MFC 2001). *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.*

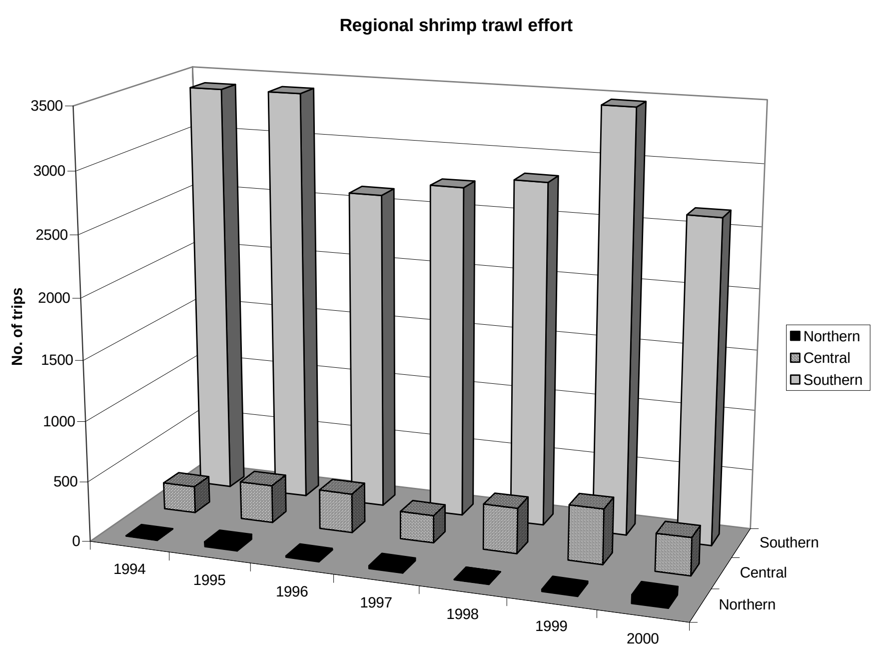


Figure 7.2a. Shrimp and flounder trawl fishing effort (number of trips) in North Carolina's nearshore ocean waters (0-3 miles from shore), 1994–2000, by coastal region. [Source: DMF, unpub. data]

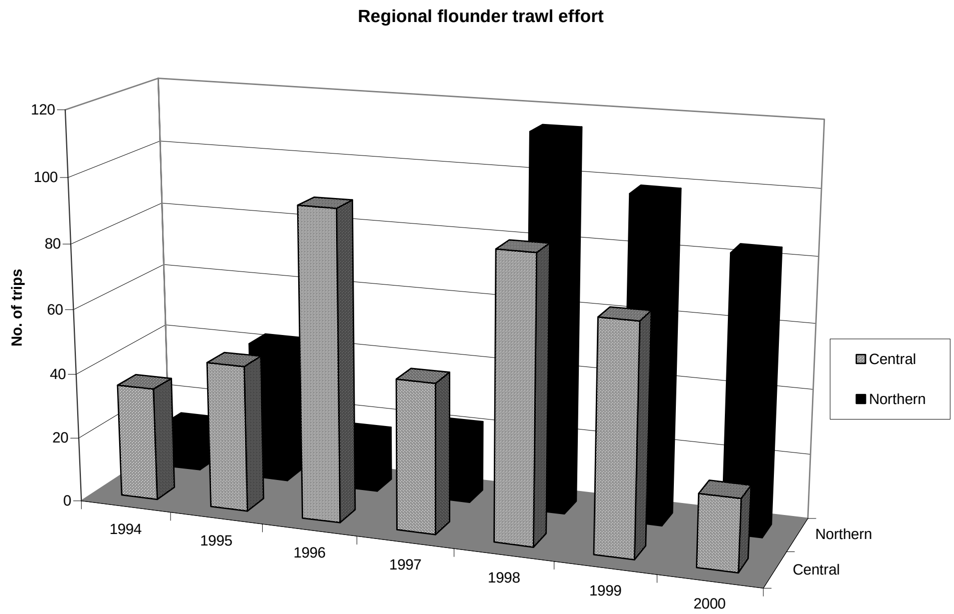


Figure 7.2b. Shrimp and flounder trawl fishing effort (number of trips) in North Carolina's nearshore ocean waters (0-3 miles from shore), 1994–2000, by coastal region. [Source: DMF, unpub. data]

Recreational fishing

Direct impacts of hook and line gear on hard bottom habitat are considered low. Recreational fishing was identified at a NMFS conference as a major concern because of the large number of participants in the fishery (Hamilton 2000). There were more than six million sport fishing trips in coastal North Carolina in 2001, including more than 500,000 by private boats and charter boats in the ocean. Federal headboat survey data indicate that, additionally, there were more than 1,000 headboat fishing trips in North Carolina's ocean waters south of Cape Hatteras during 2001, involving about 32,000 angler-days (R. Dixon, NMFS, pers. com., 2002). Hard bottom and artificial reef species are targeted by many recreational fishermen, and may receive concentrated use, leading to unknown cumulative impacts. Anchors and chains from recreational or commercial boats can break corals and other organisms and create lesions, leading to infection (SAFMC 1998b). In addition to habitat damage caused by anchors and chains, lost fishing gear (e.g., line, wire leaders, hooks, sinkers) and discarded rubbish (especially plastics) can entangle or be ingested by marine life, including bottom dwelling organisms. Roughly 52% of marine debris identified in U.S. waters originated from recreational vessels (UNESCO 1994). Chemical contamination from lost lead sinkers is also a concern. *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.* Finally, overfishing of large reef fish predators can indirectly damage hard bottom habitat by creating an imbalance of trophic structure, reducing the quality and productivity of the habitat (NMFS 1999). *This issue is best addressed through fishery management plans, rather than the CHPP process.*

Recreational diving

Diving activities can also damage hard bottom. Divers can kick or overturn corals and live rock, which results in habitat damage. Harvest of live rock for the aquarium trade was found to cause extensive destruction and loss of hard bottom, with additional damage when chemicals were used (SAFMC 1998b). The MFC prohibits harvest or possession of coral or live rock [MFC rule 15A NCAC 3I .0116]. The

Carteret County area has been rated as one of the premier offshore diving areas in the United States, especially for wreck diving. Recreational spearfishing with power heads has damaged corals where diving activity was concentrated. In North Carolina, however, damage from diving activity is probably minimal due to the relatively low numbers of divers in the inshore areas.

Infrastructure

A relatively new threat to hard bottom comes from the installation or maintenance of fiber optic cables and pipelines placed across oceans and waterways. Cables are increasingly used to transmit telecommunications over long distances and pipelines are used to transport gas products. Since 1988 when the first fiber optic cable was laid across the Atlantic Ocean, an estimated 230,000 miles of oceanic cable have been installed (Nero 2001). Fiber optic cables are generally laid directly on the seafloor, and routed into a dredged or bored trench, conduit, or access hole where the cable comes onshore (landing site). Once the access hole or conduit is in place and buried, maintenance or placement of new cables involve dredging these holes back open. While cables are currently being placed under estuarine and inland waters as part of a combined natural gas pipeline and cable project, there are no fiber optic cables located in the ocean off North Carolina at this time (<http://www.telegeography.com/products/map_cable/index.php>, August 2004).

Environmental concerns to hard bottom associated with laying cables or pipelines identified by Nero (2001) and Blue Atlantic Transmission System (2003) include:

- During installation, cable "sweeping" and crushing of hard bottom communities can occur, even when pre-construction evaluations and analyses of alternative proposed routes are conducted.
- During repairs, grappling to recover and repair damaged cable has the potential to cause additional impacts to hard bottom resources. The repaired cable is generally not returned to its original location, potentially impacting additional bottom areas.
- When directional drilling (drilling a tunnel under the seafloor) for the landing sites encounters certain subsurface conditions, the pressurized fluid mud used to lubricate the drill hole can escape into the water column. The escaped fluids may cause turbidity plumes and subsequent burial or smothering of sensitive hard bottom resources, and release potentially toxic compounds.
- Sedimentation or excessive suspended sediment can cover hard bottom or impact filter feeders.
- Pipes or cables may restrict or alter invertebrate movement on the seafloor due to physical barrier of the pipe, noise, vibrations, magnetic fields or other biochemical influences.

These cables and pipes may also pose a conflict for recreational and commercial fishing activities, as well as beach nourishment borrow areas. Permit authority for fiber optic cable corridors in the ocean is vested in the Corps of Engineers, with state review under the DCM consistency process. The ASMFC recommended that offshore corridors be pre-identified and evaluated for environmental impacts and conflicts. The ASMFC also recommended that monitoring be conducted to assess damage and recovery of habitat (Nero 2001). *North Carolina should coordinate with ASMFC, other states, and the communications 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

The quality of water at nearshore hard bottom sites is important since fisheries species are most sensitive to toxics and other pollutants during the first months of life. The effect of polluted waters on a given species depends on its life history and feeding behavior. According to the SAFMC (1998b), the primary threats to offshore water quality at hard bottom sites are oil and gas development, offshore dumping, and discharge of contaminants from river and estuarine systems.

The last active offshore oil and natural gas leases in state or federal waters off N.C. were relinquished in November 2000 (<http://www.gomr.mms.gov/homepg/offshore/atlocs/atocsfax.html>, 2003). Several companies, including Amerada Hess, Chevron, Conoco, Marathon, Mobil, Occidental Petroleum Corporation (OXY), and Shell have held interests, singly or jointly, in the Manteo Exploration Unit, a submerged area comprised of 21 lease blocks located approximately 44.8 statute miles northeast of Cape Hatteras (Vigil 1998). Currently, a federal moratorium on oil exploration and development of the eastern U.S. seaboard is in effect until 2012 (<http://dcm2.enr.state.nc.us/Facts/offshore.htm>, 2003). *However, 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.*

Offshore dumping of dredged material occurs at designated sites in federal waters seaward of the Morehead City and Wilmington ports. A new, enlarged "Ocean Dredge Material Disposal Site" (ODMDS) is being developed by COE off the mouth of Cape Fear River in close proximity to natural hard bottom. The ship channel re-alignment goes through an artificial reef established a few years ago by COE. *Adequate monitoring should be conducted prior to creation and during use of this ODMDS to determine its effect on hard bottom habitat.*

Studies in the Mediterranean Sea examining the effect of pollution on hard bottom benthic communities found that total species richness, abundance, and diversity declined with increasing influence of multiple sources of pollution (Hong 1983) and echinoderm richness and density decreased with proximity to industrial sewage outfalls (Hermelin et al. 1981). 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.*

Hard bottom can be degraded not only by point discharges but by outflowing estuarine and river waters. The effect of estuarine waters on hard bottom in North Carolina's ocean waters is largely unknown since little monitoring has been conducted. In 1999, UNC-W began a Coastal Ocean Monitoring Program (COMP) to assess physical, chemical, and biological properties of the Cape Fear River water plume, extending into Long Bay, and waters in Onslow Bay. Results following Hurricane Floyd found that approximately 200 mi^2 of coastal ocean waters were affected for approximately one month, in terms of turbidity and nutrient levels (<http://rover.phy.uncwil.edu/onslow/CFRPlume/>, 2004). In comparing water quality in nearshore ocean waters in Long Bay, where there is a large riverine influence, to Onslow Bay, where there is minimal riverine influence, the Long Bay stations had four to seven times greater chlorophyll and nitrate concentrations than stations in Onslow Bay (<http://www.uncw.edu/cmsr/cormp/results.htm>, 2003). Hard bottom is concentrated in Long Bay and the south end of Onslow Bay, where riverine influence has been noted (Map 7.1c). Declines in estuarine water quality are therefore most likely to impact hard bottom in that area. *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*.

Hard bottom in close proximity to shore is more vulnerable to coastal pollution from point and nonpoint discharge of sewage, industrial waste, and stormwater runoff than offshore hard bottom. Stormwater runoff and discharge of nutrient-rich estuarine waters can increase nutrient levels in coastal ocean waters. Problem levels of nutrients have generally not been found in North Carolina's coastal ocean waters. However, water quality sampling in the ocean waters is extremely limited.[87] Residues of the organochlorine pesticides DDT, PCB, dieldrin, and endrin have been found in gag, red grouper, black grouper, and red snapper, indicating that toxins from stormwater runoff are a potential threat to the hard bottom community (SAFMC 1998b). *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*

[87] Refer to the Water Columnchapter for more information on water quality.

that exceed designated levels of concern.

Existing management measures

Man-made structures functioning as hard bottom have been given varying levels of designation and protection. In 1975, the wreck of the USS Monitor, a Civil War ironclad located off Cape Hatteras in federal waters, was designated as the first national marine sanctuary. Within North Carolina state territorial waters, the USS Huron, a popular wreck located just 250 yards off the beach in Dare County, was designated by the state as a historic shipwreck preserve (Map 7.1). Despite some concern regarding the effectiveness of artificial reefs, all artificial reefs, along with all natural hard bottom, have been designated by the NMFS as Essential Fish Habitat (EFH). All SAFMC-designated Artificial Reef Special Management Zones (SMZs) are also Habitat Areas of Particular Concern (HAPC) under authority of the federal Sustainable Fisheries Act of 1996 (SAFMC 1998b). Artificial reef SMZs are designated areas surrounding artificial reef sites where certain fishing restrictions or regulations may apply (DMF 1988). The purpose of the designation is to prevent extremely efficient fishing gear from being used on the sites, so that user conflicts are reduced, the resource is used in an orderly manner, biological production is optimized, fish stocks are maintained, and recreational fishing is protected (DMF 1988). There are 21 SMZs in the South Atlantic: seven off Georgia, 11 off South Carolina, one shared by Georgia and South Carolina, and two off Florida. There are no SMZs in North Carolina waters. Fishery management plans adopted by the South Atlantic Council include HAPC designations, which are then put into effect through federal regulations implemented and enforced by NMFS.

Natural hard bottom is protected through several state and federal designations. Certain hard bottom areas were designated as federal Habitat Areas of Particular Concern based on four criteria: 1) importance of ecological functions; 2) sensitivity to human degradation; 3) probability and extent of effects from development; and 4) rarity of the habitat. In North Carolina, all of the nearshore hard bottom areas, two specific offshore areas in Onslow Bay (Ten Fathom Ledge and Big Rock), and the entire shelf break have been given this designation for snapper-grouper (SAFMC 1998a). Approximately 150 reef-associated species have been documented from Ten Fathom Ledge and Big Rock (SAFMC 1998a). Inshore hard bottom (<18 m water depth) is thought to support similar fish species as those documented at Ten Fathom Ledge (P. Parker, NMFS, pers. com., 2001).

The N.C. Natural Heritage Program inventories, catalogues, and facilitates protection of the rarest and most outstanding elements of natural diversity in the state. The program designates rare or significant plants, animals, or natural communities, which consequently merit protection or special consideration when making land use and conservation decisions. Currently, four hard bottom ledges within state territorial waters (Map 2.3) have been designated by this state program as Significant Natural Heritage Areas (SNHA) (Natural Heritage Program, unpub. data). These areas include rock outcrops off Bogue Banks (two acres), New River Inlet (1300 acres), South Topsail Island (38 acres), and Masonboro Island (50 acres). There is also one designated intertidal rock outcrop community—the Fort Fisher Coquina Rock outcrops (47 acres). These and other nearshore hard bottom areas are particularly vulnerable to impacts from on-shore land development activities. *These areas should be designated as Strategic Habitat Areas and considered for additional protection under the recent federal Executive Order 13158, which calls for strengthening and expansion of Marine Protected Areas in the United States or through additional state actions specifically designed to protect those sites.*

Several state and federal regulations provide protection for hard bottom habitat. Since 1995, DMF has prohibited directed harvest of all coral or any live rock in North Carolina state waters [MFC rule 15A NCAC 3I .0116]. In addition, any live rock or coral which is harvested incidentally with any gear must be returned immediately to the waters where taken. Similar NMFS regulations exist for federal waters. There are a few areas where hard bottom is present and trawling is restricted. This includes the military prohibited and restricted areas and sea turtle sanctuary that are both located in the ocean seaward of Onslow Beach [15A NCAC 3I .0110, 15A NCAC 3I .0107].

Despite the live rock prohibition, hard bottom structure can still be damaged or killed accidentally by certain commercial and recreational fishing gear and boating equipment. Although there is potential for damage, there has been no documentation that fishing gear currently used in North Carolina is damaging hard bottom. An absence of data on past conditions and current fishing and boating effects prevents accurate identification of potential damage to nearshore hard bottom. *Monitoring of hard bottom condition in nearshore waters, as well as fish utilization of the habitat, is the first step in evaluating impacts of fishing gear or threats to that habitat.*

A series of federal regulatory actions have been taken by NMFS to protect hard bottom habitat (SAFMC 1998b). Management measures from the snapper-grouper FMP and subsequent amendments focused on prevention of overfishing through harvest and gear limitations:

- Amendment 1 (1989) addressed habitat damage through prohibition of trawling gear (roller-rigged trawls) for the harvest of species in the snapper-grouper fishery south of Cape Hatteras (SAFMC 1998b);
- Amendment 2 to this plan (1994) prohibited collection of live rock in federal waters. State rules were implemented in 1995 to be consistent with this federal regulation;
- Amendment 4 (1991) prohibited use of fish traps in federal waters, with the exception of black sea bass traps north of Cape Canaveral, Florida. Fish traps cannot be used in North Carolina ocean waters to target snapper-grouper [15A NCAC 3M .0506(s)(1)]. These rules limit the potential number of traps and associated impacts to hard bottom in North Carolina. The majority of black sea bass traps are located beyond state waters. Bottom longlines are allowed in south Atlantic federal waters. Collecting corals and use of chemicals are regulated by NMFS pursuant to the 1982 SAFMC Coral Fishery Management Plan (SAFMC 1998b).

Use of Marine Protected Areas has proven effective in habitat protection and fishery enhancement in several areas of the world. A recent study of 89 marine reserves showed that fish and marine life quickly recovered when protected by establishment of marine reserves (Halpern 2003), and organisms within the protected areas repopulated adjacent waters (AAAS 2001; Roberts et al. 2001). In New Zealand, overfished snapper populations increased by 40 times within a few years of its establishment, compared to populations outside a reserve. Fish populations tripled in a St. Lucia reserve within three years. North Atlantic sea scallop populations were 14 times greater inside a reserve than outside it after five years of closure. Estuarine waters near Cape Canaveral that were closed to fishing for over 30 years had 3–12 times greater relative fish abundance than adjacent fished areas (Roberts et al. 2001). In addition, preliminary results from establishment of several no-take reserves in the Florida Keys in 1995 indicate reduced habitat damage and improvement in some reef fish populations, particularly yellowtail snapper and spiny lobster.

Since multiple harvest and gear regulations have not appeared to adequately improve the status of reef fish species in the Snapper-Grouper fishery, and additional species have become overfished, the SAFMC has considered use of Marine Protected Areas as a possible management tool since 1992 (SAFMC 1998b; SAFMC 2001). Marine Protected Areas are considered most effective at protecting species with restricted geographical movements typical of most reef animals or where habitat is limiting (Bohnsack 1993). Creation of MPAs can be a valuable tool for the prevention of or recovery from overfishing. They also protect, and potentially improve, reef habitat previously subjected to physical damage. Finally, MPAs protect age structure, biodiversity, and genetic diversity of fish stocks within their boundaries. Based on the 1992 scoping process, input from SAFMC advisory panels and committees, and an ongoing public involvement process, the SAFMC will likely use some form of MPAs as a fishery management tool in the south Atlantic. There has been little discussion concerning establishment of reserves through state management. The MFC has the authority to establish no-take areas. The Fisheries Director may prohibit or restrict taking of fish and use of any equipment in and around any artificial reef or research sanctuary subject to some conditions [15A NCAC 3I .0109]. Many areas within state waters, such as primary nursery areas, are already protected from certain fishing activities through MFC rules. For example, trawling is prohibited in over 46% of North Carolina's estuarine waters. *Hard bottom designated as Strategic Habitat Areas could be considered for incorporation into an MPA to provide protection from fishing gear impacts.*

Two federal Executive Orders issued in 1997 and 2000 also support and encourage establishment of MPAs. In 1997, Executive Order 13089 authorized establishment of a multi-agency task force to direct coral reef conservation in the United States (63 FR 32701–32703, 1998). This task force is exploring recommendations for establishment of MPAs to protect coral reef ecosystems. Establishment of MPAs was being considered at Gray’s Reef National Marine Sanctuary in Georgia waters (SAFMC 2001). In 2000, Executive Order 13158 directed federal agencies to strengthen the management, protection, and conservation of existing marine protected areas and establish new or expanded MPAs through the creation of a scientifically-based comprehensive national system of MPAs representing diverse marine ecosystems (Federal Register 2000). The MPA executive order calls for:
Integrated assessments of ecological linkages among MPAs;
Biological assessment of the minimum area of “No Take” zones needed to preserve representative habitats in different geographic areas of the marine environment;
An assessment of threats and gaps in levels of protection to natural and cultural resources;
Practical science-based criteria and protocols for monitoring and evaluating the effectiveness of MPAs;
Identification of emerging threats and user conflicts affecting MPAs and appropriate, practical, and equitable management solutions, including effective enforcement strategies to eliminate or reduce such threats and conflicts; and
Assessment of the economic effects of the preferred management solutions.

The DMF should investigate the law enforcement needs necessary to implement MPAs or similar actions for the protection of hard bottom habitat and associated fisheries.

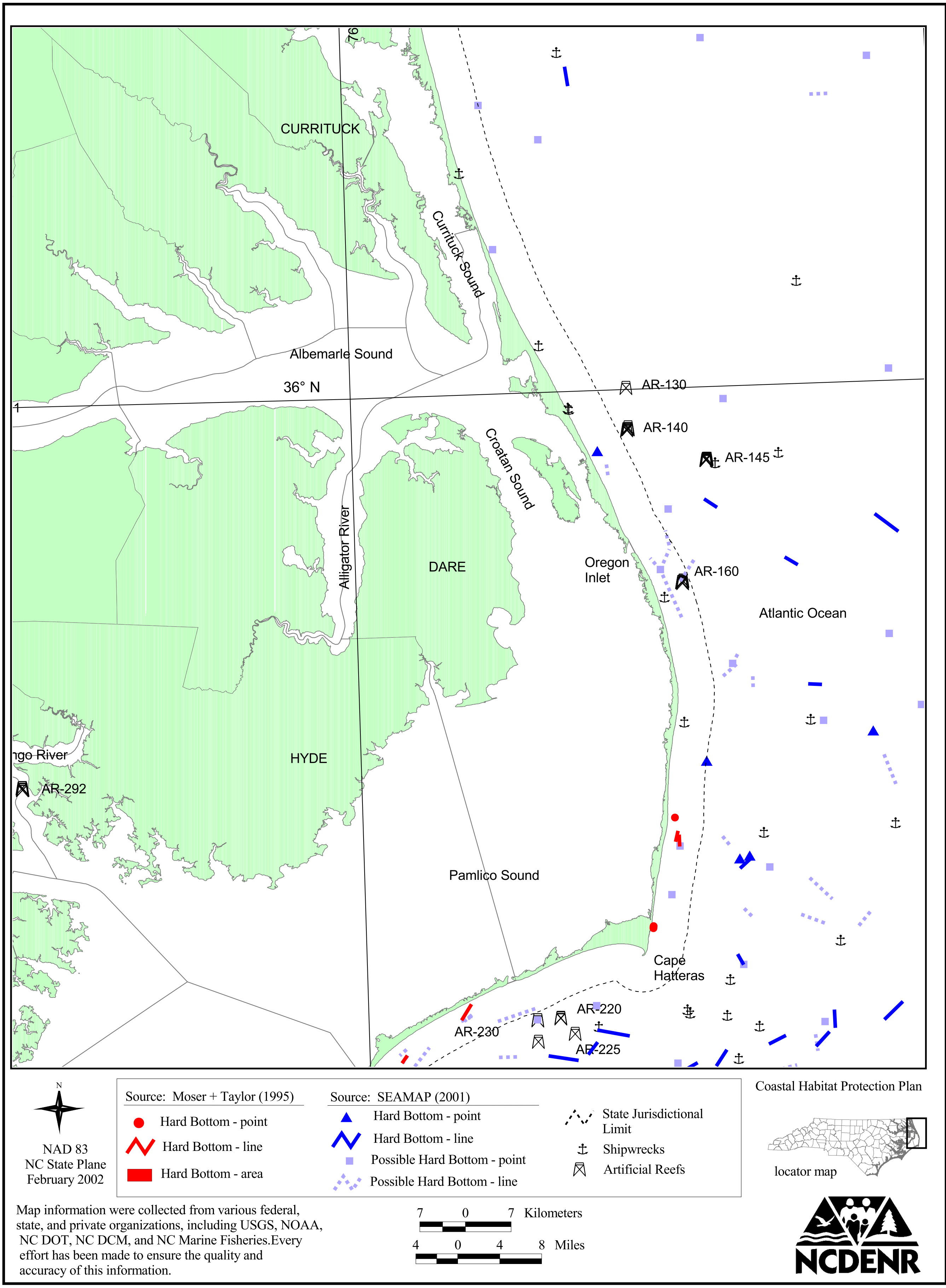
Water quality protection for hard bottom habitat may also result from Executive Order 13158. In addition to establishment of MPAs through NMFS, the order instructs the Environmental Protection Agency (EPA) to identify areas warranting additional protection from pollution and enhancement of water quality standards, and to “propose new science-based regulations, as necessary, to ensure appropriate levels of protection for the marine environment” (Federal Register 2000). The Executive Order also requires the Department of Commerce and the Department of the Interior to consult with relevant states, and to seek expert advice and recommendations of non-federal scientists and resource managers, and other interested organizations through an advisory committee. More information on MPAs is available on the web (<http://www.mpa.gov>, 2003).

7.5 SUMMARY OF HARD BOTTOM CHAPTER

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. 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.



Map 7.1a. Location of hard bottom, possible hard bottom, shipwrecks, and artifical reefs in state and federal waters off North Carolina - northern coast

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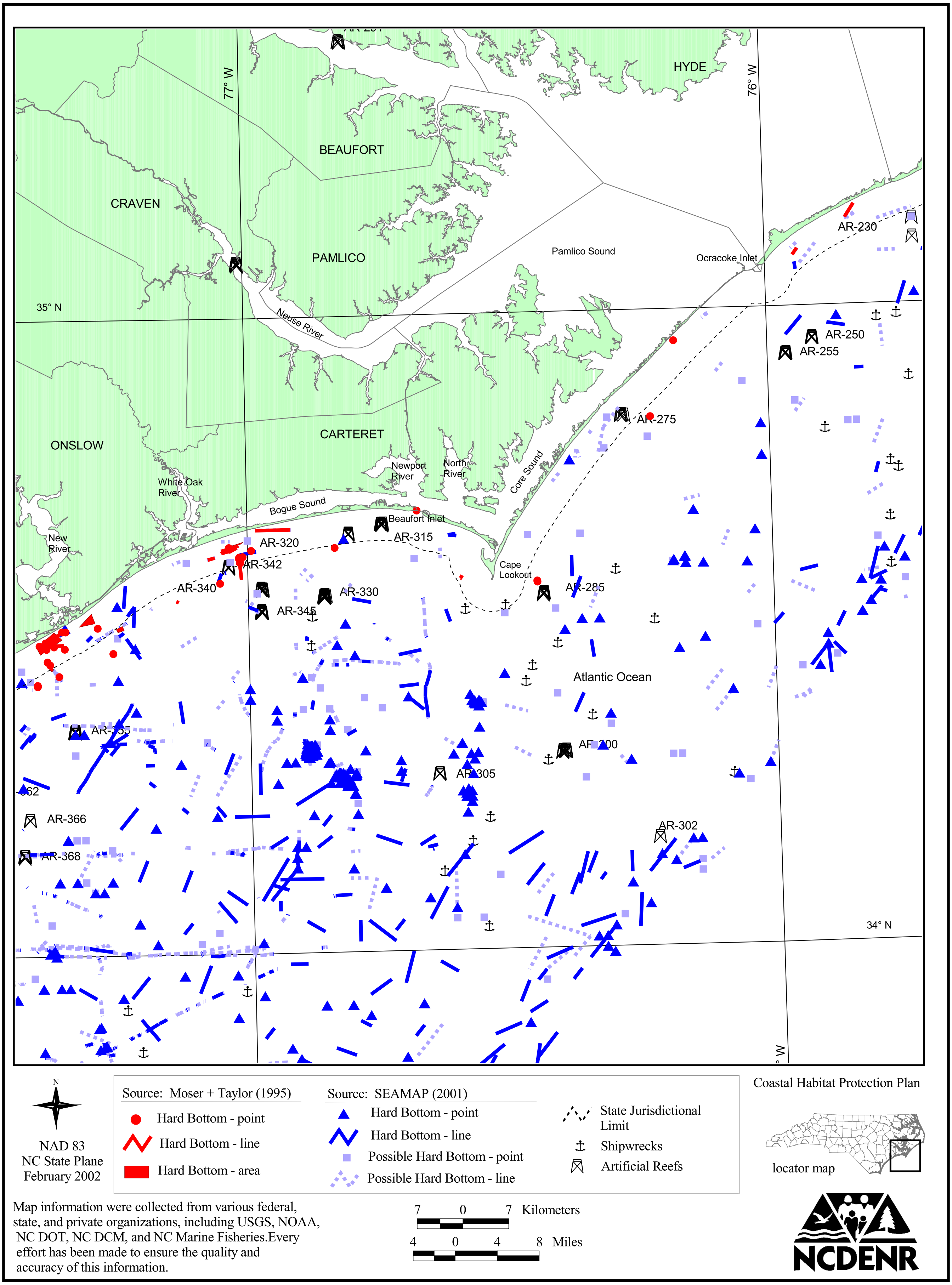

Map 7.1b. Location of hard bottom, possible hard bottom, shipwrecks, and artificial reefs in state and federal waters off North Carolina - central coast.

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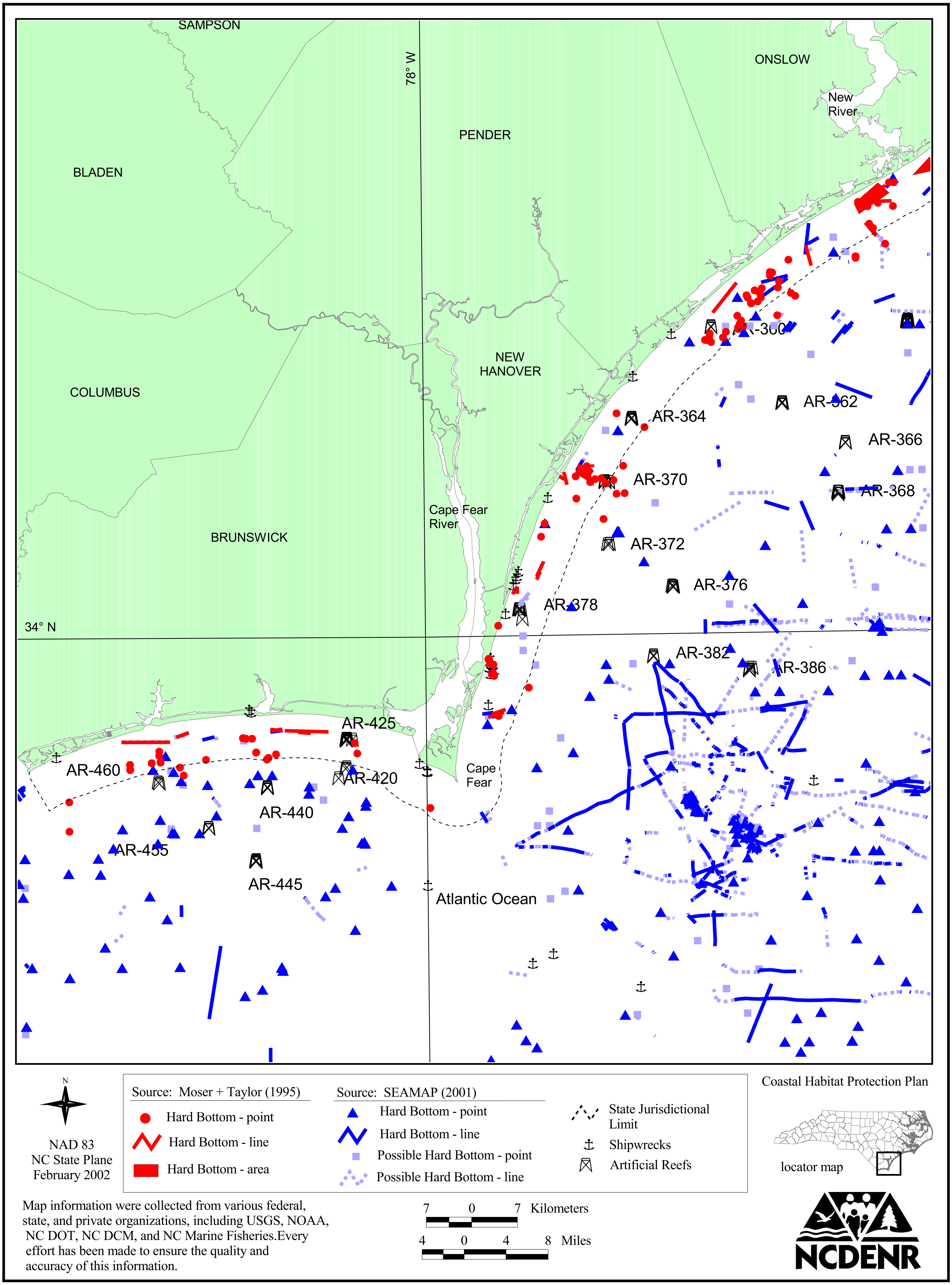

Map 7.1c. Location of hard bottom, possible hard bottom, shipwrecks, and artificial reefs in state and federal waters off North Carolina - southern coast.

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