

The Nature Conservancy

South Atlantic Bight Marine Assessment:

Species, Habitats and Ecosystems

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View the interactive map, download the data, and read the report at: http://nature.ly/marineSAtlanticBightERA

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Top (left to right): 1)Aerial photograph of Barataria Island. Barataria Island is located in Beaufort County in South Carolina. The Island is protected under a conservation easement created through the assistance of The Nature Conservancy.© R. Joseph Hamilton; 2) June 2008 - Sunrise over the lower Altamaha River and the Darien waterfront. © Erika Nortemann/TNC; 3) A male humpback whale (Megaptera novaeangliae) leaps acrobatically in a characteristic reproductive activity. © Carlos Aguilera Calderón

Bottom: Two black sea bass swimming over coral at Grays Reef National Marine Sanctuary. Grays Reef National Marine Sanctuary is one of the largest near-shore "live-bottom" reefs of the southeastern United States which contains a high level of diversity.©Greg McFall

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Mary Conley and Mark Anderson

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Table of Contents

Figures

Tables

CHAPTER

1

INTRODUCTION

Mary F. Conley

Introduction to the South Atlantic Bight

The South Atlantic Bight, an area of the Atlantic Ocean extending from Norfolk, VA to Key West, FL, is known for its vast intertidal wetland habitats, warm waters, and broad, shallow coastal shelf bounded by the Gulf Stream. Extending from the temperate waters off the Carolinas to the subtropical waters of south Florida, the region is a transition zone that supports a diverse suite of coastal habitats. Further offshore, hard bottom habitats sustain diverse communities of benthic fish and invertebrates. Along the Continental Shelf edge, marine mammals migrate along the Atlantic coast, including the endangered Northern Atlantic right whale, whose only calving ground is located in the shallow waters off northern Florida, Georgia, and the Carolinas. Cape Hatteras is a key feature in the northern portion of the region. A point of convergence along the Continental Shelf, here the southward flowing waters of the Mid-Atlantic meet the northward flowing waters of the South Atlantic, and the Gulf Stream migrates from the shelf slope into deep water (Savidge and Austin 2007). This collision of cool and warm waters results in upwelling of nutrient-rich water which supports a variety of seabirds, pelagic fish, and bottom communities. At the southern edge of the study region, the shallow, subtropical waters around the Florida Keys support the only shallow water coral reefs in the continental United States.

These coastal and marine systems have supported regional economies for centuries. Five deep water ports move cargo across the globe, commercial fisheries help sustain local waterfront communities, and wide sandy beaches and colorful coral reefs support a large tourism industry.

Much of the South Atlantic Bight coastline has not been developed as intensively as the northeast. However, the region is facing some of the highest population growth rates along the Atlantic coast. Identifying means to conserve existing natural resources while enabling economic growth is a crucial challenge. In areas where the accumulated pressures of population growth and human use have already resulted in damage to coastal and marine systems, opportunities exist to restore the region’s ecosystem services.

Marine Assessment Overview

The Nature Conservancy's South Atlantic Bight Marine Assessment (SABMA) is a data collection and analysis initiative designed to improve understanding of the regional distribution of key habitats and species. The assessment includes, but is not limited to, coastal wetlands, seagrass beds, oyster reefs, live hard bottom habitats, sea turtles, and marine mammals. Available data resources and other scientific information were assembled to produce regional baselines on the status of each resource. These baselines were then evaluated comprehensively to define conservation priority areas, places where individual habitats and species overlap. The SABMA conservation portfolio highlights areas where significant species, natural communities, and ecological processes hold the greatest promise for conservation success.

Ecological assessments of the ocean are inherently more difficult than on land because ocean ecosystems are dominated by three-dimensional and highly dynamic processes. In addition, precise data on the location of key habitats and species are difficult to collect and therefore may be limited. The SABMA utilized methods and data from previous Nature Conservancy marine ecoregional plans (DeBlieu et al. 2005, Greene et al. 2010) and built upon the foundation laid by a wide variety of scientific studies completed for the region. These include, but are not limited to, comparative estuarine analyses (Dame et al. 2000, National Fish Habitat Board 2010), fishery management council studies and reports (SEAMAP-SA 2001, Okey and Pugliese 2001, SAFMC 2009), conservation plans (DeBlieu et al. 2005, SALCC 2015), regional literature reviews (Cooksey et al. 2010) and state-led efforts (Deaton et al. 2010, Van Dolah et al. 2011). As our understanding of marine systems grows, and as tools for analyzing dynamic spatial processes become more sophisticated, we expect more refined and comprehensive assessments to emerge.

The SABMA is envisioned as a mechanism to empower stakeholders to develop strategies for long-term sustainability of the South Atlantic Bight's ecological services, from the fisheries that feed human populations to the reefs and barrier islands that absorb wave action and storm surges as sea level rises. Though spatial in nature, the portfolio should not be viewed as a recommendation for future "marine protected areas," but rather as a way to understand overlapping distribution of key natural resources. The ultimate measure of its success is tangible, effective marine conservation.

Assessment Team

Assessment development was led by a core team of marine conservation, conservation science, and spatial analysis staff from across the Eastern U.S. Division of The Nature Conservancy. Conservation staff were selected to lead each of the three resource-based technical teams: coastal ecosystems, seafloor habitat, and migratory species.

The technical teams were comprised of internal and external experts representing government agencies, industry and academia. The Conservancy is extremely grateful to the large number of scientific experts and representatives that participated.

Core Team

Conservancy conservation and science staff members responsible for the assessment came from the Conservancy's southeast state chapters (e.g., South Carolina and Florida) and the Eastern Division Science Team. The team conducted monthly meetings to direct the assessment process and address technical issues. Core team members included:

- Mary Conley: Project Lead and Coastal Ecosystem Team Lead, Southeast Director of Marine Conservation
- Mark Anderson: Science Lead and Seafloor Habitat Team Lead, Eastern Division Director of Conservation Science
- Laura Geselbracht: Marine Mammal and Sea Turtle Team Lead, Florida Marine Scientist
- Robert Newton: Data Manager and Spatial Analyst, former Southeast Regional GIS Coordinator
- Analie Barnett: Spatial Analyst, Eastern Division Landscape Ecologist
- Katherine Weaver: Data Manager and Spatial Analyst, former Eastern Division Marine GIS Analyst
- John Prince: Spatial Analyst, Eastern Division Conservation Information Manager

Technical Teams

Over forty Conservancy staff members and external experts participated on the resource-based technical teams. Each team was assigned a Conservancy lead and dedicated spatial analysts. Teams were responsible for selecting conservation targets, identifying and compiling available datasets, evaluating spatial analyses, and reviewing data products and reports. Technical team members are listed in each resource chapter.

Data and Products

Monitoring and research has been conducted in the South Atlantic Bight region for decades. The SABMA rests on the foundation of data collected by scientists whose careers have been devoted to advancing knowledge of South Atlantic Bight marine ecosystems and on the methodology from previous Conservancy assessment projects (DeBlieu et al. 2005, Greene et al. 2010). Time and data were graciously contributed by expert researchers from a wide array of state and federal agencies and academic institutions, listed throughout the report. The authors of this assessment pulled from this previous work in order to integrate millions of records of data across a wide variety of habitats and species.

Every effort was made to understand, and account for, the idiosyncrasies of each dataset, and to respect the value of each source. For each dataset, we contacted the source, met with the people responsible for collecting the data, and shared our maps and analysis with them through written materials, meetings and phone calls. Any mistakes or oversights in the use of data are solely the responsibility of the authors. Moreover, the willingness of an organization or individual to contribute data to this assessment does not imply an endorsement of the final products.

Despite the availability of considerable relevant data, the resulting map products often contain more uncertainty, or are at coarser scales, than would be ideal. However, a balance must be struck between delaying actions because of imperfect data, and taking actions based on what we do know in the face of significant threats to marine biodiversity and associated ecosystem services. The results of the SABMA are provided with caveats noted, and with the expectation that data gaps (see sidebar for examples) will help to inform and prioritize future survey efforts.

The SABMA products include:

- A geodatabase of spatial information on targeted marine ecosystems, habitats and species at the South Atlantic Bight regional scale.
- Maps that synthesize diverse spatial data, designed to meet multiple objectives for a variety of users, including support of decisions about conservation and resource use.
- A narrative (Chapters 2-4) of the approach and methods used to build the decision support database, as well as a description of current conditions and trends in all the habitats and species included in the analysis.
- A portfolio chapter (Chapter 5) that integrates the individual spatial data for all conservation targets to identify high priority conservation areas and potential strategies for conservation action.

Box 1.1. Identified Data Gaps and Opportunities

During development of the South Atlantic Bight Marine Assessment, the team came across several data gaps where limited regional data were available for analysis. The following list outlines some of the data gaps which can be considered opportunities to enhance our future understanding of the region:

- Oceanographic Data – time series and seasonality
- Coastal Birds – regional abundance and location
- Oyster Reefs – location information across Georgia and Florida, regional consistency
- Estuarine Fish – comparable data across states to enable regional analysis
- Hard Bottom – further information on location and structure
- Bottom Substrate –detailed offshore data
- Pelagic Fish – location, abundance and migration
- Marine Mammals – in-water observation and modeling, Southeast Florida sightings per unit effort
- Marine Birds – location, abundance and migration
- Coastal and Marine Use – location, volume and seasonality of activities

Outreach and Use

The outputs of the SABMA are intended to support regional coastal and ocean management decisions. Around the world, the movement towards ecosystem-based management (EBM), also referred to as multi-use ocean planning or coastal and marine spatial planning, acknowledges the interconnections among air, land, and marine habitats, marine organisms, and people. Such approaches are most effective when management of multiple human activities is integrated rather than conducted in sector-specific isolation. It is an approach endorsed by several blue-ribbon panels and the United States Ocean Policy Task Force (see Pew Oceans Commission 2003; USCOP 2004; JOCI 2006; OPTF 2009, NOC 2013). Because political boundaries are essentially irrelevant to marine ecosystem function, EBM planning areas should be defined by biogeographic rather than political boundaries. This approach requires access to spatially-relevant natural resource and use data.

Our hope is that the South Atlantic Bight Marine Assessment can support these efforts and will aid others in coming to their own conclusions with respect to the conservation of marine biodiversity. Our analysis is designed to be used by diverse stakeholders to inform decisions and is freely available for public use. The assessment data and report are available through the Conservancy’s Conservation Gateway website at http://nature.ly/marineSAtlanticBightERA.

The Study Area: The South Atlantic Bight

The South Atlantic Bight marine region, as defined for this assessment, extends southward from Virginia's James River to the Florida Keys. Seaward it encompasses the Continental Shelf, the shelf-slope break, and the deepwater plateaus and terraces that reach to the Blake Escarpment, 5000 m below sea level. Off the coast of Florida, where the United States and Bahamas exclusive economic zones (EEZ) meet, the seaward boundary reflects this political boundary for data access and comparison purposes. The study area includes the entire Atlantic shorelines of four states (North Carolina, South Carolina, Georgia and Florida) along with the southern shoreline of Virginia below the Chesapeake Bay. The 145,000 sq. mi region is home to a coastal county population of over 11.5 million (U.S. Census Bureau 2013). See Figure 1.1 for a map of the complete study area.

The region overlaps three marine ecoregions: Virginian, Carolinian, and Floridian; for planning purposes the Conservancy calls the former the "Mid-Atlantic" (Spalding et al. 2007). These three marine ecoregions served as the basis for defining the subregions used throughout the Assessment. Each subregion, described below, has distinct and unique characteristics. By stratifying our analyses by subregion, we were able to complete a more meaningful and robust evaluation of the characteristic habitats and species of the region. The division enabled geographically appropriate analytical approaches to be used in the production of maps and tools that can help guide ecosystem-based conservation.

Mid-Atlantic (Virginian) Subregion

The full Mid-Atlantic (also referred to as the Virginian) ecoregion extends from Sandy Hook, New Jersey south to Cape Hatteras, North Carolina. It is a transitional area between the rocky shores of New England and the gently sloping, warmer South Atlantic. This assessment addresses the southern end of the Mid-Atlantic ecoregion, starting at the James River in Virginia and running south to Cape Hatteras. Due to its intermediate position along the coast and the associated mixing of oceanic waters, the Mid-Atlantic subregion sustains abundant forage resources that support a diversity of migratory species from striped bass to right whales.

Along the coast, the southern portion of the Mid-Atlantic subregion is dominated by the Albemarle and Pamlico Sounds which are bounded by a chain of barrier islands and inlets. Supporting significant seagrass and coastal wetland habitats, these estuaries are valued for their productivity. The inlets between the barrier islands function as corridors between the coastal lagoons and the shelf waters. These coastal ecosystems provide critical spawning areas for sciaenids such as drum, spot, croaker and sea trout; pupping grounds for coastal elasmobranchs like sandbar, dusky, and sand tiger sharks;

foraging and nursery habitat for all life stages of the bottlenose dolphin; and nesting and juvenile habitat for loggerhead turtles.

Moving offshore, the Mid-Atlantic shelf averages 25 m in depth, growing deeper eastward until it reaches 100 m at the shelf edge and then drops to 1,000 m at the steep escarpment and deep canyons of the slope break. The topography of the Mid-Atlantic shelf is mostly flat, with low-relief features such as sandy shoals and swales, sand wedges and waves, and relict coastal features. The complex of shoals and swales is an important structural feature supporting biologically diverse and abundant benthic macrofauna, demersal fish, and foraging concentrations of sea birds, sea ducks and bottlenose dolphins. The shelf is typically covered by a sheet of medium- to coarse-grained sands with occasional pockets of sand-shell and sand-gravel sediments (Wigley and Theroux 1981). Warm core rings, filaments, and mid-water intrusions peel off the meanders in the Gulf Stream, moving warmer, higher salinity pockets of waters from the slope westward across the shelf towards the coast. When these currents cross over topographic highs such as shoals or ridges - and notably canyon heads - they create significant cold-water upwellings and extremely productive biological events (Walsh et al. 1978).

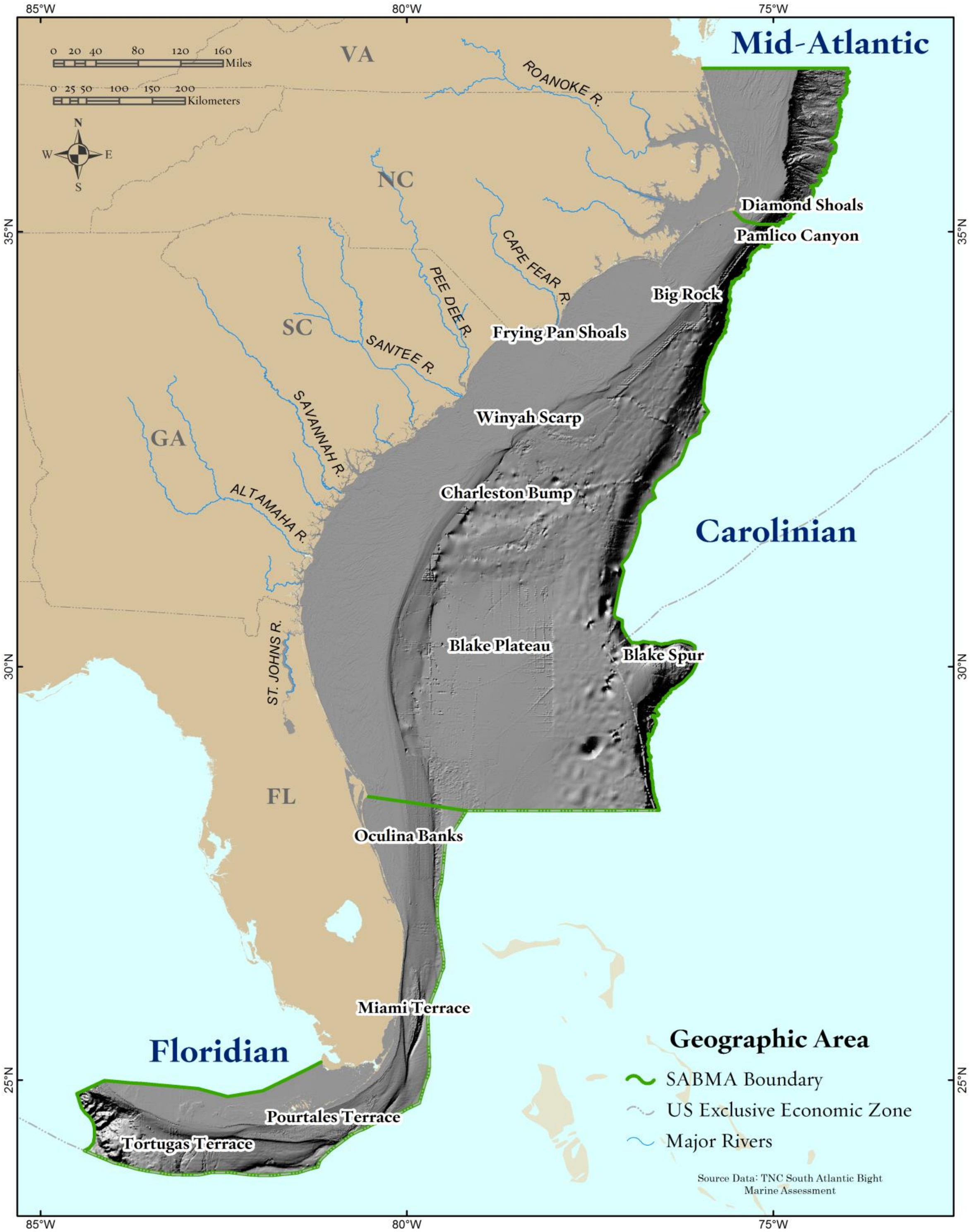

Figure 1.1. South Atlantic Bight Marine Assessment Project Area

Carolinian Subregion

Extending from Cape Hatteras, North Carolina to Cape Canaveral, Florida, the Carolinian subregion forms the central portion of the study area. The subregion functions as a transition between the cool, temperate waters to the north and the tropical waters to the south. This region is greatly influenced by the Gulf Stream which travels north along the edge of the Continental Shelf.

The shoreline between Cape Hatteras and Cape Canaveral supports some of the largest expanses of coastal wetlands in the United States, including a band of salt marsh and complex network of tidal creeks up to 12 km wide. Significant freshwater flow from large river systems, including Cape Fear, Pee Dee, Santee, Savannah and Altamaha, and large tidal range support these extensive intertidal wetland habitats which are particularly well developed along the South Carolina and Georgia coasts. These highly productive coastal wetlands are an important component of the estuarine food web; in particular, strong positive relationships between the productivity of salt marshes and the productivity of coastal fisheries have been reported (Rogers et al. 1984, Dame et al. 2000, Lellis-Dibble et al. 2008). Salt marshes and the network of tidal creeks and pools within them provide forage opportunities and important nursery grounds for shellfish, finfish and shorebirds.

One key feature of the Carolinian ecoregion is the large, shallow continental shelf, 40 to 85 miles (60 to 100 km) wide and 5 to 100 m deep. The topography of the shelf is mostly flat, covered by a sheet of sand-shell bottom with some mud bottom areas located closer to the coast. Low relief features such as sandy shoals and deltas are associated with coastal capes and rivers. Sand and mud bottoms help sustain important fishery species, including tilefish, flounder, drum, croaker, and penaeid shrimp. The Continental Shelf is underlain in places by a hard limestone pavement; corals and other species form diverse colonies in places where the limestone is exposed. Rocky outcrops scattered across the region are particularly prominent in depths from 45 to 60 m (Fautin et al. 2010), where they support an array of sessile invertebrates and algae, creating high-biomass, diverse, hard bottom habitats. Associated with these habitats is a diverse assemblage of warm-temperate and subtropical reef fish, including snapper, grouper, grunt, porgy, and wrasse.

At the shelf edge, the slope drops to 200 m and flattens out into two wide plateaus: the smaller and shallower Charleston Bump at a depth of 200-600 m, and the larger Blake Plateau at 600-750 m depth. The Blake Plateau covers almost 200 square miles and is flanked on its eastern side by the Blake Escarpment, a steep slope that drops to 5,000 m in depth. The hard bottoms of the Blake Plateau are colonized by a wide variety of deep-sea sponges and corals, and in some places the corals have formed significant mound and ridge systems (up to 150m tall) with associated sponges, other cnidarians, mollusks, polychaetes, crustaceans, echinoderms, and fishes. The escarpment and its two deepwater spurs (Blake Spur and McAlinden Spur) mark the eastern edge of the ecoregion.

Floridian Subregion

The Floridian ecoregion extends from Cape Canaveral, FL down the Atlantic seaboard past the Florida Keys, and up the Gulf of Mexico coast to St. Petersburg. This assessment includes only the eastern portion of the ecoregion, defining the Floridian subregion as the stretch from Cape Canaveral to the Florida Keys. This section of the Atlantic coast, classified as subtropical, supports a unique suite of marine habitats (e.g., mangrove swamps and shallow water coral reefs) not found further north. South of Cape Canaveral, a drowned coral reef creates a ridge system parallel to the shoreline of Florida where shallow water coral reefs harbor a myriad of reef species. The Florida reef tract encompasses 6,000 patch reefs and coral ridge formations, the only system of shallow reef-building corals in the continental U.S. seaward of the shelf (adapted from Fautin et al. 2010). The coastline of the Floridian subregion is the most developed in the study area, containing major human populations south of Cape Canaveral in the South Florida Metro area, with Miami being the largest city.

The coastal systems of the Floridian subregion encompass the shift from temperate to subtropical habitats. While the Mid-Atlantic and Carolinian regions are dominated by salt marsh, the Indian River Lagoon, Biscayne Bay and Florida Bay estuaries are fringed by mangrove swamps. Mangrove ecosystems provide habitat for a variety of attached epifauna, invertebrates, and fishes. Mangroves are primarily found in estuarine waters where they serve as valuable nurseries for recreationally and commercially important marine species (Dahl and Stedman 2013, National Park Service 2010). Human-induced impacts to mangrove wetlands include proliferation of invasive species, cutting/removal, and coastal development resulting in drainage, filling, or changes to shoreline structure (Dahl and Stedman 2013).

Florida’s extensive estuarine and nearshore seagrass beds have developed as a result of the unique and stable regional geological history, climate, and circulation patterns along the Florida peninsula since the last ice age (Handley et al. 2007). The waters around the Florida Keys and Florida Bay include the largest contiguous seagrass beds in the continental United States (Carlson and Madley 2007), representing almost 60% of the total seagrass acreage in the state. Positioned at the confluence of temperate and tropical influences, Indian River Lagoon is particularly high in diversity. Florida’s coastal waters are dominated by subtropical species such as turtle grass (*Thalassia testudinum*) and host a greater diversity of species than North Carolina. Eight seagrass species are present in Florida’s estuarine and coastal ocean waters.

Offshore, the Floridian subregion's shallow continental shelf is a relatively modest feature constricted to 7 miles at its narrowest and about 40 miles at it is widest. The subregion is heavily influenced by the Strait of Florida, a trough separating the Florida Peninsula from the Bahama Platform and Cuba which conveys the Florida Current through a narrow channel, eventually forming the Gulf Stream. The initial shelf-break sharply drops to 200 m. It is then broken up by relatively flat terraces -- the Miami Terrace, the Pourtales Terrace, and the Tortuga Terrace -- before reaching a depth of 750 m. The consistent one-way flow of the Florida current creates an environment that enables many bottom dwelling species found in northern South America to extend their range into southern Florida (Messing n.d.). The geologic and hydrologic characteristics of the area support a high diversity of fish, including species of snapper, grouper, grunt, billfish, and reef fish (Messing, n.d).

Selection of Species and Habitats

In consultation with external advisors, a suite of habitats and species, characteristic and representative of the region's diversity, was selected for inclusion in the marine assessment. Emphasis was placed on opportunities to refine analyses completed as part of the 2005 Carolinian Ecoregional Assessment (DeBlieu et al. 2005) and incorporate methods used in the Northwest Atlantic Marine Ecoregional Assessment (Greene et al. 2010). The latter supports creation of consistent datasets on coastal habitats for the entire U.S. Atlantic Coast. In some instances, inclusion of desired habitats and species was limited by availability of data that could be evaluated at the regional scale.

Following the Conservancy's standard conservation planning methods, the selected habitats and species are referred to as "conservation targets." Both coarse and fine filter targets were incorporated into the selection process. The "coarse filter" approach enables the efficiency of using large-scale habitat conservation strategies to benefit many species at once. Two broad habitat targets, coastal ecosystems and seafloor habitats, were identified as coarse filters designed to account for all the species and processes that they support. Both of these habitats were mapped comprehensively, classified into subtypes based on structure and composition, and characterized in detail.

However, habitat conservation alone is not sufficient for conserving all species, and so with guidance from each technical team, a "fine filter" approach was used to select a subset of species found within the study area. Because it is not practical or feasible to produce a detailed and spatially explicit analysis for every species in the region, the teams identified focal species, taking into consideration representative guilds, ecological processes, life cycles, and rarity. The subset of species selected includes marine mammals, sea turtles, and fish.

Following is a brief overview of the selected conservation targets. Additional details are available in the individual resource-based chapters: coastal ecosystems, seafloor habitats and migratory species.

Coastal Ecosystems

The South Atlantic Bight coastline is characterized by stretches of barrier islands that protect coastal lagoons and river-influenced coastal waters which support extensive wetland habitat. These fringing ribbons of habitats that comprise the land-sea interface help maintain marine diversity and play critical roles for both nearshore and offshore plants and animals. These estuarine systems serve as nurseries, breeding grounds, and forage areas for a variety of species while helping to maintain good water quality and protect upland areas from flooding and storm damage.

Recognizing the heterogeneity and ever-changing nature of the coastline, this section of the assessment provides an overview of coastal habitats such as salt marshes, seagrass beds, and oyster reefs; examines some of the threats to and human interactions with these systems; and reviews potential strategies for enhancing the resilience of coastal systems. Focus was placed on the contributions that coastal ecosystems make to marine diversity.

Integrating population data into the coastal analysis enables understanding of connections between habitats, both within estuaries and with offshore areas, and targeted species groups. The following coastal species groups were incorporated into the coastal ecosystem analysis and are described further in the associated chapter:

- <u>Diadromous fish</u> utilize both freshwater and salt water habitats during their life cycle. These species have great cultural and ecological significance in the region and provide an important energy link among freshwater, estuarine, and marine food webs. Six species were included in the assessment based on their use of the region and conservation status: alewife, American shad, Atlantic sturgeon, blueback herring, hickory shad, and shortnose sturgeon.

- <u>Coastal birds</u> depend on estuarine habitats in the South Atlantic Bight as migratory stopover sites, overwintering areas, and breeding locations. The highly migratory species connect geographically disparate marine environments, from South America to the Arctic. Emphasis was placed on shorebirds and wading birds, including four federally listed threatened bird species (piping plover, roseate tern, rufa red knot and wood stork) and seventeen species classified as species of concern by national or state organizations.

- Sea turtles nest on ocean beaches within the South Atlantic Bight. All five species found in the South Atlantic Bight are listed federally as either threatened or endangered, however, only the loggerhead has a nesting range that extends from North Carolina through Florida. This distinction led to the selection of the loggerhead sea turtle as a target species for the coastal analysis.

- Estuary-dependent fish are species that utilize coastal ecosystems for a portion of their life cycle. They are often found in estuarine habitats such as seagrass beds and salt marsh as juveniles and then travel offshore as adults. In the South Atlantic Bight these species include Atlantic croaker, Atlantic menhaden, southern flounder and weakfish. With an assessment goal of linking coastal and offshore habitats, the portfolio chapter includes an analysis of the relationship between offshore fish surveys and nearshore habitats for these species.

Seafloor Habitats

The seafloor habitats of the South Atlantic Bight are a foundation of the region's extensive biodiversity. Sandy habitats on the Continental Shelf sustain important fishery species such as tilefish, flounder, scallops, and penaeid shrimp. Rocky outcrops that punctuate the shelf provide substrate for a wealth of sponges, corals, and algae. Like coral reefs, these "live" rocky reefs support varied assemblages of mollusks and crustaceans, and sustain economically valuable fisheries of snapper, grouper, grunt, and porgy. South of Cape Canaveral, a drowned coral reef creates a ridge system parallel to the shoreline of Florida where shallow water coral reefs harbor a myriad of reef species.

By compiling and evaluating existing regional data sources, the Assessment depicts the diversity of seafloor habitats found off the coast of North Carolina, South Carolina, Georgia and Florida. In addition to the physical and geologic analysis of the seafloor, the assessment considers the relationship between habitats and bottom dwelling species. In particular, demersal fish (or groundfish) are characterized by their close association with the seafloor for feeding, spawning, and juvenile nursery areas. Along with invertebrate communities, demersal fish typically occur within a certain bathymetry range. South Atlantic Bight fish species, including snapper and grouper, are used in the assessment to define bathymetry zones and to help prioritize conservation portfolio sites.

Pelagic and Migratory Species

We considered a variety of pelagic species for inclusion in the assessment. Regional data limitations challenged incorporation of several pelagic and migratory species groups and habitats, including seabirds (e.g., petrels, gannets, and shearwaters), pelagic fish (e.g., herring, mackerel, swordfish and tuna), and Sargassum. As a result, the assessment focuses on those species groups for which sufficient data were available: marine mammals and sea turtles. Many of the selected species and species groups within these two categories are highly migratory, utilizing multiple habitats and a wide area throughout their life cycles. Their inclusion provides a unique opportunity to consider water column habitat conditions across the project range. As additional information from other pelagic and migratory species becomes available, it will be a beneficial addition to the analysis.

- Marine Mammals (dolphins, whales, and manatees) are large migratory species that utilize both the nearshore and offshore waters of the South Atlantic Bight. As predators, cetaceans are major consumers at most trophic levels, targeting organisms ranging from zooplankton to invertebrates to small pelagic fish. Eleven marine mammal species or species groups were chosen for this study based on their population status and distribution: beaked whales, bottlenose dolphin, common dolphin, fin whale, Florida manatee, humpback whale, North Atlantic right whale, oceanic dolphin, pilot whale, Risso's dolphin, and sperm whale.

- Sea turtles utilize both oceanic (inner shelf region and offshore) and terrestrial (beach) ecosystems. Their highly migratory and long-lived life history characteristics present unique challenges to their continued protection and recovery. Five species of sea turtle (green, hawksbill, Kemp's Ridley, leatherback and loggerhead) were selected based upon their status as endangered species and distribution within the region.

Human Interactions and Threats

Human interactions have a significant impact on the abundance, condition, and connectivity of coastal and marine ecosystems, habitats, and species in the South Atlantic Bight. The specific human uses of and threats to each of the three resource areas covered by the assessment are discussed in the individual chapters. This section provides a brief overview of several core threats.

Coastal Development and Pollution

The Southeast is experiencing some of the fastest rates of population growth of any coastal region in the conterminous United States (Kildow et al. 2009, EPA 2012). This increase in population and associated development can lead to direct destruction of coastal habitats, increased inputs of nutrients and toxins, and alterations of tidal flow, all of which can impact estuarine and nearshore systems. One potential result is the eutrophication of coastal ecosystems (Nixon 1995, CENR 2003), leading to elevated levels of chlorophyll *a*, low dissolved oxygen, extensive macroalgae blooms, loss of seagrass and reef-forming corals, and harmful algal blooms (Bricker et al. 1999, CENR

2003; National Marine Sanctuary Program 2007). Nitrogen, the most common driver of estuarine eutrophication, comes from a variety of point (e.g., treatment plants, industrial sources) and non-point sources (e.g., septic systems, agricultural runoff, combined sewage overflows) (CENR 2003).

Shoreline stabilization is another way that development can impact coastal systems. Shoreline armoring of all types (e.g., groins, bulkheading, rip rap) can cause direct loss of habitat, most often impacting adjacent properties (Nordstrom et al. 2003). An associated impact is the inability of development-constrained wetlands to migrate with changes in ocean processes and sea level rise. For sea turtles, degradation of nesting areas in the form of beach replenishment and armoring, coastal development, and sand removal has been identified as a key threat to terrestrial life stages (Lutcavage et al. 1997, Conant et al. 2009, NMFS USFWS 2008, Wallace et al. 2011 as reported in Tiwari et al. 2013, NMFS USFWS 2007). Finally, dredging of nearshore sand flats, shoals, and shoal-ridge complexes can impact the physical and biological structure of seafloor habitats (Michele et al. 2013).

Unsustainable Fisheries

Fishing activities have both direct and indirect impacts on the species and habitats of the South Atlantic Bight. Impacts include overharvest of commercially and recreationally important species, bycatch, and habitat degradation. Several fisheries in the region are closely linked to seafloor habitats. Offshore fisheries in the region often target the highly diverse assemblage of reef fishes associated with hardbottom substrates or coral reefs. Current and past fishing levels have depleted populations of demersal predatory fishes such as snappers, groupers, and tilefish (NOAA 2015). Their high trophic level in offshore food webs and role as ecosystem engineers, combined with fishing gear effects on habitats, likely impact the health of associated reef species (Coleman and Williams 2002). In the case of oyster reefs, overharvest can both deplete populations and reduce ecosystem services (e.g., water quality, shoreline protection, fish refugia) provided by these complex structural habitats.

The limited selectivity of fishing gear can impact species that are not targeted. For example, turtle species at multiple life stages are vulnerable to bycatch and entanglement in fishing gear. Comprehensive threat assessments for the Northwest Atlantic population of loggerheads conclude that a principal threat in the Northwest Atlantic is fisheries bycatch, specifically in the bottom trawl, demersal longline, demersal large mesh gillnet, and pelagic longline fisheries (Conant et al. 2009, NMFS USFWS 2008).

Climate Change and Sea Level Rise

Extreme precipitation events, warming sea surface temperatures, accelerated sea level rise, and ocean acidification due to global climate change will affect a variety of marine habitats and species. Coastal habitats will likely be increasingly stressed by climate change impacts that have resulted from sea level rise and coastal storms of increasing frequency and intensity (Field et al. 2007, Riggs and Ames 2003). Warmer water temperatures associated with climate can lead to community and population shifts, particularly at ecoregion transition zones such as Cape Hatteras and Cape Canaveral. In addition, lower ocean pH due to elevated global CO_2 concentrations (ocean acidification) may inhibit biochemical processes that coral reefs and bivalves rely upon for development (Beesley et al. 2008, National Marine Sanctuary Program 2007).

Conservation Action for the South Atlantic Bight

The South Atlantic Bight region continues to face the accumulating pressures of population growth and human use of the coasts and oceans which can negatively impact marine and coastal resources. Over the past several years, the region has witnessed the deepening of several port facilities, continued increase in coastal populations and associated development, increased beach nourishment, potential offshore alternative and conventional gas development, and the impacts of climate change. In the face of these changes, significant resilience remains and it is not too late to take action to improve conservation of the region's biodiversity.

Since the 1970s, strong regulations have helped conserve critical salt marsh habitats. Southeast states are currently evaluating alternatives to hardening estuarine shorelines (e.g., bulkheads and rip-rap). Often referred to as living shorelines, the alternatives will better maintain the ecological values of these habitats and enable their migration in the face of sea level rise. Fisheries managers, led in federal waters by the South Atlantic Fisheries Management Council, have approved habitat-based conservation regulations designed to protect sensitive hard bottom habitats and the species that depend upon them. Management tools include the designation of marine protected areas (MPAs), habitat areas of particular concern (HAPCs), and, most recently, special management zones designed to protect snapper and grouper spawning areas. Critical area designations for threatened and endangered migratory marine species in the region have recently been expanded to include a suite of nesting beaches for loggerhead sea turtles and larger stretches of coastal waters for North Atlantic right whale calving grounds.

Management actions such as those described above are critical to the long-term conservation and resilience of the natural communities of the South Atlantic Bight. Moving forward, there is opportunity to increase coordination across decision-making bodies, taking a more comprehensive ocean planning approach to decision-making. Effectively moving in this direction takes coordination across agencies, consideration beyond jurisdictional boundaries, and understanding of both the natural resources and human uses occurring in coastal and marine ecosystems. By highlighting significant species, natural communities and ecological processes in the region, and identifying areas that represent conservation opportunities for maintaining coastal and marine ecosystems, our hope is that the SABMA can help inform future research, single sector management, and ocean planning decisions.

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CHAPTER 2

COASTAL ECOSYSTEMS

Mary F. Conley, Robert Newton

Introduction

At the edge of land and touching the sea is the coastal zone, a patchwork of habitats critical to diverse assemblages of species, influential to the environment further offshore, and valuable to humans. The coast along the South Atlantic Bight is recognized for its productive estuaries, extensive wetlands, and long stretches of barrier islands. These areas provide juvenile nursery and spawning grounds for fish and shellfish, feeding areas for shorebirds, and nesting beaches for sea turtles. This chapter discusses the status of coastal systems in the southeastern United States, with particular emphasis on the contributions that coastal ecosystems make to marine diversity.

The coastline is the ultimate ecotone, a critical ecological transition, as dramatic and obvious a natural boundary as one can find on Earth. While well defined, coastline ecosystems are very dynamic. Over geologic time, estuarine and ocean shorelines have advanced and retreated thousands of kilometers inland and seaward. The coastal zone is shaped by waves and tides and by the continuous flow of new sediments carried by fresh water in coastal watersheds. The adjacent shallow and productive coastal waters give rise to habitats like salt marshes, oyster reefs, and seagrass meadows. In turn, these critical habitats directly and indirectly support a diversity of animals.

The coasts and estuaries of the South Atlantic Bight have attracted and sustained humans for thousands of years. The oyster rings, mounds, and middens found along the southeast coast illustrate the connection between Native Americans and the coast. Beginning in the late 1500s, European settlers established colonies in cities such as St. Augustine, FL and Charleston, SC. Today, coasts are where we live, recreate, work, and gather. They help support the economy, providing opportunities for tourism, shipping and transportation routes, and commercial fishing.

Coastal systems are also at risk from pollution, habitat destruction, harmful algal blooms, fishery collapses, and increased coastal erosion. In the South Atlantic Bight, these threats continue to increase as population and uses grow. Between 1980 and 2006 the coastal counties along the Southeast Atlantic had the largest rate of population increase (79%) of any coastal region in the conterminous United States (Dahl 2011). This growth can not only impact natural resource health, but can also have devastating social and financial impacts for coastal communities.

Additional uncertainty about the future of coastal ecosystems comes with climate change. Sea level rise, intense storms, droughts and ocean acidification will impact both human communities and coastal ecosystems. Flooding is already increasing in coastal cities as sea levels rise. North Carolina's bays, which lie at the intersection of two ecoregions, are experiencing shifts in coastal plant and animal communities as southern species extend further north with warming seas and temperatures.

Recognizing the heterogeneity and ever-changing nature of the coastline, this section of the assessment provides an overview of coastal habitats such as salt marshes, seagrass beds, and oyster reefs; discusses linkages between coastal and marine systems by examining species that utilize both; discusses some of the threats to and human interactions with these systems; and reviews strategies for conserving and restoring coastal systems.

Box 2.1. Coastal Ecosystems Technical Team Members

The Coastal Ecosystem Technical Team provided feedback on conservation targets, data resources, and analysis.

Cynthia Bohn, U.S. Fish and Wildlife Service
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Laura Geselbracht, The Nature Conservancy, Florida
Kathy Goodin, NatureServe
Eric Krueger, The Nature Conservancy, South Carolina
Christi Lambert, The Nature Conservancy, Georgia
Kathleen O'Keife, FL Fish and Wildlife Commission
Arlene P. Olivero, The Nature Conservancy, Eastern Division
Brad Pickens, South Atlantic Landscape Conservation Cooperative/NC State Univ.
Christine Pickens, The Nature Conservancy, North Carolina
Denise Sanger, SC Department of Natural Resources
Anna Toline, National Park Service
Maria Whitehead, The Nature Conservancy, South Carolina
Amber Whittle, FL Fish and Wildlife Commission
Pace Wilber, National Oceanic and Atmospheric Administration

Selection of Target Coastal Habitats and Species

Coastal ecosystems of the South Atlantic Bight include a matrix of habitats extending from sandy beaches at the ocean's edge to tidally influenced wetland communities that can extend miles inland. Habitat targets were selected for inclusion in the assessment based upon their unique communities and importance across the region as follows:

- Salt Marsh - estuarine and brackish emergent wetland communities
- Tidal Freshwater Marsh - oligohaline and palustrine emergent wetland communities within the tidal zone
- Tidal Forests - estuarine and palustrine scrub-shrub and forested wetland communities within the tidal zone, including mangrove swamps, limestone rocky barrens and cypress-tupelo swamps
- Tidal Flats - unvegetated mud and sand wetlands located away from the coastline
- Estuarine Beaches - unvegetated wetlands along sheltered shorelines of bays and estuaries
- Ocean Beaches - unvegetated wetlands located directly next to the Atlantic Ocean
- Seagrass Beds - areas with submerged aquatic vegetation, including eelgrass, shoal grass, turtle grass, and manatee grass
- Shellfish Reefs - structural habitats formed by shellfish, with an emphasis on oyster reefs

Appendix 1 describes the relationship between these selected coastal habitats and the Coastal Marine Ecological Classification Standard (CMECS) types (FGDC 2012; Madden et al. 2005). To further assess the role that these habitats play in the marine environment, select species groups were incorporated into the analysis. Emphasis was put on species that connect the marine and estuarine systems: diadromous fish, coastal birds, and sea turtles. For each species group, the team identified a set of individual species to evaluate. The selection process included consideration of population status, emphasizing at-risk populations; relationship with target coastal habitats; and importance of the South Atlantic Bight to the species' global range. This prioritization corresponds with the overall goal of the assessment: to highlight linkages among the coastal, estuarine, and marine environments. Following are brief descriptions of the species selected as targets:

- Diadromous Fish – Six target species were selected for this assessment: alewife (*Alosa pseudoharengus*), American shad (*Alosa sapidissima*), Atlantic sturgeon (*Acipencer oxyrhinchus*), blueback herring (*Alosa aestivalis*), hickory shad (*Alosa mediocris*), and shortnose sturgeon (*Acipencer brevirostrum*). American eel (*Anguilla rostrata*) was also considered, but given this species' broad range across the northern Atlantic Ocean and limited availability of population data, it was not included in the assessment. The six species selected correspond with work completed as part of the Southeast Aquatic Connectivity Assessment Project (SEACAP, Martin et al. 2014), a Conservancy-led initiative designed to identify opportunities to improve aquatic connectivity through dam removal or bypass projects.

- Coastal Birds – Four federally listed threatened bird species, piping plover (*Charadrius melodus*), roseate tern (*Sterna dougallii dougallii*), rufa red knot (*Calidris canutus rufa*) and wood stork (*Mycteria americana*), are present in the assessment area. An additional twenty-four species of shorebirds and wading birds are listed as rare, threated, or of special concern by individual states. To refine the list of species considered as part of this assessment, the team compared federal and state listed species with those prioritized in the North American Waterbird Conservation Plan (Kushlan et al. 2002), United States Shorebird Conservation Plan (Brown et al. 2001), and USFWS Birds of Concern 2008 (USFWS 2008). Shorebirds and wading birds considered at risk by at least two agencies or organizations (Table 2.1) were identified as target species.

- Sea Turtles – Five sea turtle species nest on ocean beaches within the within the South Atlantic Bight. All species are listed federally as either threatened or endangered, however, only the loggerhead has a nesting range that extends from North Carolina through Florida. This distinction led to the selection of the loggerhead sea turtle as a target species for the coastal analysis.

Table 2.1. Prioritized coastal bird species listed status from the North American Waterbird Conservation Plan (MWB) and the United States Shorebird Conservation Plan (USSCP), United States Fish and Wildlife Service (USFWS), and Florida (FL), Georgia (GA), South Carolina (SC) and North Carolina (NC) State Wildlife Action Plans. HI = Highly Imperiled, H = High Concern, T = Threatened, BCC = Birds of Conservation Concern and X = State Rare, Threatened, and Species of Concern

Species	MWB/ USSCP	USFWS	FL	GA	SC	NC
American Bittern		BCC				X
American Oystercatcher		BCC	X	X		X
Black Rail		BCC				X
Black Skimmer	H	BCC	X	X	X	X
Brown Pelican			X			X
Glossy Ibis					X	X
Gull-Billed Tern	H	BCC		X	X	X
Least Bittern		BCC				X
Least Tern	H	BCC	X	X	**X**	X
Limpkin (FL)		BCC	X			
Little Blue Heron	H		X		**X**	X
Marbled Godwit	H	BCC			X	
Piping Plover	**HI**	**T**	**X**	**X**	**X**	**X**
Red Knot	**HI**	**T**		**X**		
Roseate Spoonbill		BCC	X			
Roseate Tern	**H**	**T (FL)**	**X**			**X**
Snowy Egret	H		X			X
Tricolored Heron	H		X			X
Whimbrel	H	BCC				
Wilson's Plover		BCC		X	X	X
Wood Stork	**H**	**T**	**X**	**X**	**X**	**X**

Population Status and the Importance of the South Atlantic Bight Region

For centuries, coastal population density in North Carolina, South Carolina, and Georgia has been low in comparison to other areas along the Atlantic coast (Dame et al. 2000). This smaller human population corresponds with less development along the majority of the southeast coast, though significant habitat and resource alterations have taken place in the region through silviculture and agriculture practices. As a result, stretches of the South Atlantic coastline retain extensive wetland communities, undeveloped barrier islands, and healthy water quality. The 2012 National Coastal Condition Report

IV (EPA 2012) reflects this status. With an overall ranking of “fair,” the southeast region is in the best overall condition compared to other regions in the continental United States. Population growth, climate change, and increasing coastal and ocean uses challenge the region’s ability to maintain these natural resources. This section provides an overview of the status of targeted habitats and species in the South Atlantic Bight project area and information on their importance to the broader Atlantic coastal and marine ecosystems.

Coastal Wetlands

Those coastal wetlands that fall within a coastal watershed boundary are estimated to represent 38 percent of all wetland acreage in the conterminous United States (Dahl and Stedman 2013; Stedman and Dahl 2008). While coastal wetlands occur on shores across the United States, the largest expanses are located on the southern Atlantic and the Gulf of Mexico coasts. Coastal wetland density in all South Atlantic Bight coastal watersheds was ranked high (17.1 – 32.5%) or very high (>32.6%) in the 2008 *Status and trends of wetlands in the coastal watersheds of the Eastern United States 1998 to 2004* report (Figure 2.1; Stedman and Dahl 2008).

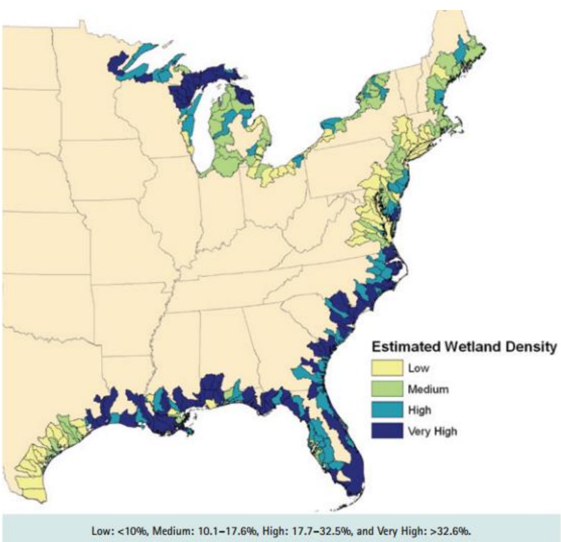

Figure 2.1. Wetland density in coastal watersheds from Stedman and Dahl (2008)

For this assessment, emphasis was placed on tidally-influenced coastal wetlands, recognizing the connection they represent between estuarine and marine environments. This emphasis eliminates some freshwater wetlands from the analysis. Wetland types included in this classification include mangrove forests, tidal fresh and saltwater marshes, tidal forested and shrub wetlands, coastal shoals, tidal mud flats, sand spits (bars), beaches, and tidal pools that occur in coastal wetlands.

The southeast has the largest extent of salt marsh and tidal freshwater wetlands along the Atlantic coast (Odum et al. 1984; Wiegert and Freeman 1990). These communities are particularly prevalent along the South Carolina and Georgia coasts where larger tidal ranges, significant freshwater flow, and geology support salt marsh directly along the coast as well as tidal freshwater marshes and forests inland and upriver.

Studies of wetland coverage in the conterminous United States have documented losses totaling about half of the wetland acreage that existed prior to European colonization (Dahl 1990; Kusler and Opheim 1996). Wetlands were diked, drained, and filled for human uses, including development, industry, silviculture, agriculture, and mosquito control. More specifically, as much as 20% of the original tidal freshwater wetlands have been lost to development on the Atlantic coast (Mitsch and Gosselink 2000).

The impoundment of coastal marshes for rice cultivation in the 18th and early 19th centuries had a unique role in shaping South Atlantic marshes through to the present day. It is estimated that 14-16% of coastal marshes in South Carolina are functional impoundments (Wenner, n.d.). Since the original diking of these systems for rice culture, many have been maintained or built to attract water fowl. These impoundments continue to provide some of the ecological functions of salt and freshwater marshes, including nesting and foraging areas for waterbirds and nursery habitat for estuarine fish. However, they can also restrict water exchange and species movement within coastal wetlands (Tufford 2005).

Outright destruction of coastal wetlands has been greatly reduced by implementation of federal and state laws such as the Clean Water Act and Coastal Zone Management Act. Several reports document that salt marsh extent has remained relatively stable since the 1970s (Hefner et al. 1994; Stedman and Dahl 2008). The 2013 USFWS Report, *Status and trends of wetlands in the coastal watersheds of the conterminous United States 2004 to 2009*, documented a decline of less than 1% in Atlantic salt marsh acreage between 1998 and 2008 (Dahl and Stedman 2013). Other coastal wetland types have not fared as well. Ongoing threats to coastal wetlands include sea level rise and coastal development.

Seagrass Beds

Seagrass beds are prominent features in the coastal estuaries of North Carolina and Florida, but are extremely limited along the coasts of South Carolina and Georgia where light penetration, turbidity, freshwater flow, and tidal regimes limit their growth (Street et al. 2005). North Carolina represents the transition from northern eelgrass (*Zostera marina*) beds to southern shoalgrass (*Haloduli wrightii*)-dominated systems; both are found in the Albemarle-Pamlico Sound region (Street et al. 2005). Florida's coastal waters are dominated by subtropical species such as turtle grass (*Thalassia testudinum*) and host a greater diversity of species than North Carolina. Eight seagrass species are present in Florida's estuarine and coastal ocean waters. The list of Florida species includes the rare Johnson's seagrass (*Halophila johnsonii*), endemic to Florida's Atlantic coast (Yarbro and Carlson 2013). Florida and North Carolina estuaries and coastal ocean waters support the two largest seagrass populations along the Atlantic coast.

The physical and chemical conditions of the Albemarle-Pamlico estuarine system provide the most suitable habitat for seagrass growth in North Carolina, though small patches have been identified in other estuaries. SAV covers approximately 200,000 acres (80,937 hectares (ha)) or about 7% of the estuarine bottom in North Carolina (Ferguson and Wood 1990; Ferguson and Wood 1994; Street et al. 2005; Deaton et al. 2010). Seagrass wasting disease devastated eelgrass populations in North Carolina and throughout the North Atlantic between 1930 and 1933 (Steel 1991; Street et al. 2005). Healthy eelgrass beds were generally re-established by the 1960s. High sediment loads, turbidity, herbicides, and hurricanes have also resulted in seagrass loss in North Carolina estuaries (Street et al. 2005). Seagrasses have shown signs of recovery from many of these episodic events; however, limited consistent surveying makes it difficult to quantify current trends.

Florida's extensive estuarine and nearshore seagrass beds have developed as a result of the unique and stable geological history, climate, and circulation patterns along the Florida peninsula since the last ice age (Handley et al. 2007). The waters around the Florida Keys and Florida Bay include the largest contiguous seagrass beds in the continental United States (Carlson and Madley 2007), representing almost 60% of the total seagrass acreage in the state. Seagrass beds in Florida's other Atlantic coast estuaries are less extensive, representing approximately 4% of the total extent. Seagrass coverage in western Florida Bay suffered significant losses in the late 1980s and early 1990s as the result of a massive, apparently natural die-off (Yarbro and Carlson 2013). Based on 2004 surveys, populations appear to have recovered from this event. In Lake Worth, episodic seagrass loss has been associated with freshwater releases which impact water quality; however, recovery has occurred quickly. Overall, seagrass extent within the South Atlantic Bight portion of Florida is stable (e.g., Florida Bay, Biscayne Bay, and Florida Keys) or increasing (e.g., Indian River Lagoon) (Yarbro and Carlson 2013).

Shellfish Reefs

The primary shellfish species found across the study area are Eastern oysters (*Crassostrea virginica*) and hard clams (*Merceneria merceneria*). The historic role of oysters in the southeast is evident from the oyster shell rings and middens located along estuaries and tidal rivers. These shell piles are monuments to the persistence of both abundant shellfish resources and their human harvesters for thousands of years before European settlers stepped ashore.

It is estimated that 85% of oysters have been lost globally, with populations in some individual bays classified as functionally extinct (Beck et al. 2011). The overall regional population status in the South Atlantic has been described as poor, with 90-99% of historic populations lost (Beck et al. 2011). However, the condition of populations in individual estuaries varies, with rankings from good to functionally extinct (Table 2.2).

Extensive harvest and the resulting loss of reef structure is the primary reason for the decline in oyster populations. In turn, the reef loss exacerbates the impact of additional stresses from anoxia, sedimentation, disease, and nonnative species (Lenihan and Peterson 1998, 2004; Lenihan 1999). Efforts are underway in coastal systems across the southeast to restore oyster populations through the installation of substrate materials that enable oyster settlement.

Table 2.2. Shellfish Reefs at Risk Report (Beck et al. 2009) - Condition of oyster reefs in ecoregions and their bays. Condition is based on the percent of current to historical abundance of oyster reefs remaining, where: <50% lost (good), 50-89 % lost (fair), 90-99% lost (poor), and >99% lost (functionally extinct)

Bay	Rated Condition	Data Sources/ References
Pamlico Sound (NC)	Poor	Brickell (1737); Catesby (1996); l(1905); Ingersoll (1881); Street et al. (2005); Kellog (1910); Lawson (1712); Lenihan (1999); Lenihan and Peterson (1998); NMFS (2002)
Wilmington (NC)	Fair	Street et al. (2005)
Georgetown County (SC)	Poor	Battle (1890); Burrell (2003); SC DNR (2008)
Charleston County (SC)	Fair	
Beaufort County (SC)	Good	
Georgia Coast	Poor	Bahr and Lanier (1981); Burrell (1997); Cowman (1981); Drake (1891); Harris (1980)
Mosquito Lagoon (FL)	Poor	Grizzle (1990); Grizzle et al. (2002)
South Indian River (FL)	Poor	
Sebastian River (FL)	Good	Gambordella et al. (2007)
St. Lucie (FL)	Poor	
Lake Worth (FL)	Fair	
Loxahatchee River	Fair	
Biscayne Bay (FL)	Functionally Extinct	

Diadromous Fish

A variety of organizations evaluate the population status of the six diadromous fish species selected as targets for the assessment, including the International Union for the Conservation of Nature (IUCN), U.S. Fish and Wildlife Service (USFWS), Atlantic States Marine Fisheries Commission (ASMFC), FishBase, and NatureServe. As such, the conservation status of each species varies based on an organization's criteria for evaluation.

The two species of sturgeon have a NatureServe global rank of G3, considered "globally rare." Shortnose sturgeon is listed as threatened under the Endangered Species Act (ESA). In 2012, the Carolina and South Atlantic populations of Atlantic sturgeon were listed as endangered under the ESA.

The remaining species are all ranked G5, or "globally secure" by NatureServe, but FishBase vulnerability rankings vary from moderate to very high. In addition, the ASMFC assesses and manages those species stock which are considered depleted or data-limited. Alewife and blueback herring are listed by NOAA as species of concern and are considered depleted by the ASMFC (2012). The American shad stock assessment found that stocks are currently at all-time lows and do not appear to be recovering (ASMFC 2007). Limited data are available to classify the status of hickory shad stocks.

Coastal Birds

The four federally listed coastal bird species associated with coastal systems in the South Atlantic Bight are piping plover, rufa red knot, wood stork, and roseate tern. These migratory species travel significant distances during their life histories. The role of the South Atlantic Bight varies across species and is related to particular seasons, life stages, or coastal habitats. Protection and conservation in this region is critical to the long-term recovery of all four populations.

Piping plovers breed only in North America and are classified in three geographically-based populations: Atlantic Coast (threatened), Great Lakes (endangered) and Northern Great Plains (threatened). The South Atlantic Bight is an important wintering area for the Atlantic Coast and Great Lakes populations, with seventy-five percent of the Great Lakes population utilizing the Atlantic Coast from North Carolina to the Florida Keys (USFWS 2009). To help conserve the population, critical wintering habitat areas, including estuarine and ocean beaches, have been designated.

The rufa subspecies of red knot was listed as a federally threatened species under the ESA in December 2014. Monitoring data from two locations, Tierra Del Fuego and Delaware Bay, show population declines of 70 to 75 percent since about 2000 (USFWS 2014). Coastal habitats in the southeast U.S. provide critical stop over areas during migration and can serve as a wintering areas for this highly migratory species.

Wood storks are found in freshwater and estuarine wetlands, primarily nesting in cypress and mangrove swamps. The cypress and wooded swamps along the southeastern coasts are the lone remaining breeding grounds for wood storks in the U.S., supporting over 8,000 nesting pairs (Brooks and Dean 2008; USFWS 2007). The U.S. breeding population is currently listed as endangered though the USFWS proposed a status upgrade to threatened in December 2012. The initial listing was due to a significant decrease in population between the 1930s and 1970s related to a reduction in food base associated with loss and alteration of wetland habitat.

In the U.S., the roseate tern (Caribbean population, threatened) breeds only on select shoals and beaches in the Florida Keys, Dry Tortugas, and Florida Bay (USFWS 2010; Kushlan et al. 2002). The breeding colonies face challenges of storm impacts on habitats and coastal development and have shifted locations multiple times since the 1970s.

Sea Turtles

Loggerhead sea turtles (*Caretta caretta*), found in temperate and tropical waters across the globe, are the most abundant sea turtle found in U.S. coastal waters. The Northwest Atlantic population of loggerhead sea turtle is federally listed as threatened. While juvenile and adult loggerheads can be found in the estuarine and nearshore waters of the South Atlantic, use of sandy ocean beaches for nesting is a critical connection to the coast for this migratory species. Beaches throughout the South Atlantic Bight, from Virginia to Florida, support loggerhead nesting, including South Florida which has one of two primary global loggerhead nesting aggregations with greater than 10,000 nesting females per year (NMFS USFWS 2008). Nesting levels in the southeast U.S. have shown periods of increase and decrease over the past four decades with the total estimated nesting in the U.S. fluctuating between 47,000 and 90,000 nests per year (NMFS USFWS 2008). Additional information on all sea turtle species, including in-water sightings, is available in the SABMA Marine Mammal and Sea Turtle chapter.

Ecosystem Interactions and Ecological Dependencies

Coastal Wetlands

Coastal wetlands are found at the interface of land and sea where they form linkages between inland landscapes and the ocean. Vegetated tidal wetland systems found along the South Atlantic include coastal salt marshes, freshwater marshes, forested freshwater swamps, and mangrove swamps. Non-vegetated coastal wetland habitats include tidal flats, shoals, sandbars, sandy beaches and small barrier islands (Dahl and Stedman 2013). Each of these wetland communities is influenced by tidal regime, hydrologic connection between the watershed and the ocean, and presence of vegetation. The specific type and extent of vegetated tidal wetlands varies within the project area. For example, along the coasts of southern South Carolina and Georgia, larger tidal ranges, flat geography, and significant freshwater inflow result in wide stretches of salt marsh transitioning into tidally influenced freshwater marsh and forests within coastal watersheds. Along the subtropical stretch of the coast in southeast Florida, mangrove swamps become prominent.

Coastal wetlands serve a variety of ecological roles in southeast estuaries. Wildlife such as finfish, shellfish, and birds use these habitats as spawning grounds, nurseries, and feeding areas. More than half of the fish caught recreationally and commercially depend on estuaries and associated coastal wetlands during some part of their life cycles (Lellis-Dibble et al. 2008). Movement of fishes and other macrofauna between coastal wetlands and the Continental Shelf facilitates the export of nutrients and carbon from coastal to offshore food webs (Dahl and Stedman 2013). Vegetated wetlands also have a role in improving water quality through the filtering and detoxification of runoff from upland ecosystems. Finally, they help to stabilize shorelines and buffer upland communities from storms and waves (Costanza et al. 2008).

Salt Marsh

Among the most biologically productive ecosystems on Earth (Teal 1962; Odum 1970; Valiela et al. 1976; Nixon 1980, Tiner 1984), salt marshes perform many ecosystem services that are highly valued by society. The lower salt marsh, which is covered daily by the tide, is a monoculture, dominated by the tall form of smooth cordgrass (*Spartina alternaflora*). Flooded at irregular intervals, the upper salt mash has great plant species diversity, including short smooth cordgrass, salt grass (*Distichlis spicata*), black needlerush (*Juncus roemerianus*), glasswort (*Salicornia spp.*) and sea lavender (*Limonium spp.*) (Wiegert and Freeman 1990).

Salt marshes protect estuarine water quality by acting as a sink for land-derived nutrients and contaminants (Valiela et al. 2004; Teal and Howes 2000). They are also an important component of the estuarine food web: there is a strong positive relationship between the productivity of salt marshes and the productivity of coastal fisheries (Peterson et al. 2000; Stedman and Hanson 2000; Boesch and Turner 1984). During high tide, salt marshes and the network of tidal creeks and pools within them provide food and important nursery grounds for shellfish and finfish, including many commercially harvested species (Teal 1962; Weisburg and Lotrich 1982; Dionne et al. 1999; Able et al. 2000; Cicchetti and Diaz 2000). During low tide, salt marshes provide foraging opportunities for terrestrial species including songbirds and shorebirds (Withers 2002). Salt marshes also provide valuable wildlife habitat and nesting areas for osprey, sharp-tailed sparrow, and clapper rail.

Freshwater Tidal Marsh
In regions where rivers deliver large quantities of fresh water to coastal habitats, salt water tidal marshes may grade to brackish and even completely freshwater marshes. Long bands of freshwater tidal marsh occur along the shores of the Savannah and Altamaha River estuaries, for instance. Here, the graminoid (grass and grass-like) species shift from cordgrass to cattails, rushes, wild rice, and numerous forbs, many of which are restricted to this habitat and thus rare in the region (Odum et al. 1984). Brackish and freshwater tidal marshes are important for migrating waterfowl and anadromous fishes and, like salt marshes, contribute considerable carbon to the estuaries of which they are part. In some parts of the region, these wetlands have been heavily impacted by industrial development of major ports or by dams which have shifted tidal flooding and salinity regimes. Rising sea level is a particularly important factor in determining future trends in tidal marsh health and distribution.

Tidal Forests
Freshwater tidal swamps are forested or shrub-dominated tidal wetlands that occur along freshwater tidal portions of large river systems characterized by gentle slope gradients coupled with tidal influence over considerable distances. The swamp substrate is always wet and is subject to semidiurnal flooding by fresh tidal water (salinity less than 0.5 ppt). In the temperate portion of the South Atlantic Bight, the characteristic trees are bald cypress (*Taxodium distichum*) and tupelo (*Nyssa spp*) (Mitsch et al. 2009).

Along the subtropical coastline of southern Florida, intertidal areas are often dominated by mangrove swamps. Three mangrove species are found in Florida: the red mangrove (*Rhizophora mangle*), black mangrove, (*Avicennia germinans*), and white mangrove (*Laguncularia racemosa*). Mangroves are primarily found in estuarine waters where they serve as valuable nurseries for recreationally and commercially important marine species (Dahl and Stedman 2013; National Park Service 2010). Human-induced impacts to mangrove wetlands include proliferation of invasive species, cutting/removal, and coastal development resulting in drainage, filling, or changes to shoreline structure (Dahl and Stedman 2013).

Estuarine Beaches and Tidal Flats
Estuarine beaches and tidal flats have received less attention by resource managers than vegetated tidal wetlands or ocean beaches. Sediment size, sediment chemistry, inundation cycle, salinity, frequency of disturbance, and latitude are all determinants of the biotic community within tidal flats (Peterson and Peterson 1979). Notably, these areas often provide habitat for shellfish such as Eastern oyster (*Crassostrea virginica*) and hard clam (*Mercenaria mercenaria*). In addition to the typical resident invertebrate communities of annelids, crustaceans, and bivalves, tidal flats are foraging grounds for

marine organisms such as eels, crabs, fish, snails, and shrimp at high tide and terrestrial organisms, particularly shorebirds, at low tide (Harrington 1999).

Ocean Beaches

Sandy ocean beaches in the region are primarily associated with barrier island systems. In their natural state, sand-derived barrier islands and barrier beaches attached to the mainland are highly dynamic, constantly shaped and reshaped by winds, storms and ocean currents (Stedman and Dahl 2008). Generally speaking, prevailing winds and nearshore currents cause North Atlantic barrier islands to migrate slowly southward, with sand lost from the north end often transported to build new beaches and dunes at the south end. Hurricanes and nor'easters episodically move tremendous quantities of sand both onshore and offshore as well as along the main axis of the islands. Barrier beaches typically protect tidal lagoons, coastal salt ponds, or salt marshes behind them.

Sandy beaches are breeding grounds for endangered and threatened species such as the piping plover, least tern, and roseate tern as well as several species of sea turtles. They also provide overwintering sites for migrant shorebirds (Harrington 1999). The sand of an open beach may appear relatively devoid of marine life, but a variety of species live in the sand as infauna, often serving as important food sources (Bertness 2006).

Seagrass Beds

Seagrasses are marine, subtidal, rooted vascular plants found on the bottom of protected bays, lagoons, and other shallow coastal waters along most of the East Coast of the United States. The exception is the coastal waters of South Carolina and Georgia where high freshwater input, turbidity, and large tidal amplitude inhibit seagrass occurrence (Street et al. 2005). Eight seagrass species occur in the South Atlantic project area. Eelgrass (*Zostera marina*) and shoal grass (*Halodule wrightii*) are the primary species found in North Carolina, while turtle grass (*Thalassia testudinum*) and manatee grass (*Syringodium filiforme*) are the two subtropical species that dominate southern Florida.

Highly productive seagrass beds provide food and critical spawning and refuge habitat for fish and invertebrates (Wyda et al. 2002; Heck et al. 2003). The plants can contribute significantly to the overall primary productivity of an estuary with energy present in seagrass entering the estuarine food web as detritus. In addition, numerous animals feed directly on seagrasses, including fishes, geese, swans, manatees, sea turtles, and crabs. The South Atlantic Fisheries Management Council (SAFMC) classifies submerged aquatic vegetation, including seagrasses, as Essential Fish Habitat for peneaid shrimp, red drum, and snapper/grouper species. In addition, the complex networks of leaves, roots, and rhizomes serve to trap nutrients and sediments, protect shorelines from erosion, and filter pollution (SAFMC 2009).

Shellfish Reefs

Prominence as a food source often overshadows the critical roles that shellfish play in ecosystem function (Grabowski and Peterson 2007). A variety of bivalves occur in the coastal waters of southeastern estuaries, including Eastern oysters (*Crassostrea virginica*), hard clams (*Mercenaria mercenaria*), ribbed mussels (*Geukensia demissa*), and bay scallops (*Argopecten irradians*). Bivalves are suspension feeders that, in abundant colonies, have the capacity to filter volumes of water equivalent to entire bays in a matter of days (Newell and Koch 2004). As the region's most prevalent, monitored, and commercially valuable shellfish species, the assessment focuses on the Eastern oyster. Oysters form reefs in subtidal areas to depths of 10 m and in intertidal areas, tolerating a wide range of temperatures and salinity levels. Outside of the Albemarle and Pamlico Sounds, the majority of oysters in the South Atlantic are found in the intertidal zone.

Oysters are widely recognized as "ecosystem engineers" that create essential fish habitat, augment water quality, and provide services fundamental to the ecological health of estuaries and nearshore areas. Reefs formed by oysters provide refuge and structure for many marine plants, animals, and invertebrates (ASMFC 2007), including economically valuable fish (Peterson et al. 2003; Coen et al. 2007). In intertidal areas, shellfish beds trap sediments and stabilize shorelines against wave and storm erosion (Piazza et al. 2005; Meyer et al. 1997). Larval forms of bivalves serve as prey for marine invertebrates and fish. As juveniles and adults, bivalves are major forage for all forms of fish, invertebrates (especially crabs, whelks, and starfish), shorebirds, seabirds, and even mammals (Coen et al. 2007).

Diadromous Fish

Diadromous fish are those species that travel between freshwater and marine environments to complete different stages of their life cycle. The target species in this assessment are anadromous, migrating from salty ocean and estuarine waters upstream to breed in freshwater rivers. Because of this migration pattern, diadromous fish provide unique connections among marine, estuarine, and riverine habitats. Healthy populations of diadromous fish are dependent on access to spawning areas upstream, appropriate flow and temperature conditions, and viable estuarine and nearshore marine nursery and feeding grounds (ASMFC 1999).

While serving as keystone species, diadromous fish themselves can influence systems as migratory fauna by providing a significant source of energy input. Species like alewife and American shad appear to play an important role in their freshwater spawning habitats, providing nutrients that assist microbes in the breakdown of leaf litter and the resulting release of that stored energy to consumers (Durbin et al. 1979; ASMFC 1999). Specific associations between diadromous fish and other species also exist. For example, many freshwater mussels are dependent upon migratory fishes as hosts for their parasitic larvae (Neves et al. 1997; Vaughn and Taylor 1999), such that loss of upstream migratory fish habitat is a major cause of mussel population declines (Williams et al. 1992; Watters 1996). These historically abundant species serve as prey in rivers and estuaries for larger predatory fish such as bluefish and striped bass, gulls, osprey, cormorants, river otter, and mink, and at sea for seals, sea birds, and a wide range of piscivorous (fish-eating) marine fish.

Coastal Birds

A wide variety of birds utilize the coastal systems of the South Atlantic Bight for breeding, overwintering, migration and foraging (Hunter et al. 2006). Many species of seabirds, shorebirds, and wading birds found along the coast are highly migratory, making use of South Atlantic coastal habitats for only a portion of their life cycle. Sandy beaches, tidal flats and bays along the coast are particularly important habitats. For example, salt marshes, coastal swamps, and sandy beaches within the South Atlantic Bight serve as critical nesting habitat for migratory species such as wood storks and American oystercatchers. The Florida Keys, Dry Tortugas and Florida Bay support the only breeding colonies of bridled tern, great white heron, magnificent frigatebird, masked booby, and roseate tern in the U.S. (Kushlan et al. 2002). While global populations of these subtropical waterbirds may be stable, there is conservation interest in ensuring that these Florida sites are maintained.

Many migratory species that breed in colder regions, including the Great Lakes and Canada, overwinter in the warmer southeast United States. For example, the federally threatened piping plover roosts on sandy beaches in close proximity to sand and mudflats for foraging across the region (Elliot-Smith et al. 2009; USFWS 2009). Though it does not breed in the southeast, the American bittern is fairly common during the winter, with the Southeast U.S. supporting perhaps a third of all North American breeding birds in the nonbreeding season (Watson and Malloy 2008).

Stopover sites are areas where migrating species stop to feed and refuel. Because many seabirds and shorebirds breed in the far north and winter in the southern hemisphere, productive stopover sites are important to maintaining the species. Intertidal areas, mudflats, and sandy beaches are particularly important to many shorebird species. Recently listed by USFWS as threatened, the rufa red knot is an example of a long-range migrant that makes use of South Atlantic unvegetated wetland areas as stopover sites (USFWS 2014).

Sea Turtles
Loggerhead sea turtles utilize three ecosystems throughout their lifetime – beaches, open water and nearshore coastal areas - generally preferring high energy, relatively narrow, steeply sloped, coarse-grained beaches for nesting (NMFS USFWS 2008). Ocean beaches are threatened by activities including coastal development, beach renourishment and climate change. In July 2014, the USFWS designate 88 nesting beaches located in the southeast U.S. and Gulf of Mexico as terrestrial critical habitat areas, accounting for 48 percent of an estimated 2,464 km (1,531 miles) of coastal beach shoreline and about 84 percent of the documented nesting within these six states (79 CFR 39756).

U.S. South Atlantic Distribution and Important Areas

Methods

Coastal Wetlands
The National Wetland Inventory (NWI) was used as the base regional dataset to map intertidal wetland habitats, including 1) saltwater and brackish marsh, 2) tidal freshwater marsh, 3) tidal forests, 4) tidal flats, 5) estuarine beaches, and 6) ocean beaches. The NWI database provides a consistent categorization of wetland habitat types throughout the project area and is the best source for incorporating tidal influence across coastal habitat types. The USFWS provides access to the NWI database online (http://www.fws.gov/wetlands/NWI/index.html); the data used in the assessment were downloaded in August 2013.

The six wetland habitat types listed above were mapped by extracting polygons coded as tidal from the NWI (USFWS 1990; Cowardian et al. 1979) and using the Sea Level Affecting Marshes Model (SLAMM) classification system (Craft et al. 2009; Clough et al. 2010) to categorize polygons into SABMA wetland habitat types (Table 2.3).

Table 2.3. Classification of NWI codes into SABMA target categories using the SLAMM classification

SABMA Habitat	SLAMM Model Classification System National Wetland Inventory Codes
Salt Marsh	E2EM, selected portion E2US located in salt marsh complexes (salt pans)
Freshwater Marsh	E2EM with oligohaline (6) modifier, PEM with tidal regime modifier (R to V). Includes freshwater marsh impoundments found in the tidal range (h)
Tidal Forests	E2SS or E2FO, excludes modifier 3 represents tropical areas (Mangroves); E2SS or E2FO with oligohaline {6} modifier and PSS or PFO with R to V tidal regime modifier
Oceanfront Beach	Marine Unconsolidated Substrate M2US
Estuarine Beach/Tidal Flats	Estuarine and Freshwater unconsolidated shores (E2US & E1US with modifiers P, N, and M), Estuarine aquatic bed (E2AB).

The age of the NWI data varies significantly across the South Atlantic project area (Figure 2.2). For example, updated wetland data have been processed using 2006 imagery for the entire coast of Georgia (Tiner 2011), while available NWI data for portions of South Carolina and northeast Florida uses imagery dating from the 1980s and 1990s. To evaluate the effect of data age on spatial representation of wetlands, the NWI was compared to available national, regional and state data resources. Habitat-specific decisions were made on whether enhance or substitute for the base NWI dataset. Final modifications are described below.

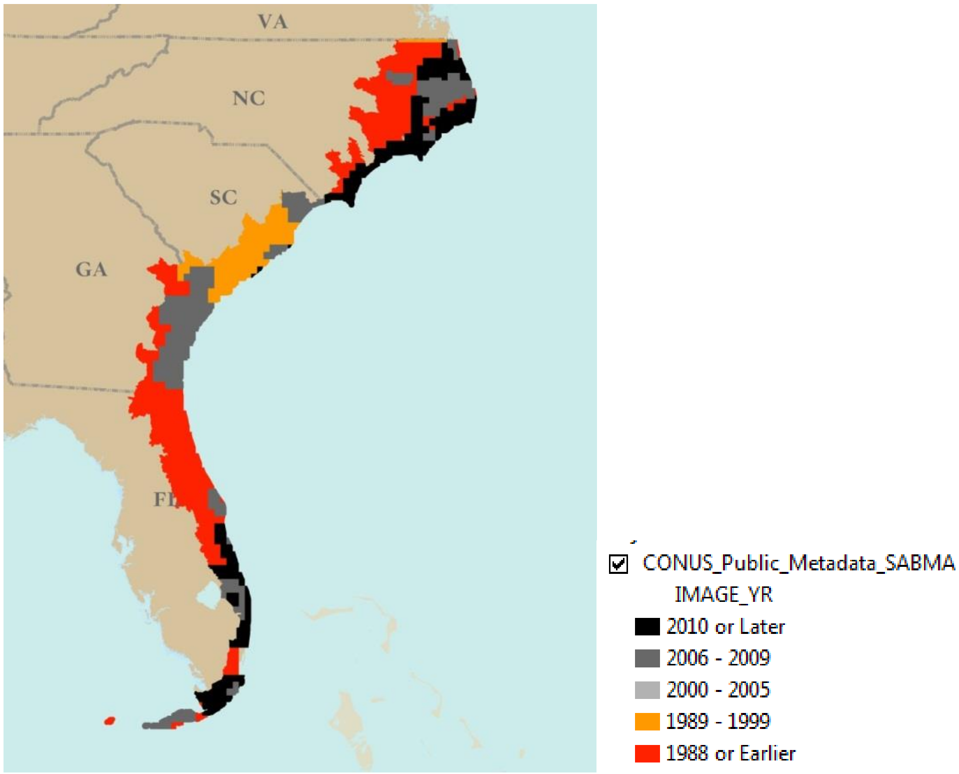

Figure 2.2. Age of National Wetland Inventory (NWI) as of August 2013 when data was downloaded for the Assessment

SALT MARSH AND TIDAL FRESHWATER MARSH

NWI data were visually compared to the U.S. Geological Survey (USGS) Gap Analysis Program Land Cover (GAP) - Southeast dataset (USGS and NC State University 2010) and National Oceanic and Atmospheric Administration's (NOAA) Coastal Change Analysis Program (C-CAP) Regional Land Cover (NOAA Coastal Services Center 2006). Both are available for the entire project area and utilize more recent satellite imagery. Where appropriate, the NWI data were augmented by "heads up" or hand digitizing polygons based on the GAP and CCAP data. A total of 21,631 acres was added to the salt marsh and tidal freshwater marsh datasets using this methodology. The ACE Basin in southern South Carolina serves as an example (Figure 2.3).

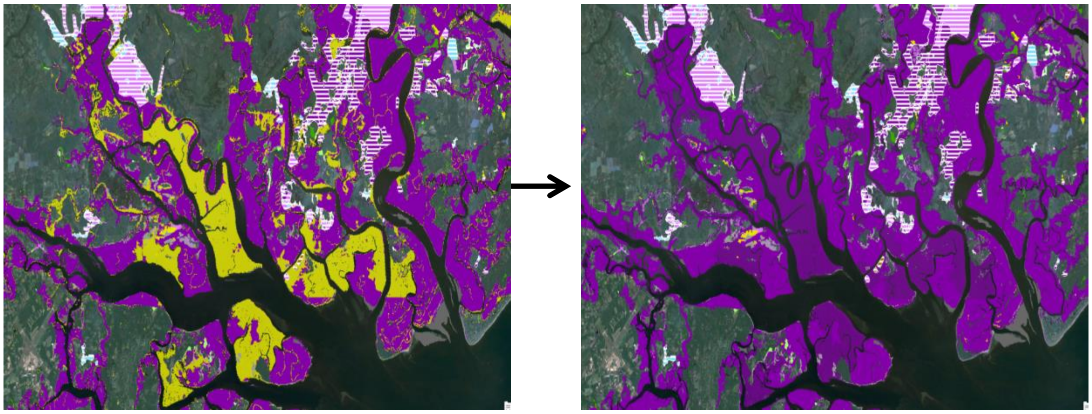

Figure 2.3. Visualization of the ACE Basin (SC) area depicting hand digitizing used to refine the NWI: Purple = salt marsh, Yellow = uncharacterized in NWI, White Striped = Impoundments

TIDAL FLATS AND BEACHES

The NWI unconsolidated sediment classes were separated into tidal flats, estuarine beaches, and ocean beaches based on location using SLAMM guided methodology. Review of the ocean beach classification revealed a significant gap using NWI along the Atlantic coast of Florida. To overcome this gap, the decision was made to substitute Florida Cooperative Land Cover (CLC, v2.3) data for NWI for the entire stretch of Florida Atlantic coastline. The CLC uses the Florida Land Cover Classification System (FLCS), a hierarchical classification system developed by the Florida Fish & Wildlife Conservation Commission (FL FWC, Kawula 2009). Areas classified as "Sand Beach" in the FLCS were incorporated into the SABMA ocean beach dataset.

MANGROVES

Mangrove ecosystems are identified within the NWI; however, discussion with Florida state agency partners revealed that the mangrove dataset maintained by the FL FWC is the preferred data source. The FL FWC data layer has increased accuracy and is generally more up-to-date. Since mangroves are only found in Florida, the FL FWC mangroves dataset was used as the primary dataset to classify mangrove habitats within the SABMA analysis.

SEAGRASS BEDS

Limited seagrass habitat data are available through the NWI, given their submerged nature. Therefore, seagrass coverage was determined by combining state and local data sources from North Carolina and Florida. The North Carolina seagrass data, extending from Back Bay, Virginia south through Bogue Sound, are based on aerial imagery collected between 2003 and 2008. It is a compilation of several data sets from the Albemarle-Pamlico National Estuary Program, Elizabeth City State University and NC Department of Environment and Natural Resources, Division of Water Quality. The Florida seagrass dataset is a compilation of imagery and field measurements dating between 1987 and 2010 (Yarbro and Carlson 2013). Seagrass is not present in South Carolina and Georgia (Figures 2.4-2.7).

Seagrass patches are inherently dynamic with respect to interannual location and density. North Carolina and Florida use different definitions to describe the condition of and connectivity between seagrass beds within their individual datasets. This variation limited the viability of regional evaluation that incorporates condition information. The decision was made not to include details related to seagrass "patchiness" or density as part of the SABMA analysis. The result is an accounting of total seagrass presence within the project area which provides a more robust evaluation of habitat. When available, the finer scale delineations of continuity/discontinuity are preserved in the dataset.

Shellfish Reefs

Shellfish habitat is not categorized in the NWI, so alternative data sources were evaluated. Reports of shellfish population distribution, abundance, and health status are not available consistently for the region. Oyster information was the most readily available, though the extent and condition of the data varied significantly from state to state. The entire coastlines of North Carolina and South Carolina have been surveyed while Georgia and Florida surveys are limited to certain waterbodies or managed areas. To analyze oyster distribution, state-specific data (Table 2.4) were compiled to create a regional oyster data set that spatially describes areas surveyed and associated distribution of oyster reefs (Figures 2.8-2.11).

Table 2.4. Description of state data sources used to map oyster populations

State Shellfish Habitat Data Sources		
North Carolina	Estuarine Benthic Habitat Mapping Program (2011)	Based on high resolution imagery of coastal shoreline areas from 1989 to 2011. Aerial extent includes Roanoke Island southward to NC/SC state line.
South Carolina	Intertidal Oyster Reef Map (2010)	Based on high resolution imagery from 2003 to 2008. Statewide.
Georgia	Shellfish Harvest Areas Mapping (2013)	Based on high resolution imagery from 2010. Limited to designated shellfish harvest areas.
	GA Coastal Georgia Shellfish Inventory: Chatham County (2007), McIntosh County (2011)	Based on field mapping using GPS to identify live oyster reefs in Chatham and McIntosh County from 2007–2011.
Florida	FWC Oyster Data Layer (2011)	Based on high resolution imagery from 2003 – 2009. Limited to select study sites.

Diadromous Fish

As part of the Southeast Aquatic Connectivity Assessment Project (SEACAP), The Nature Conservancy compiled available historic and current population information for six diadromous fish species: blueback herring, American shad, hickory shad, alewife, shortnose sturgeon, and Atlantic sturgeon using data collected by the Atlantic States Marine Fisheries Commission as the primary data source (Greene et al. 2009). This data set was updated with direct feedback from biologists serving on the SEACAP working group (TNC, in progress; E. Martin, personal communication). The metric used in this assessment was presence/absence of the six selected species in southeast river stretches, primarily mainstem rivers, based on a combination of population monitoring and availability of critical habitat (e.g., spawning, overwintering) (Figure 2.12).

Coastal Birds

In selecting data resources for the coastal bird analysis, the desire was to incorporate population-based data that could augment the regional habitat maps being developed. A variety of data sources were considered (see sidebar); however, difficulty in comparing state data at a regional scale, use of habitat versus population to define important areas, and time limitations led to a focus on the Western Hemisphere Shorebird Reserve Network (WHSRN 2010). Sites are selected for inclusion in the WHSRN based on the exceptional number of shorebirds that visit annually or the representative percent of a biogeographic population for a given species. The three WHSRN site categories are:

- Hemispheric Importance: at least 500,000 shorebirds annually, or at least 30% of the biogeographic population for a species
- International Importance: at least 100,000 shorebirds annually, or at least 10% of the biogeographic population for a species
- Regional Importance: at least 20,000 shorebirds annually, or at least 1% of the biogeographic population for a species

Two WHSRN sites are located in the SABMA project area. Cape Romain National Wildlife Refuge is listed as a Site of International Importance. The refuge supports over 10% of the wintering population of American oystercatchers along the Gulf and Atlantic Coasts and peak counts during spring and/or fall equaled or exceeded 15% of the eastern U.S. totals for eight species (American oystercatcher, short-billed dowitcher, dunlin, willet, whimbrel, Wilson's plover, and semipalmated plover). The Altamaha River Delta is designated as a Site of Regional Importance with at least 20,000 shorebirds visiting annually. Polygons for both sites are included within the assessment (Figure 2.13).

Loggerhead Sea Turtle Nesting

As described in the Marine Mammal and Sea Turtle chapter, five genetic subpopulations of loggerhead sea turtles have been identified in the region (Shamblin et al. 2011, 2012; FWC 2014). The goal for the coastal analysis was to identify the most critical beaches for each subpopulation of loggerhead turtle. Surveyed shoreline that was ranked in the top 25% for loggerhead nesting density for each subpopulation was selected in order to quantify the shoreline distance (km) of high-density nesting beaches.

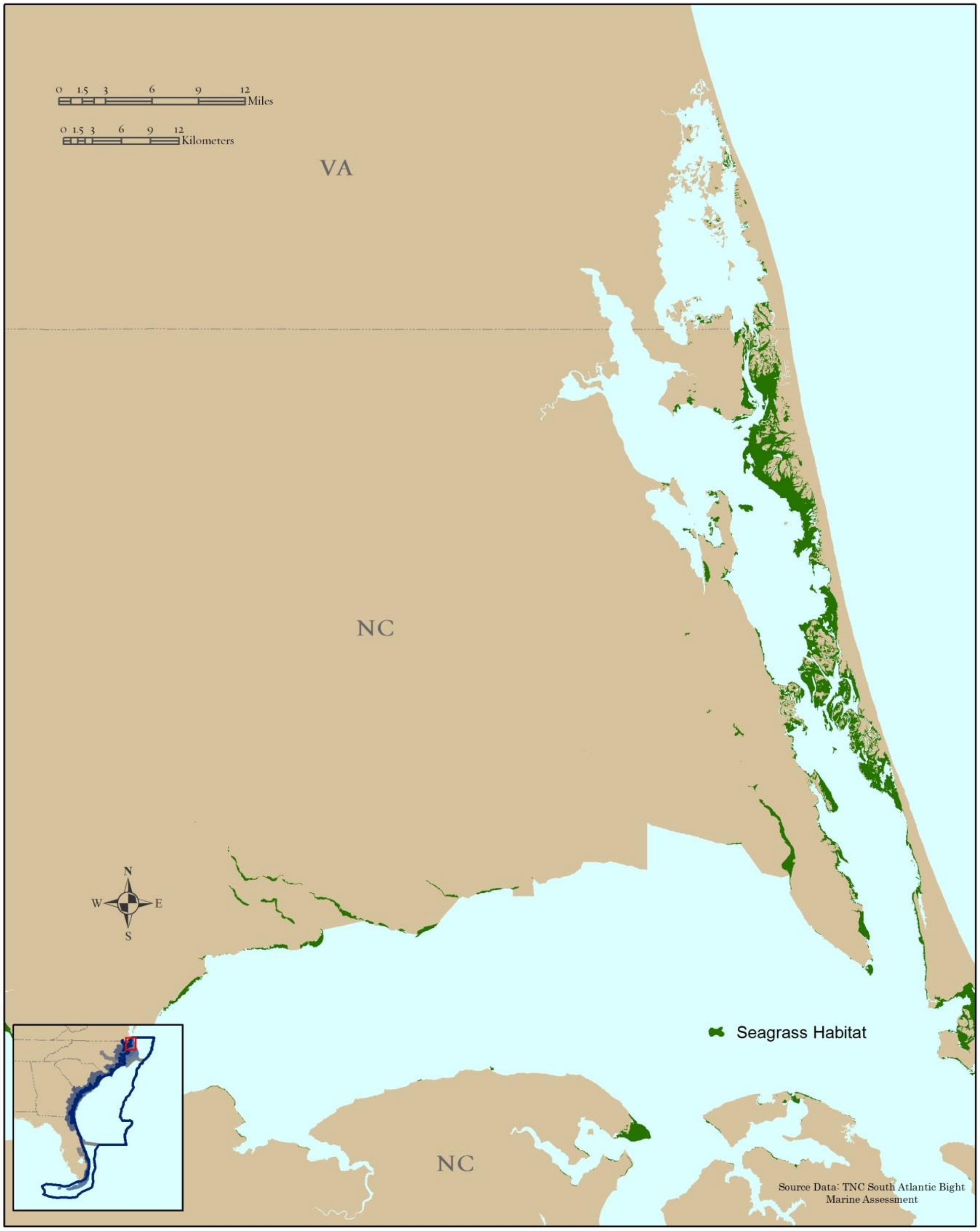

Figure 2.4. Map of seagrass habitat in southern Virginia and northern North Carolina

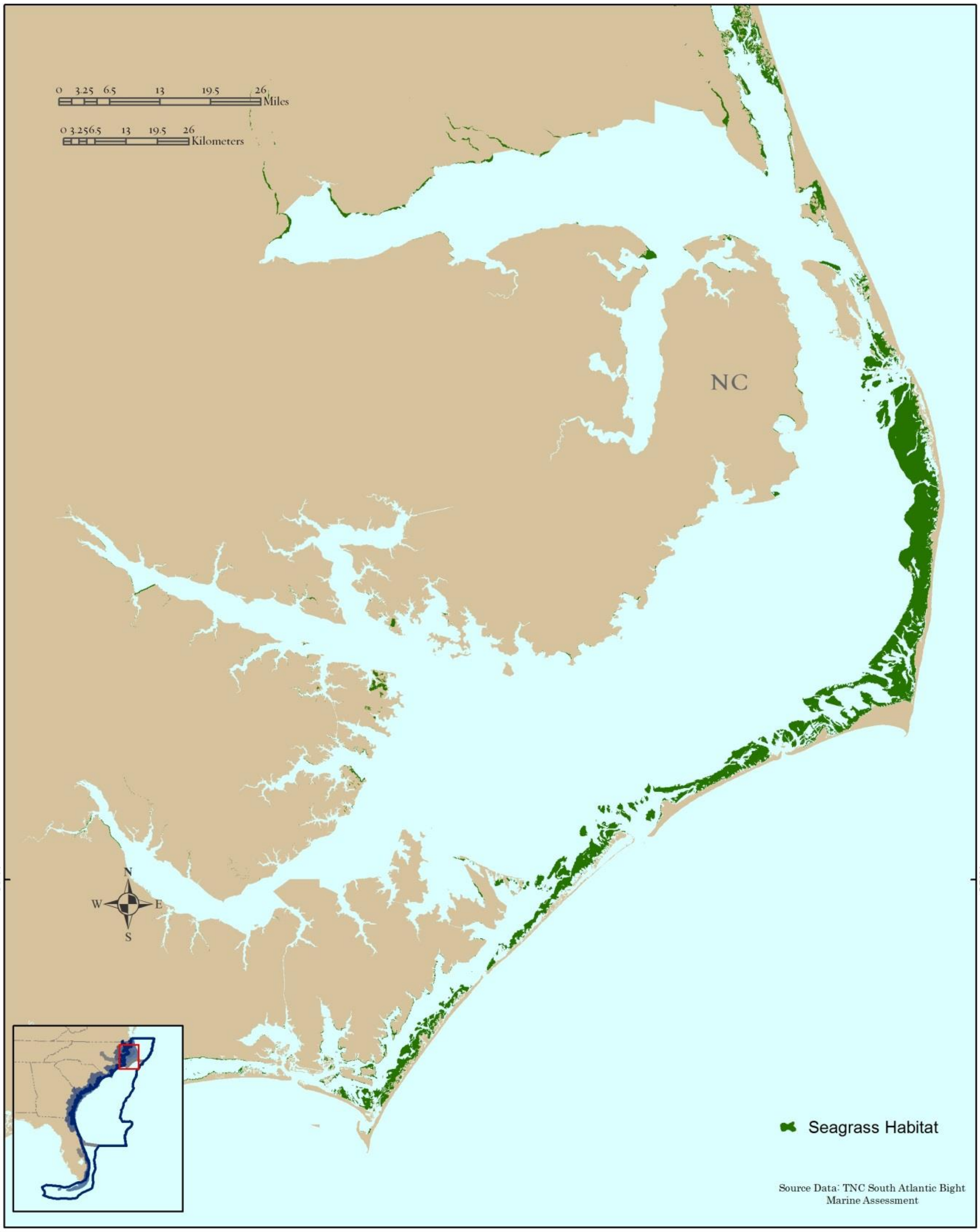

Figure 2.5. Map of seagrass habitat in Albemarle-Pamlico Sound

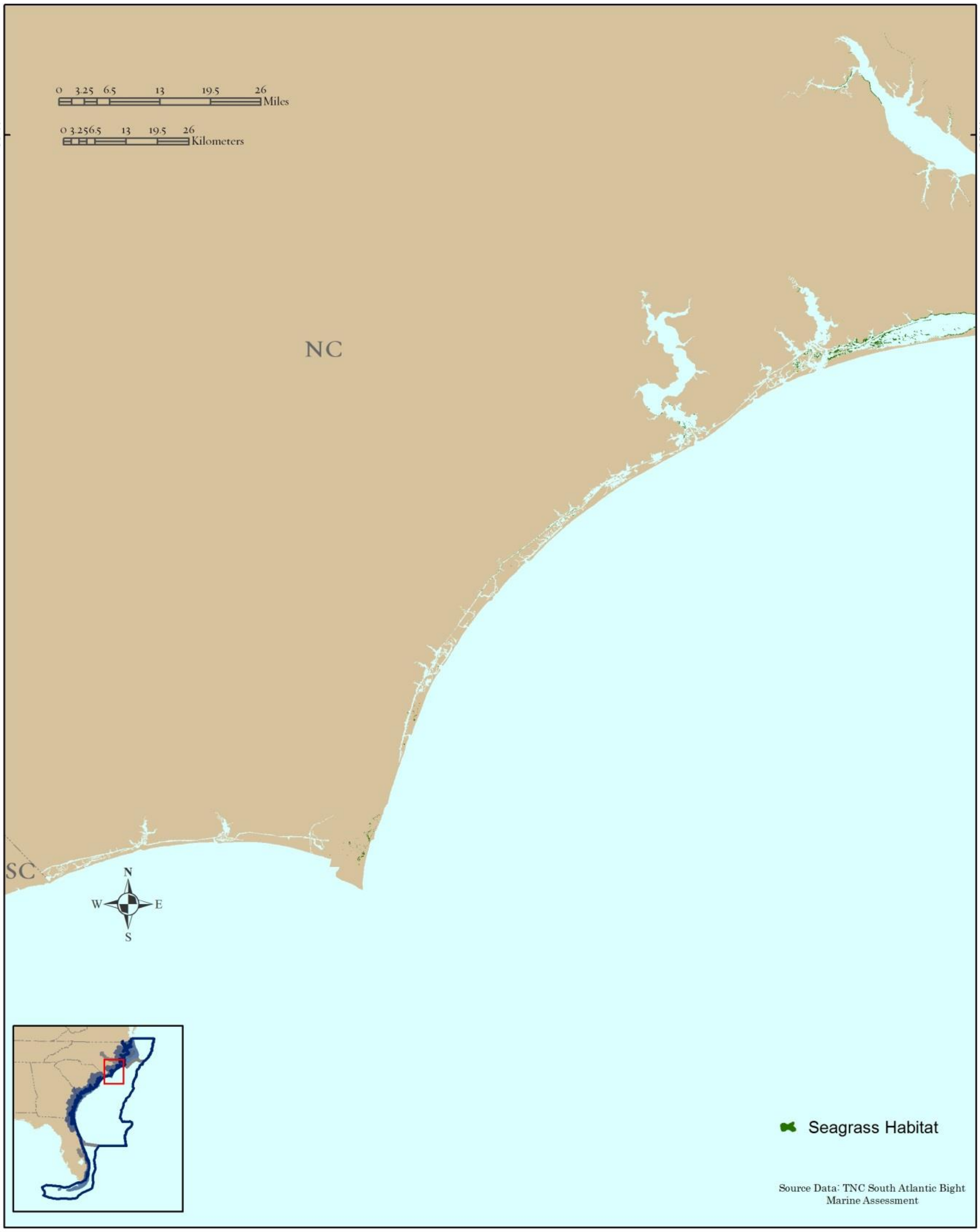

Figure 2.6. Map of seagrass habitat in southern North Carolina

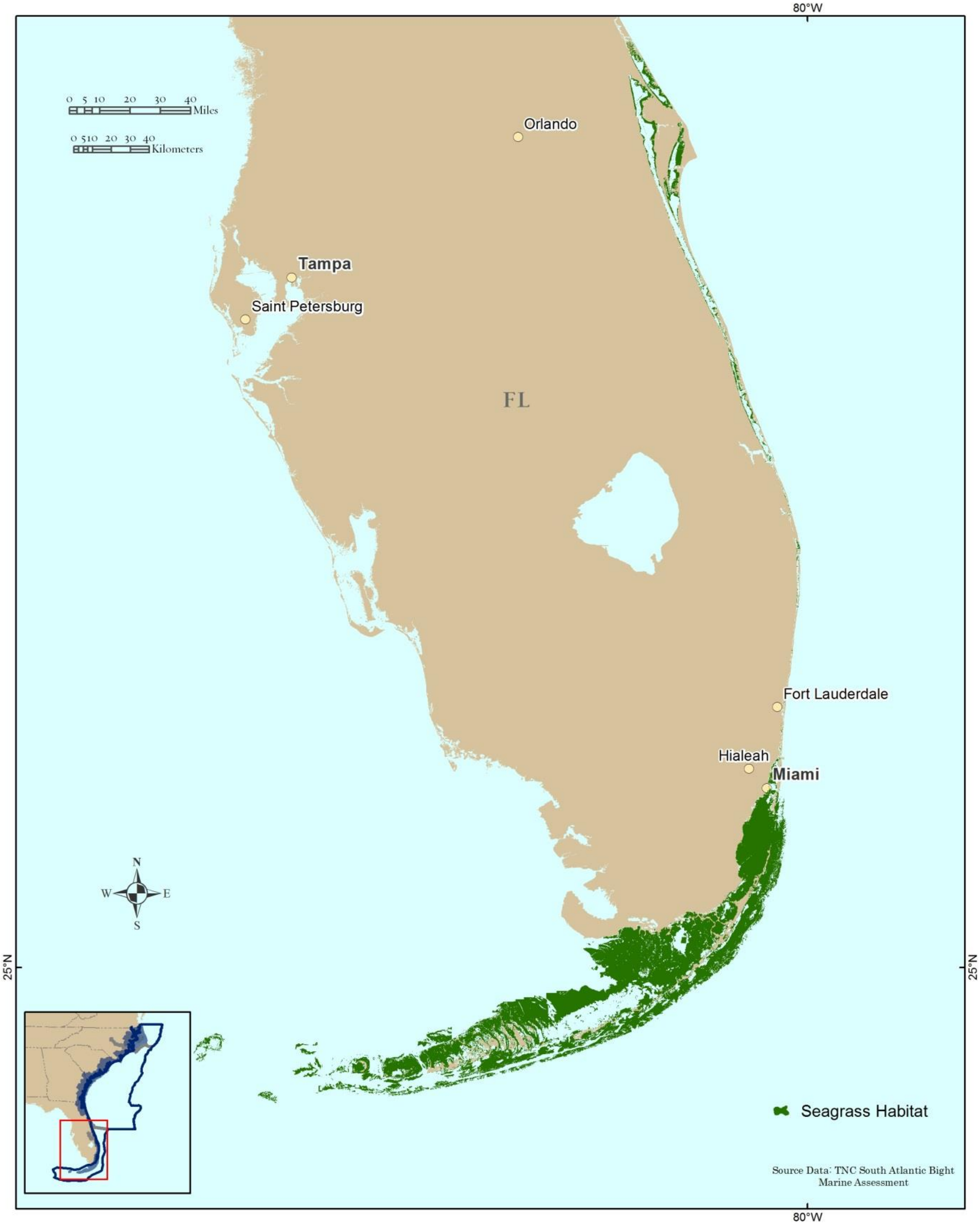

Figure 2.7. Map of seagrass habitat in Florida

Figure 2.8. Map of shell bottom (including oyster) locations and surveyed areas

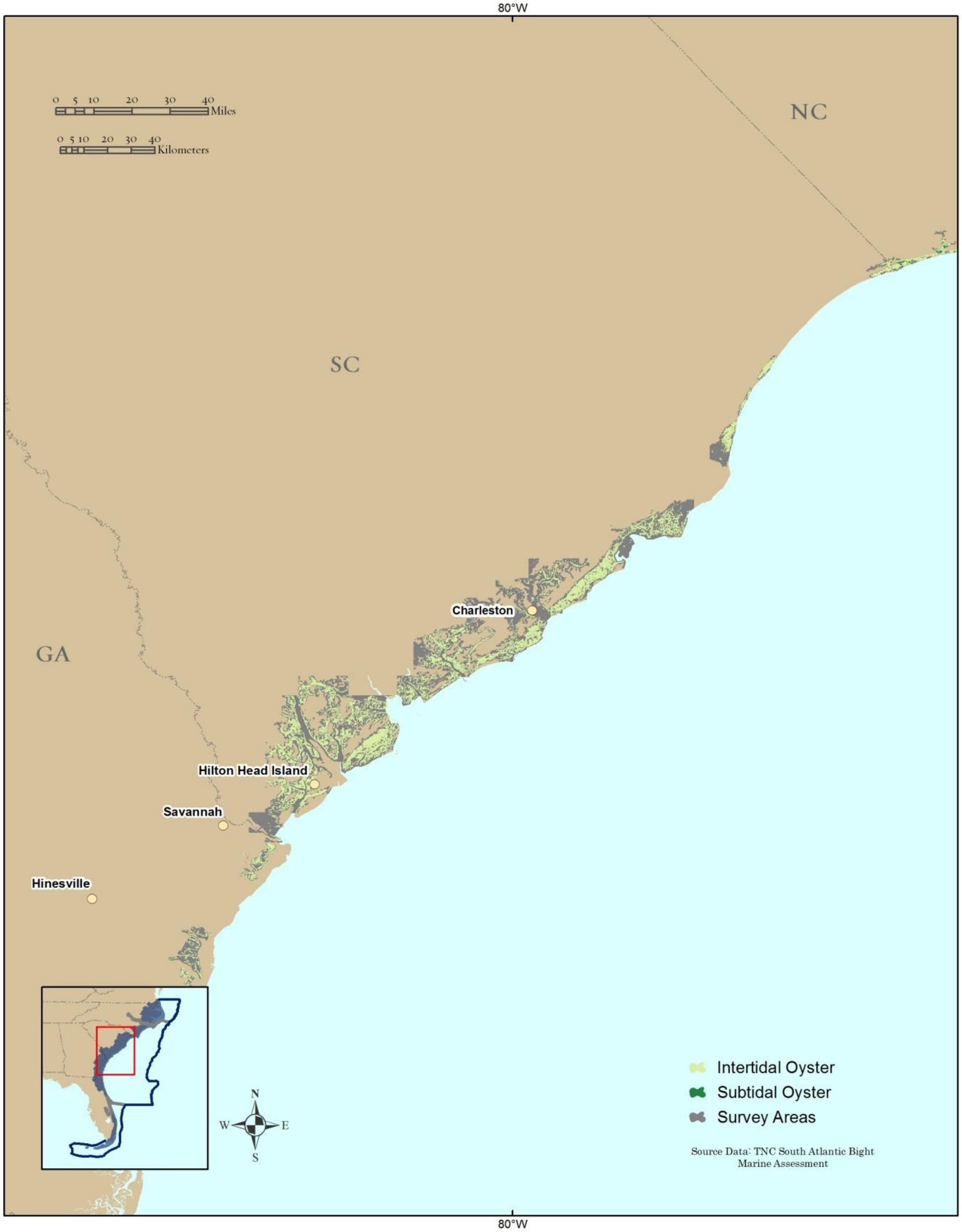

Figure 2.9. Map of oyster reef locations and surveyed areas in South Carolina

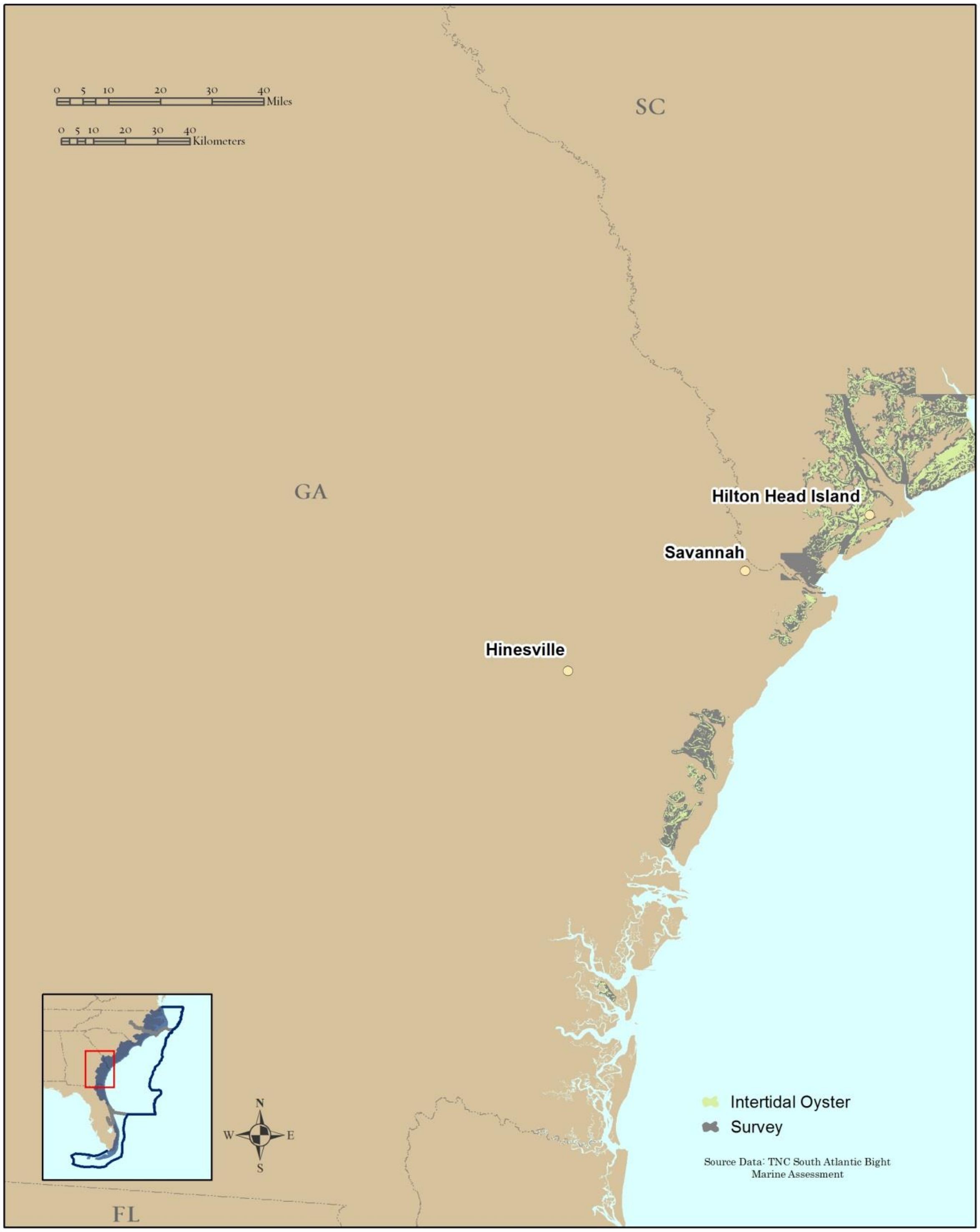

Figure 2.10. Map of oyster reef locations and surveyed areas in Georgia

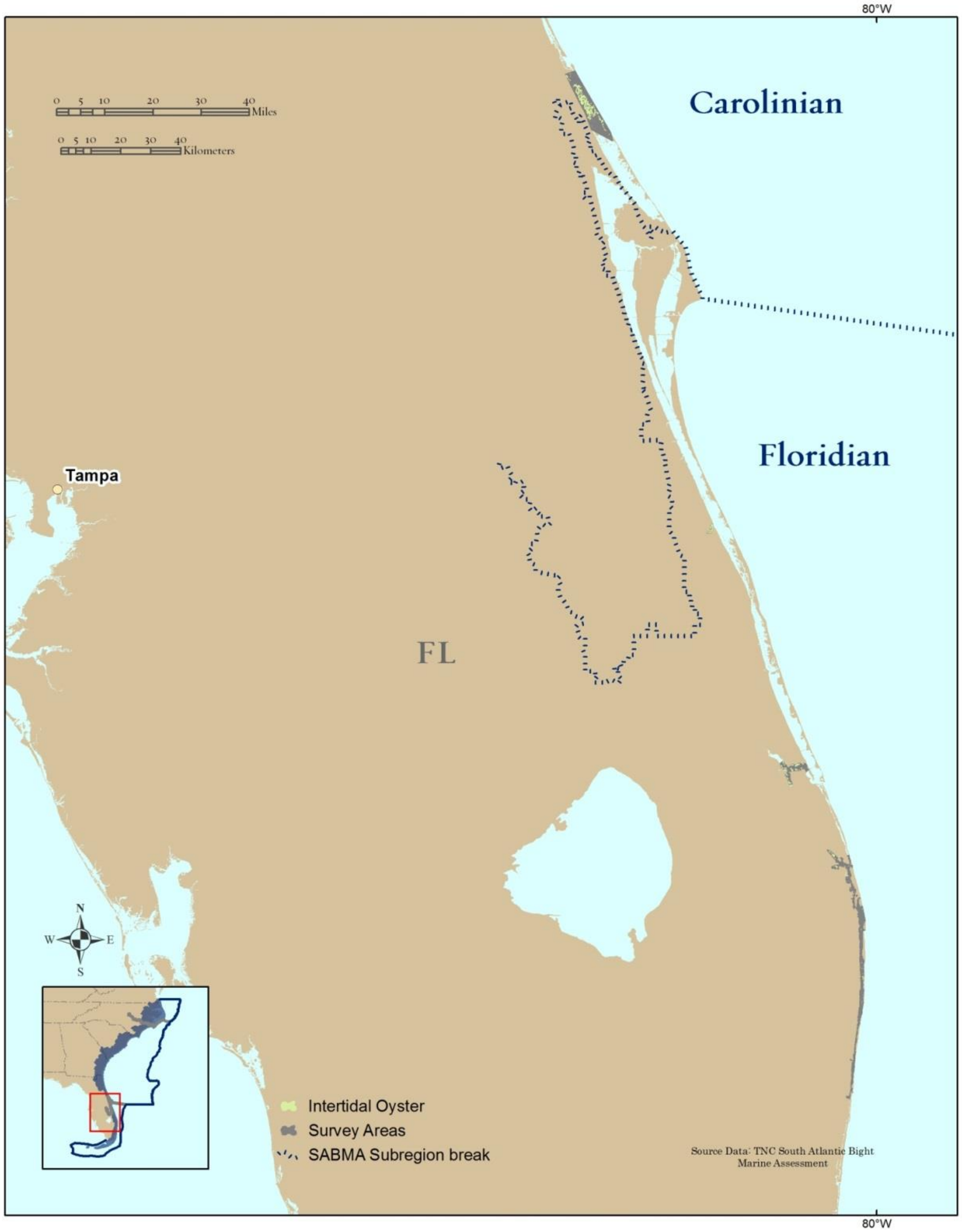

Figure 2.11. Map of oyster reef locations and surveyed areas in Florida

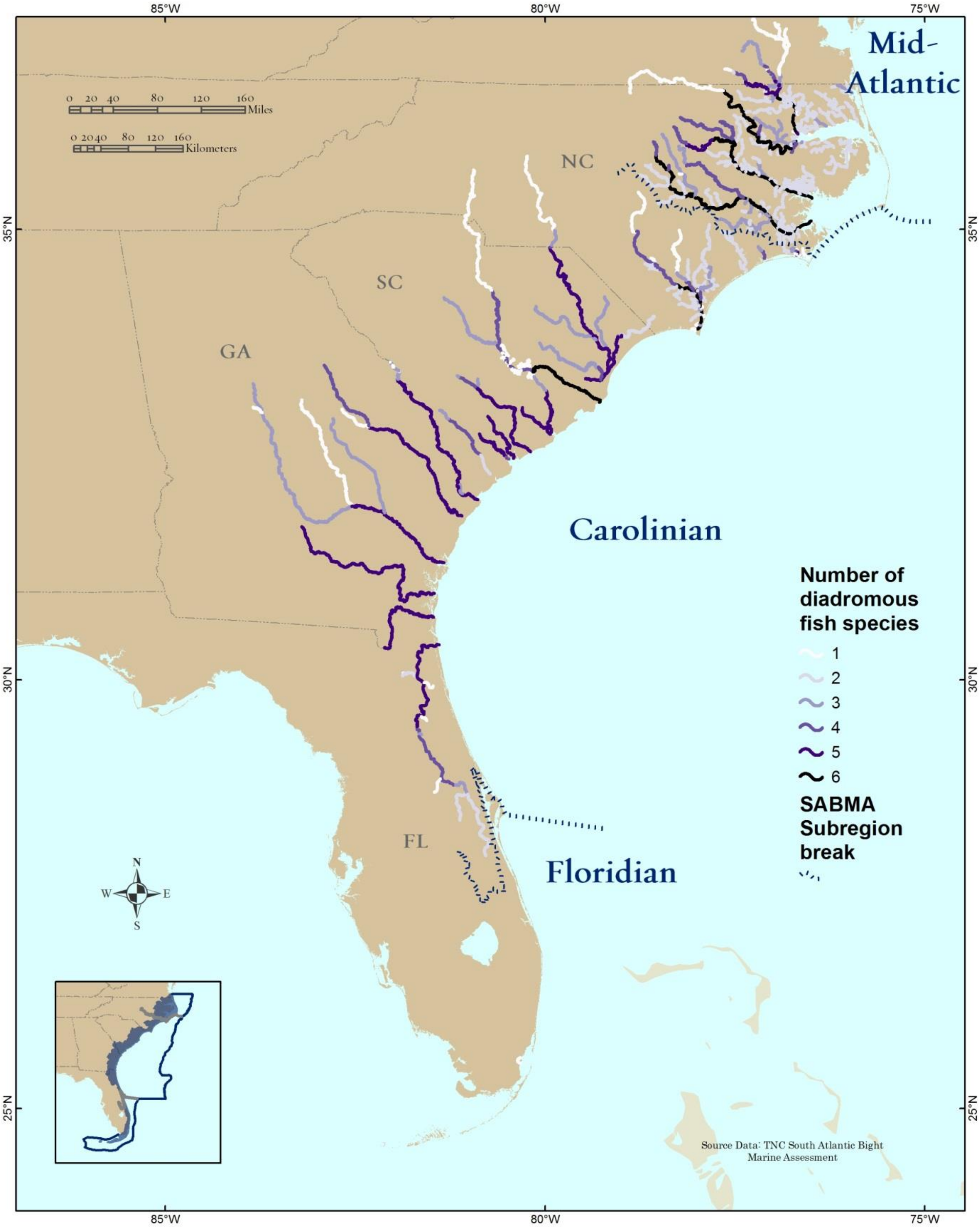

Figure 2.12. Map representing the number of prioritized diadromous fish species present within given stream miles

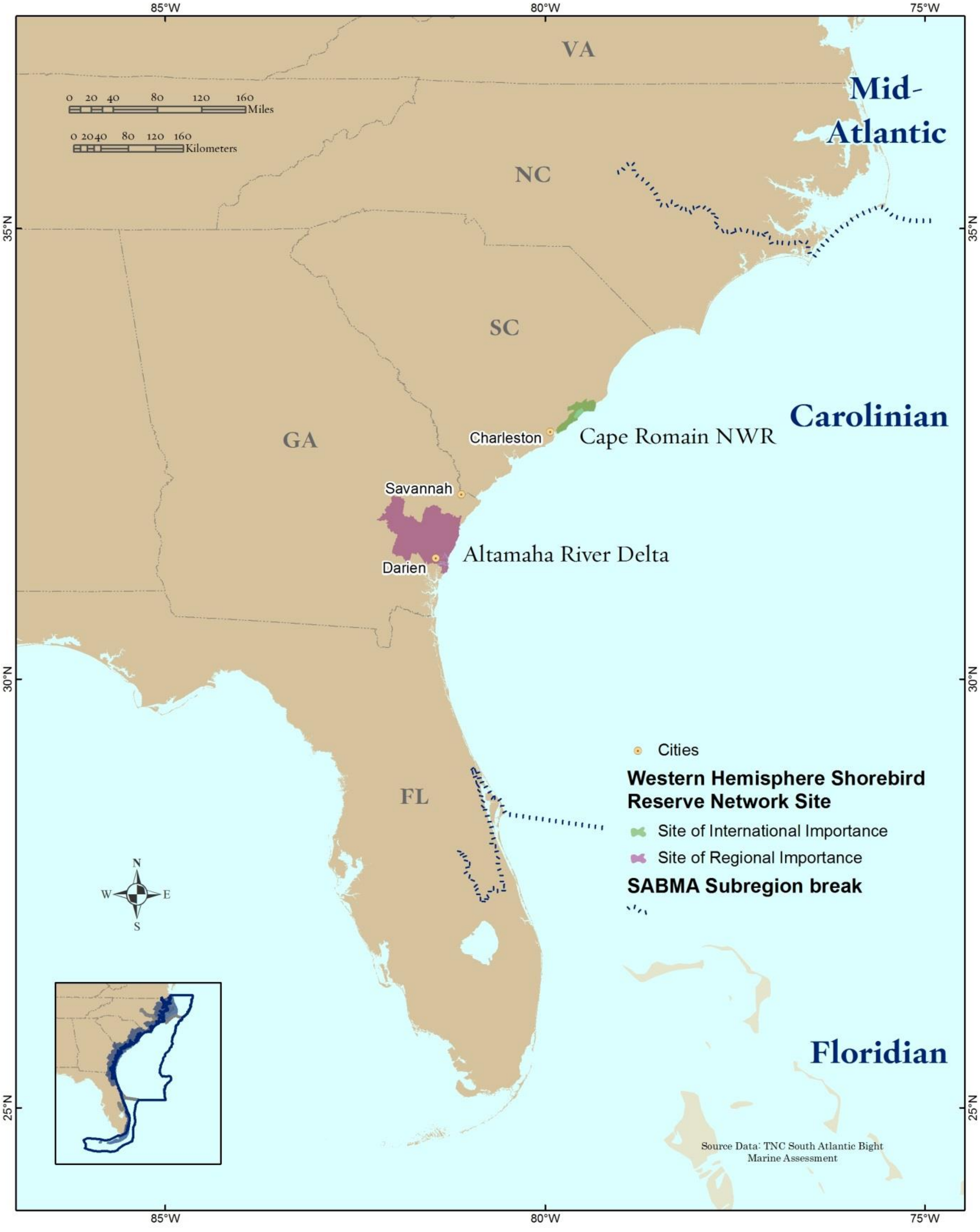

Figure 2.13. Map of Western Hemisphere Shorebird Reserve Network Sites in the South Atlantic

Box 2.2. Shorebird and Waterbird Resources in the South Atlantic

A variety of regional and state data sources were reviewed for their potential to identify and delineate high population areas for prioritizing shorebirds and waterbirds within the project area. Time constraints, data gaps, spatial challenges, and inconsistency across region level did not enable their incorporation in this iteration of the assessment. However, with further investigation and analysis, the population-based surveys could help improve our understanding of coastal bird habitats.

Wood Stork Aerial Survey: Aerial surveys have been used to census wood stork nesting colonies beginning between 1957 and 1960. Brooks and Dean (2008) compiled and summarized survey data from 1984 to 2006 to determine status of the species using number of nesting pairs and regional productivity over time.

International Piping Plover Winter Census Survey (Elliot-Smith et al. 2009): The International Piping Plover Winter Census Survey has been conducted by federal and state agency partners every five years since 1991. All sites are surveyed between late January and early February to capture wintering areas. Though this sampling window may miss peak migration and wintering populations, the consistency of data collection across the project area made the data set viable for the assessment with limited changes.

American Oystercatcher Aerial Survey: During the 2002-2003 non-breeding season, the Manomet Center for Conservation Sciences conducted an aerial survey in cooperation with members of the American Oystercatcher Working Group. The survey of the Atlantic and Gulf coasts encompassed the entire winter range of the eastern race of the American oystercatcher in the United States. The survey resulted in a population estimate of 10,971 ± 298 individuals, with 8,500 wintering on the Atlantic (Brown et al. 2005). The USFWS Oystercatcher Working group used this survey data in combination with state-based surveys to identify a suite of important breeding and wintering sites, each of which represents >1% of the biogeographical population.

eBird.org: Launched in 2002 by the Cornell Lab of Ornithology and National Audubon Society, eBird enables participants to record bird sightings using an online checklist. EBird can provide rich data sources for basic information on bird abundance and distribution at a variety of spatial and temporal scales.

BirdLife International/NatureServe: BirdLife's Global Species Programme collates and analyzes information on all the world’s birds in order to set priorities for action, through species-specific initiatives, safeguarding of sites, campaigns, and policy interventions.

Audubon Important Birding Areas: Some bird data sets available at a national or regional scale, such as Audubon’s Important Birding Areas (Audubon 2015), focus primarily on habitat considerations. Wanting to avoid duplication of the habitat characterization being completed in this assessment, most resources of this nature were not selected

Coastal Condition

Upland land use can have a significant impact on the condition of estuarine systems. Land use affects nutrient loads, water quality, and the ability for intertidal habitats to migrate under pressure from sea level rise. Previous research suggests that watersheds with relatively high percentages of urban and agricultural land are associated with lower estuarine benthic indicators of condition and biodiversity (Hale et al. 2004) and reduced submerged aquatic vegetation (Li et al. 2007). Freshwater aquatic systems also become seriously impacted when impervious cover exceeds 10% (CWP 2003), and reductions in certain taxa sensitive to urban contaminants and habitat disturbance have been found where as little as 3% of the land cover of the watershed is urban (Coles et al. 2004). Similar impacts have been recognized in estuarine systems, though the relationship is more complex given the influence of tidal regimes and mixing with ocean waters.

To help quantify the condition of coastal waters and habitats based on land cover, the extent of secured, agricultural, and developed lands along with the distance of hardened shoreline across the region was incorporated into the assessment.

<u>SECURED LANDS</u>

Secured lands are used to evaluate the level of land protection across the region. The Conservancy's secured lands database tracks properties that are under permanent protection, including federal and state lands and private easements (Figure 2.14).

<u>AGRICULTURAL LANDS</u>

Agricultural lands can influence estuarine systems through increased runoff of nutrients (e.g., nitrogen and phosphorus) from row crops and animal operations. The extent of agricultural lands was evaluated using the 2011 National Land Cover Database (NLCD, Jin et al. 2013). The NLCD row crops and pasture land categories were combined to represent agricultural areas (Figure 2.14).

<u>DEVELOPED LANDS</u>

Development, including roads, industrial areas, large cities and less dense rural communities, can impact estuarine systems. The area of developed lands was calculated using the 2011 NLCD (Jin et al. 2013). The NLCD High, Medium, Low and Open Space developed land categories were combined into a single developed land data layer (Figure 2.14).

IMPERVIOUS SURFACE

Another way to look at the level of development is by calculating the amount of impervious surface. The 2011 NLCD includes a calculation of imperviousness. For the assessment, these imperviousness values were assigned to a grid which enabled a calculation of extent.

HARDENED SHORELINES

Evaluating the proportion shoreline that is hardened can provide information on both the level of development and the potential for habitat migration. The length of man-made shoreline was derived from a combined dataset that included the Environmental Sensitivity Index, City of Virginia Beach Shoreline Inventory, NC Estuarine Shoreline Mapping Project and GA Armored Estuarine Shoreline data (Figures 2.15-2.18). The age of the data sources and the classification system vary, limiting comparison at a regional scale.

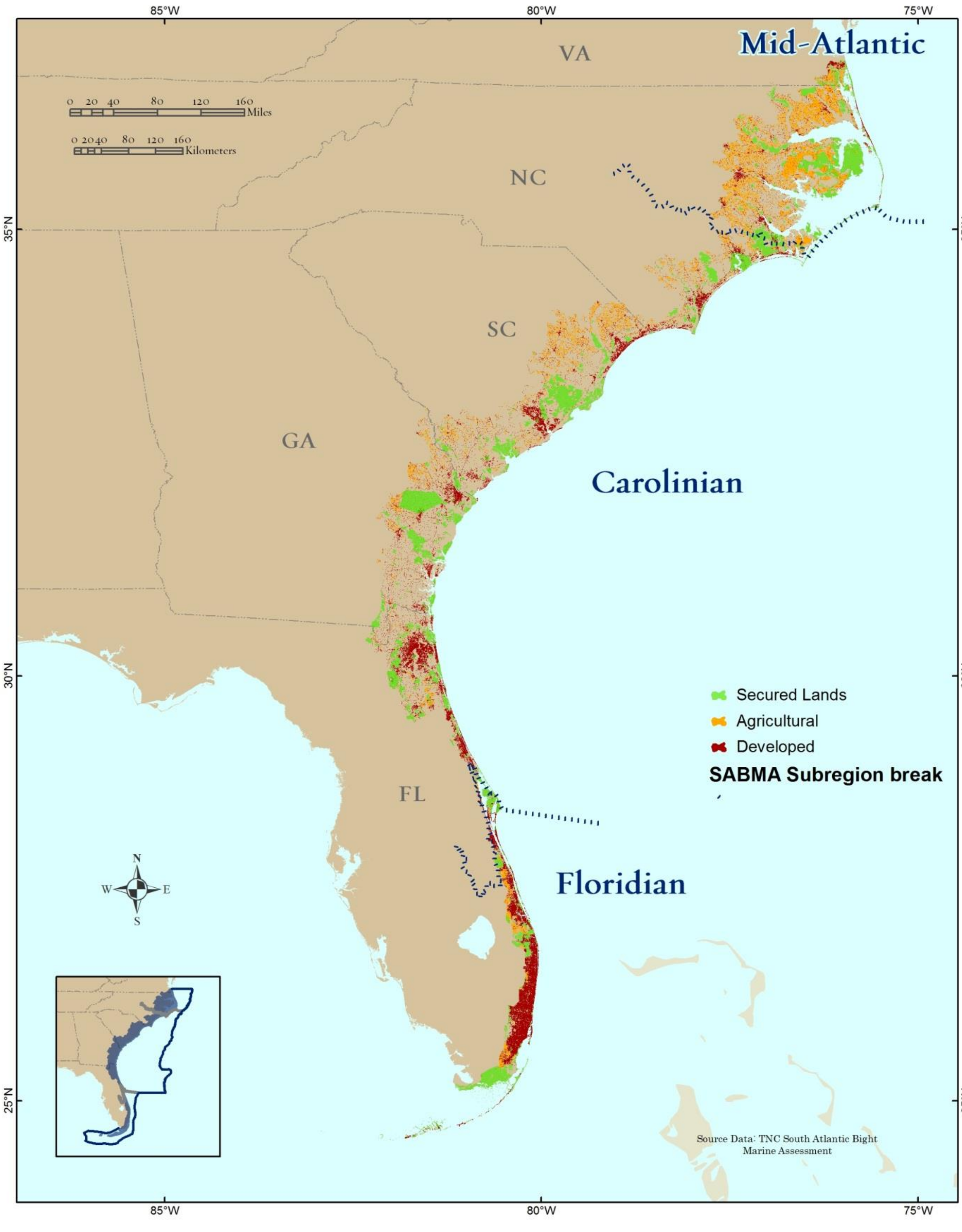

Figure 2.14. Map of secured (green), agricultural (orange) and developed (red) lands

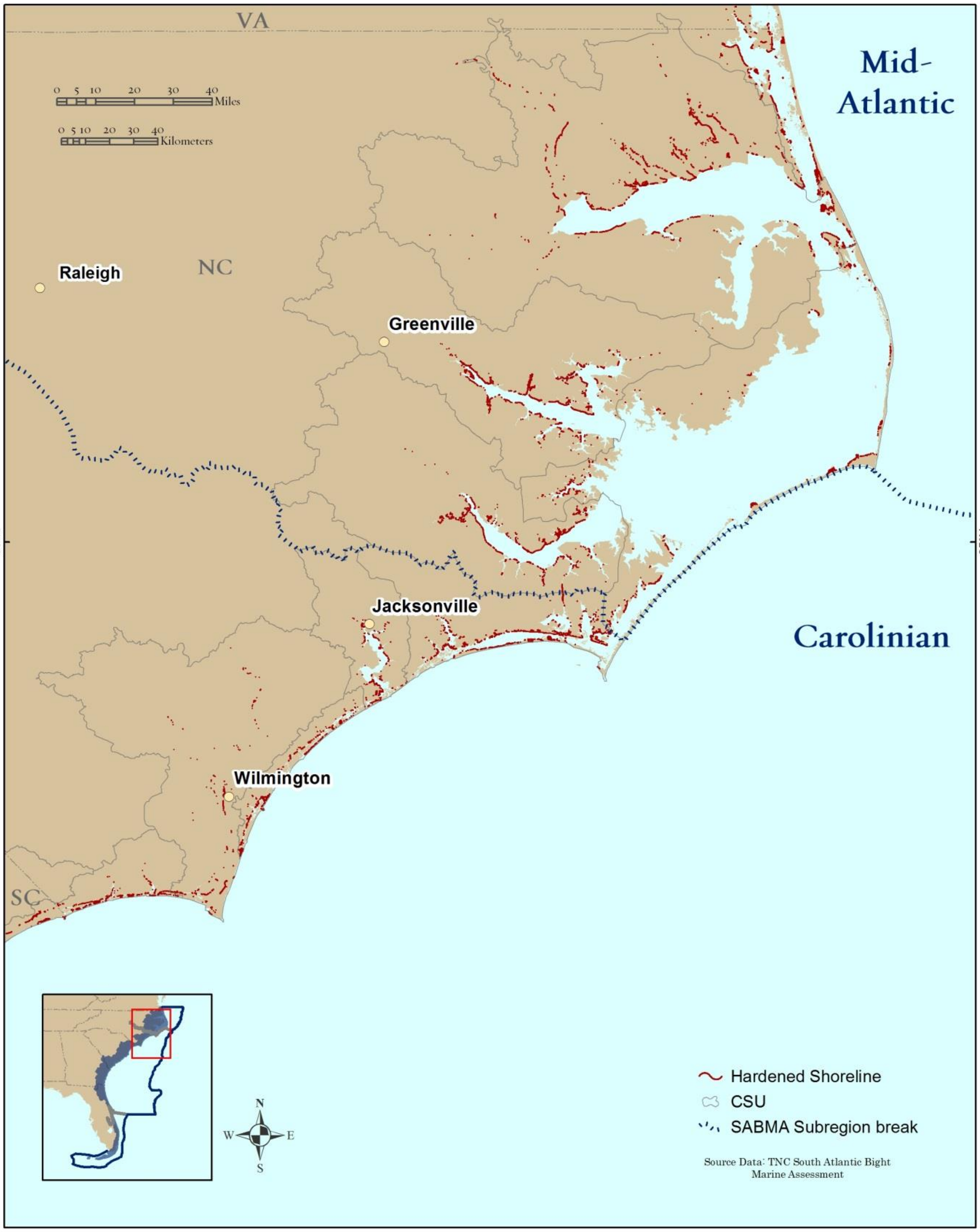

Figure 2.15. North Carolina hardened shoreline

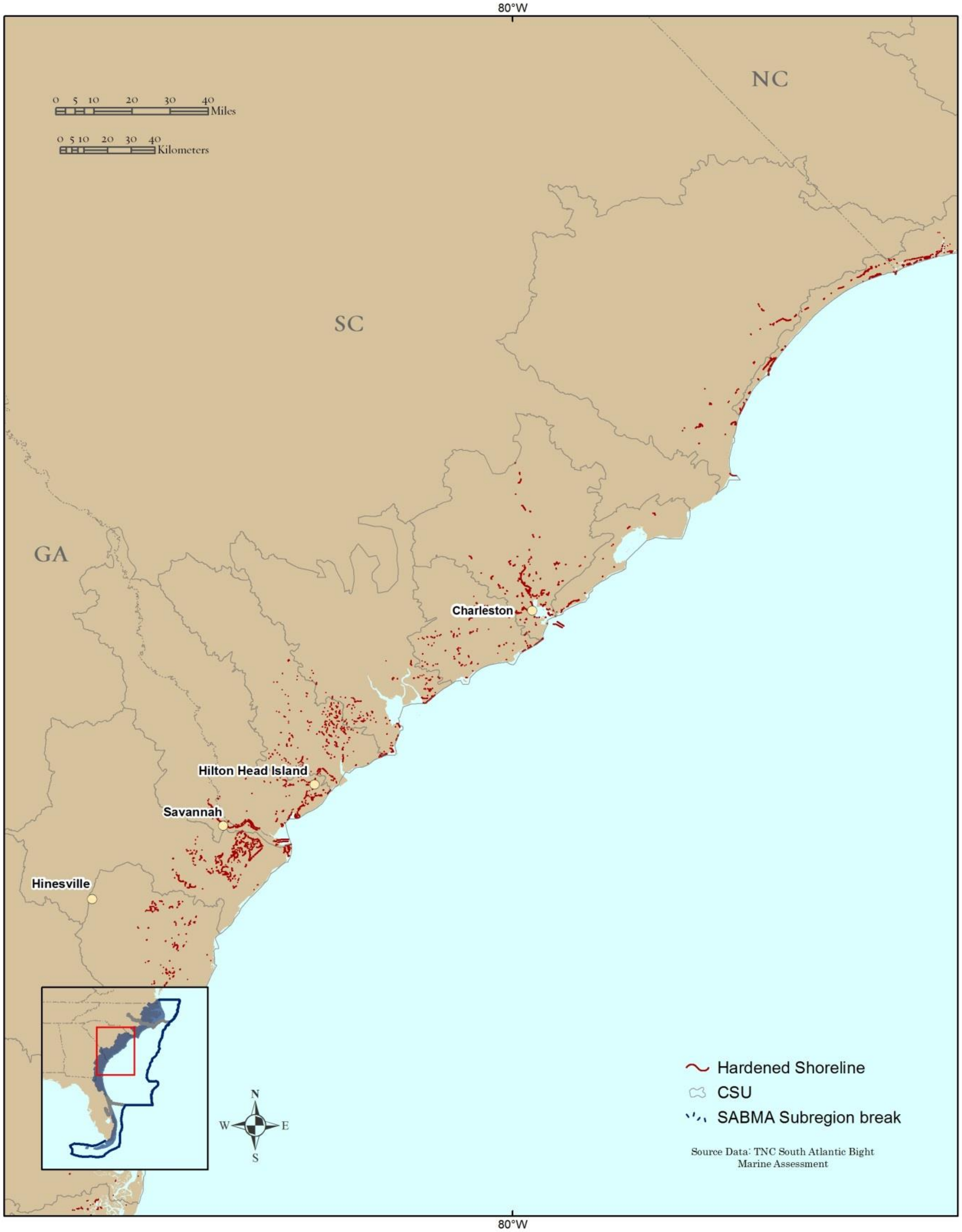

Figure 2.16. South Carolina hardened shoreline

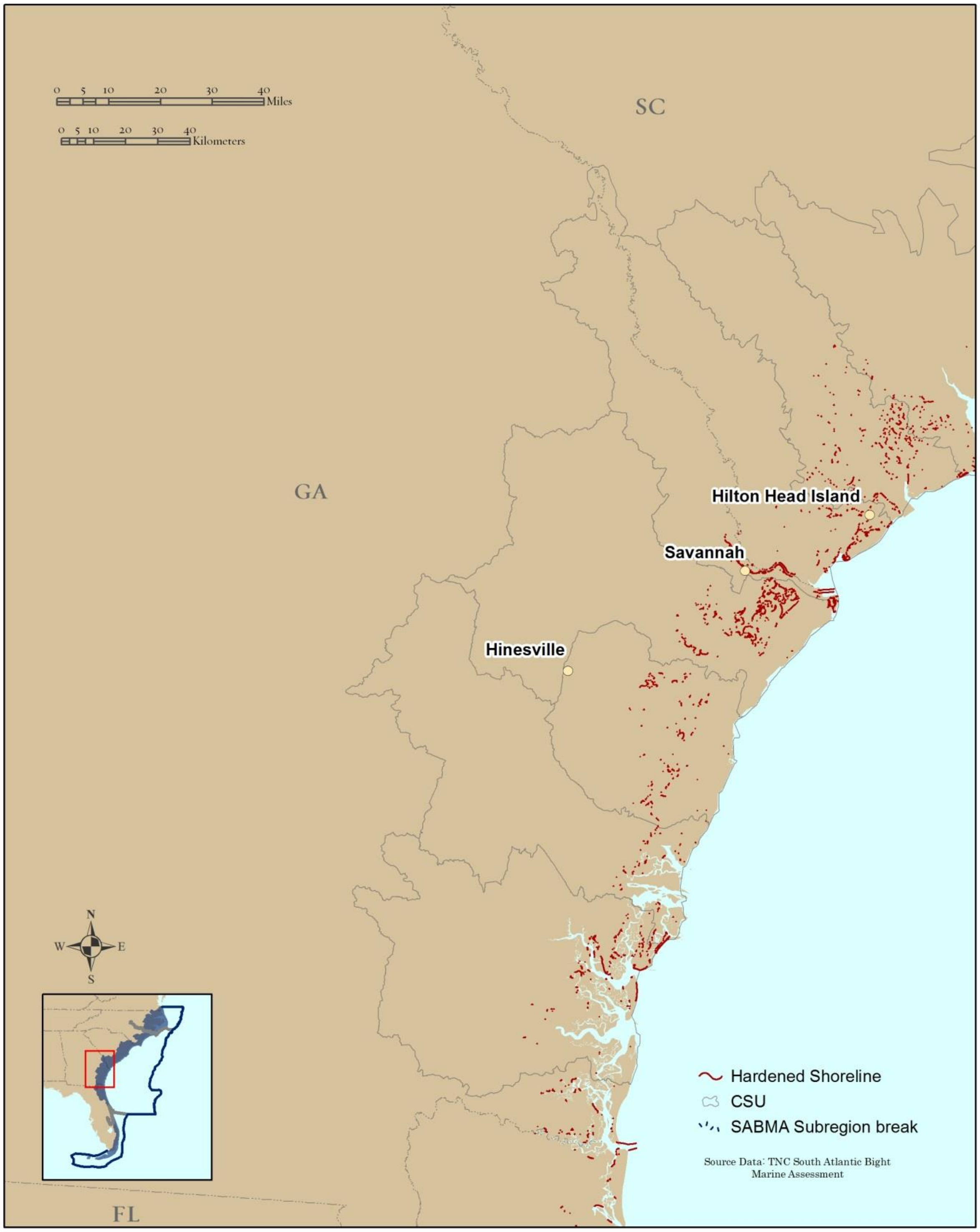

Figure 2.17. Georgia hardened shorelines

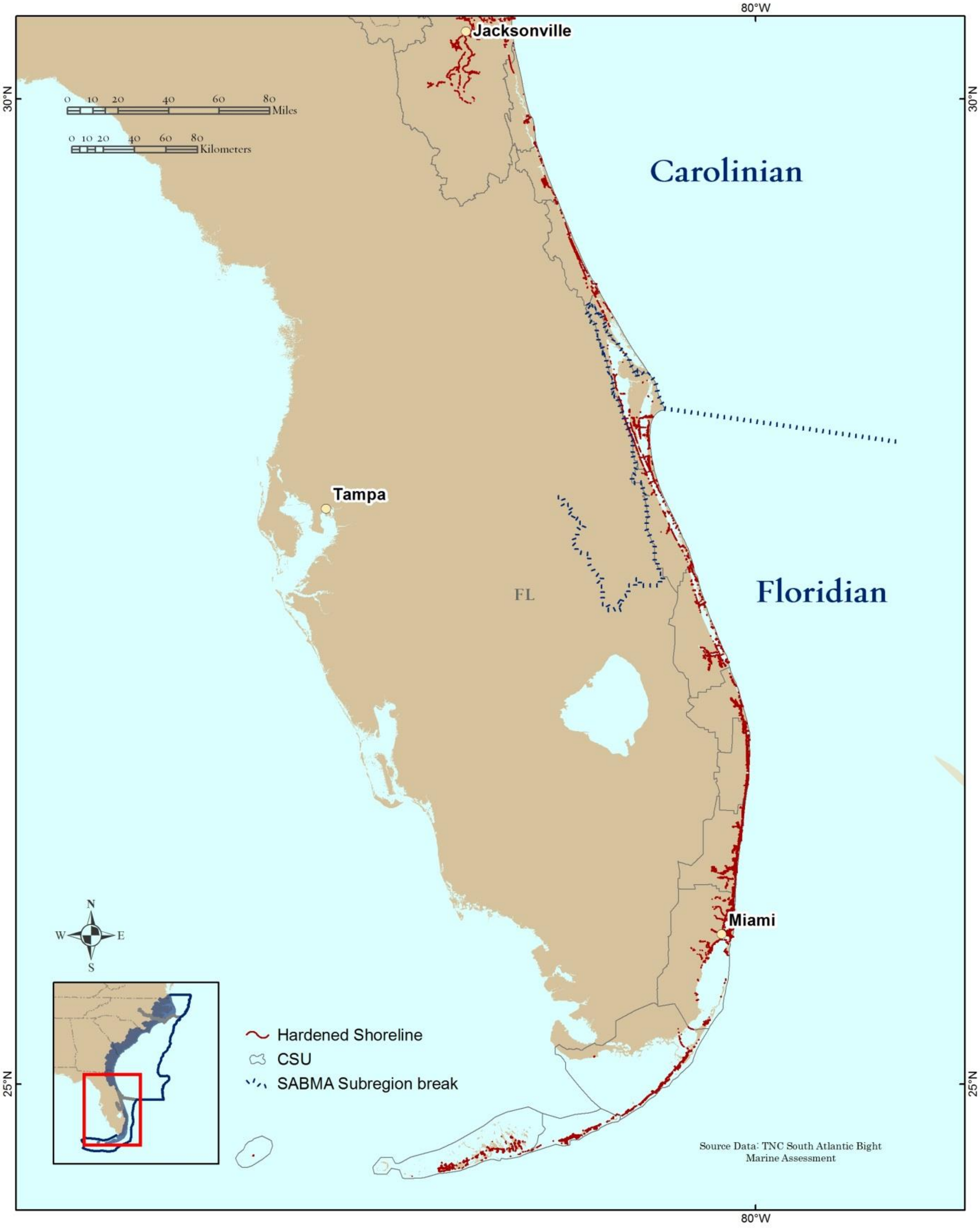

Figure 2.18. Florida hardened shoreline

Development of Coastal Shoreline Units and Watersheds
To facilitate characterization of the entire coastline, the South Atlantic Bight project area was divided into 39 Coastal Shoreline Units (CSUs). Each CSU is associated with a discrete stretch of shoreline, nearshore habitat, and coastal watershed. Four state-based project teams made CSU delineations based upon continuity of processes and natural breaks. The sub-teams attempted to avoid crossing over watersheds and consolidating areas with very different freshwater inputs. The United States Geologic Survey (USGS) 10-digit Hydrologic Units (HUCs) were used as the base for CSU delineation (Seabar et al. 1987). Directly along the coast, limited elevation change and alteration of tidal flow patterns present some difficulty with HUC classification. NOAA Coastal Assessment Framework – Estuarine and Coastal Drainage Area watersheds (EDAs and CDAs), natural features, current patterns, and local knowledge were used to further refine a continuous string of CSUs.

The SABMA subregion stratification (mid-Atlantic, Carolinian, and Floridian) was applied to the CSUs in order to account for variation in climate, habitat types, and species use within South Atlantic Bight estuaries. CSUs were then assigned an estuary type based on the CMECS types. Building upon the Environmental Protection Agency's (EPA) *Classification Framework for Coastal Systems* (Burgess et al. 2004), three CMECS estuary types are used in the assessment: 1) river dominated estuaries, 2) lagoonal estuaries, and 3) island archipelagos. Given the limited variation in CMECS types found in the region, the decision was made to further divide the river dominated estuary type into coastal plain and Piedmont estuaries. This distinction, described by Dame et al. (2000), is based on variation in freshwater flow, watershed drainage, and proportion of wetlands. Further subdivision of the lagoonal estuaries was considered, however, the inclusion of SABMA subregions as part the characterization accounts for the core variation from north to south. In the end, the CSUs of the South Atlantic Bight were sorted into the following types (Figures 2.19-2.24):

- Lagoonal Estuaries (19 CSUs)
- River-dominated Estuaries (18 CSUs)
    - Coastal Plain Basins (9 CSUs)
    - Piedmont Basins (9 CSUs)
- Island Archipelagos (2 CSUs)

Box 2.3. Definitions of Estuary Types

The CMECS classification focuses on the importance of estuary size, shape, and flushing in dictating processes within an estuary and the adjacent coastal area. The classification variables are considered to be "natural" characteristics of the estuary, in both material and energetic terms, meaning those which influence estuarine processing to varying degrees and are not generally controllable or influenced by either stressor or response variables.

Coastal Lagoons: include lagoons, sloughs, barrier island estuaries, bar-built estuaries, and tidal inlets.

- Tend to be shallow and highly enclosed, with reduced exchange with the ocean
- Often experience high evaporation, and are quiescent in terms of wind, current, and wave energy
- Tend to have a very high surface to volume ratio, low to moderate watershed to water area ratios, and can have a high wetland to water ratio

River Dominated Estuaries: include river channels, drowned river valleys, deltaic estuaries, salt wedge estuaries, and tidal fresh marshes.

- Tend to be linear and seasonally turbid, especially in upper reaches, and can be characterized by high current speeds
- Sedimentary and depositional, and can be associated with a delta, bar, or barrier island and other depositional features
- Tend to be highly flushed, with a wide and variable salinity range, and seasonally stratified
- Moderate surface to volume ratios, high watershed to water area ratios, and can have very high wetland to water area ratios
- Often characterized by a V-shaped channel configuration and a salt wedge

Coastal Plain Basins have watersheds entirely contained within the coastal plain. These systems have highly variable discharge rates and low loads of suspended sediments. A larger proportion of the watershed is covered by wetlands, and they generally contain a more extensive saline zone due to the lack of significant freshwater inflow (Dame et al. 2000).

Major River/Piedmont Basins receive significant inflows of freshwater as a result of an extensive upstream watershed that frequently contributes a substantial load of suspended sediments. Most often these systems have a relatively smaller proportion of the watershed covered by wetlands (Dame et al. 2000)

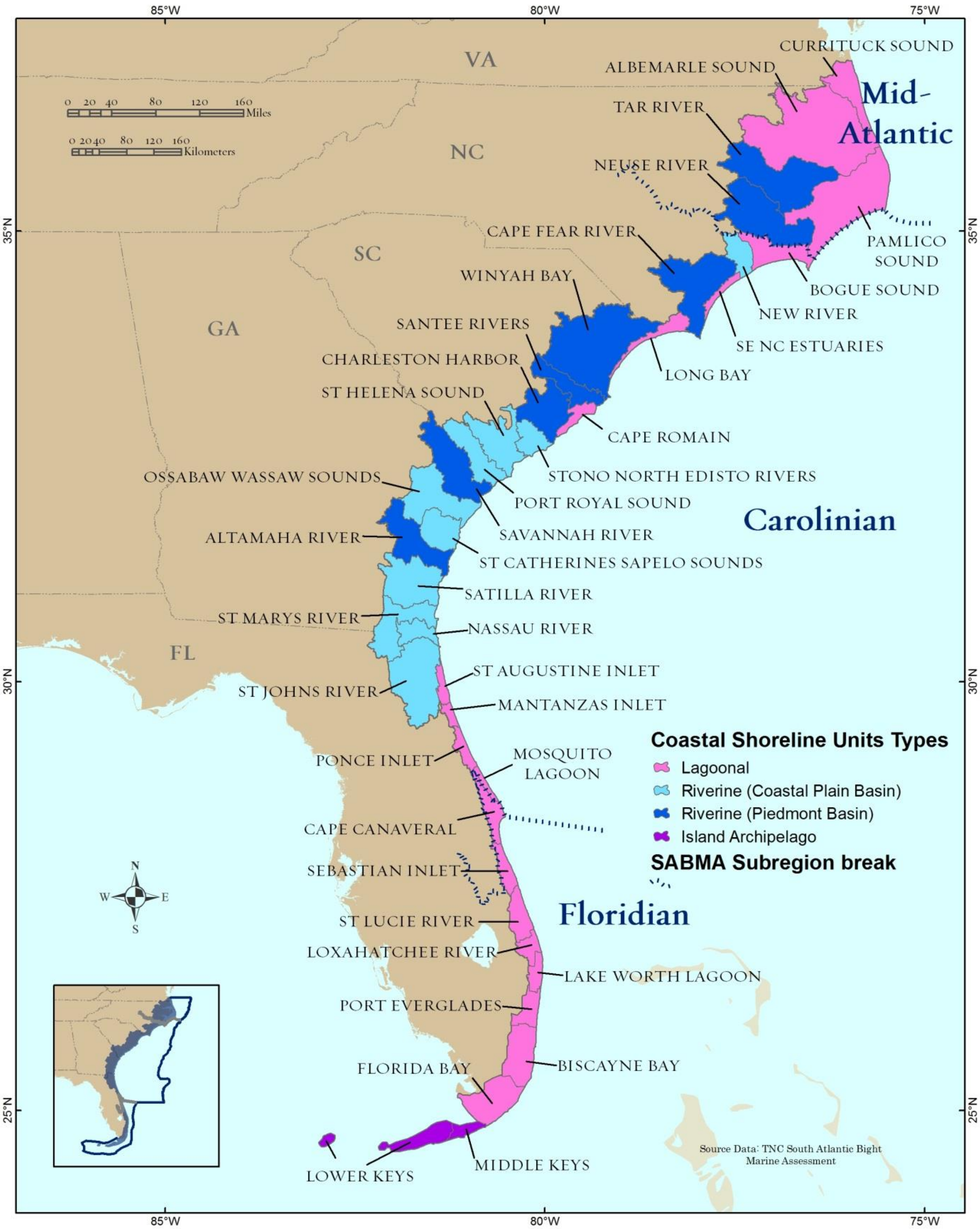

Figure 2.19. Map of Coastal Shoreline Units (CSUs)

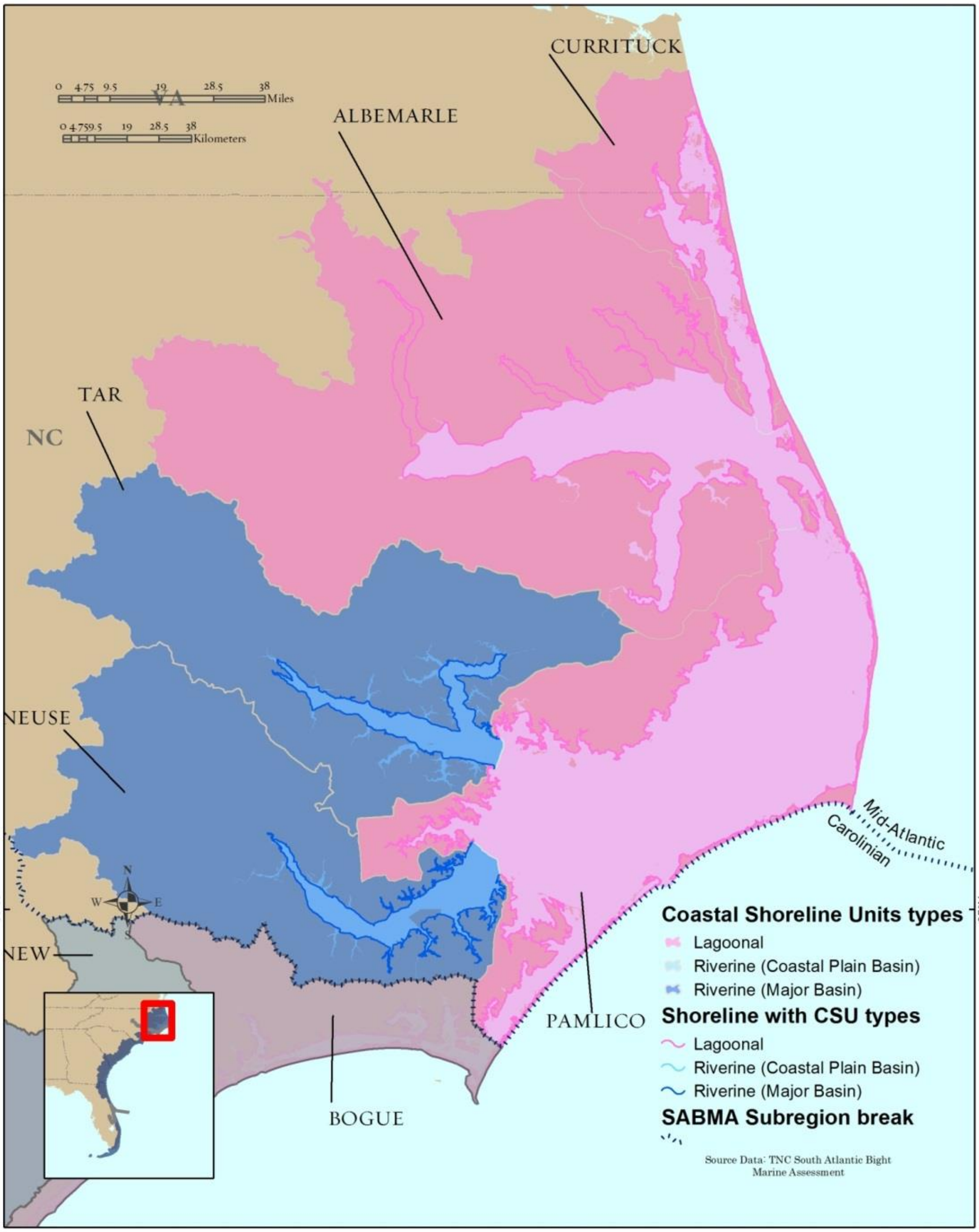

Figure 2.20. Coastal Shoreline Units in the mid-Atlantic subregion

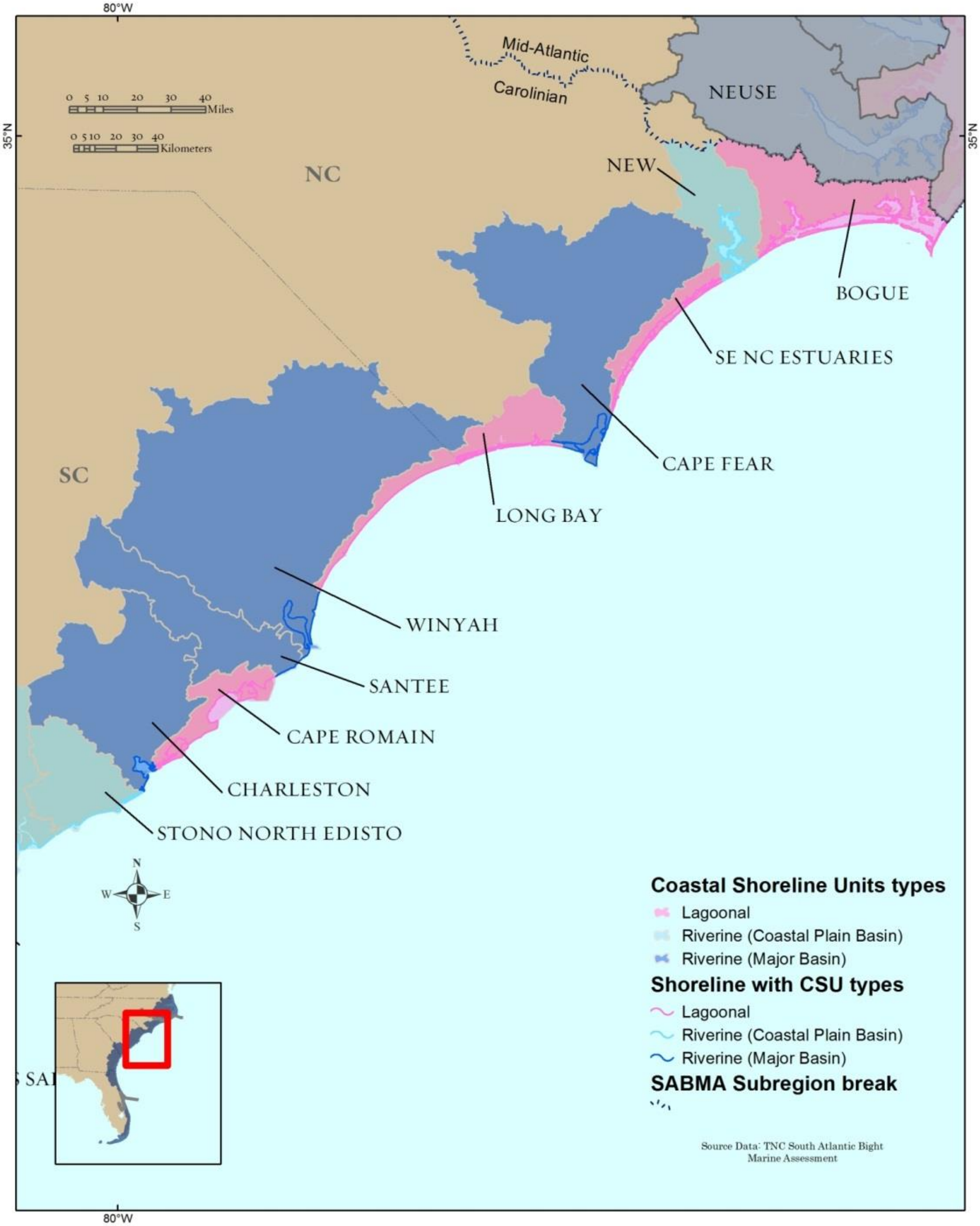

Figure 2.21. Coastal Shoreline Units in the northern portion of the Carolinian subregion

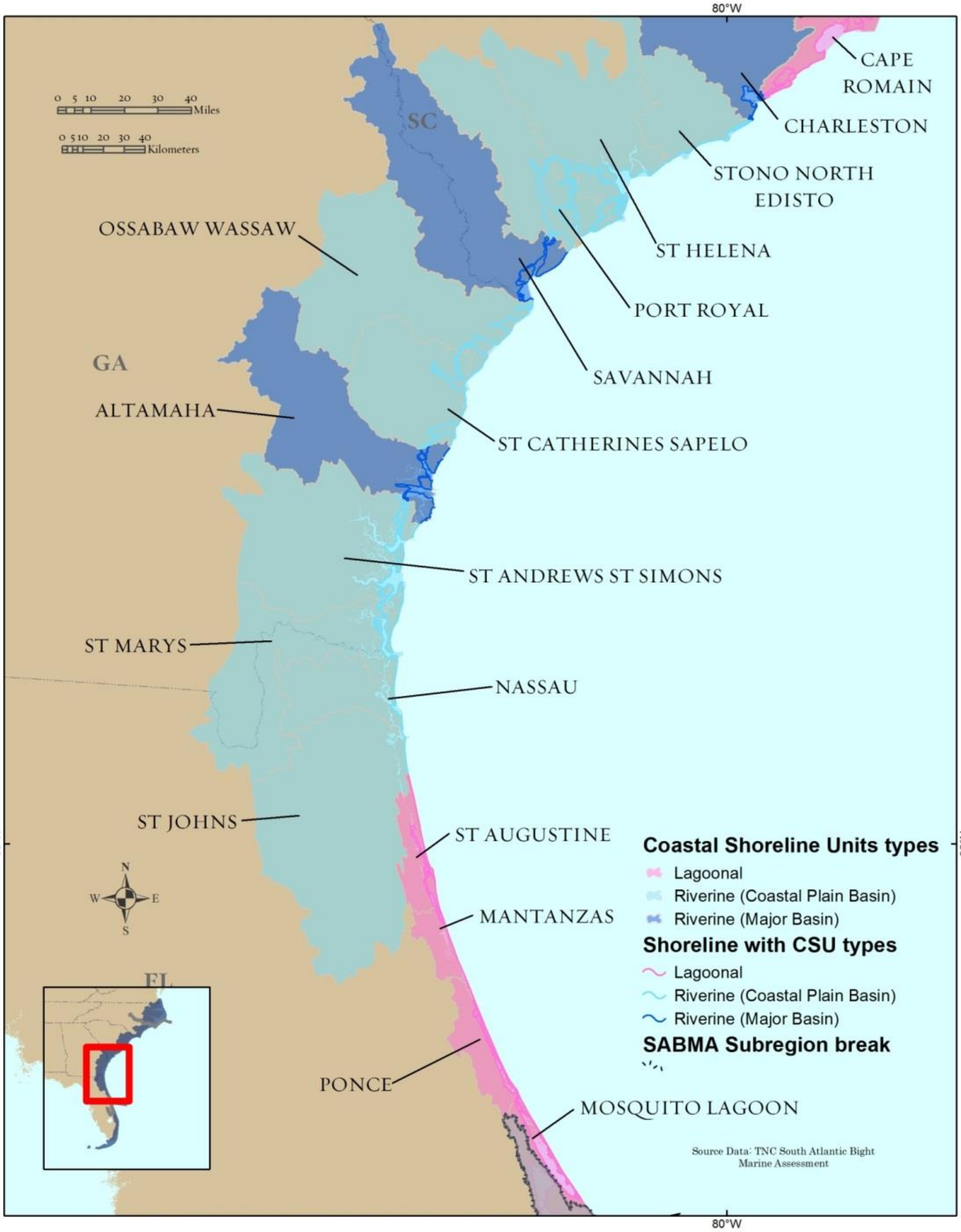

Figure 2.22. Coastal Shoreline Units in the southern portion of the Carolinian subregion

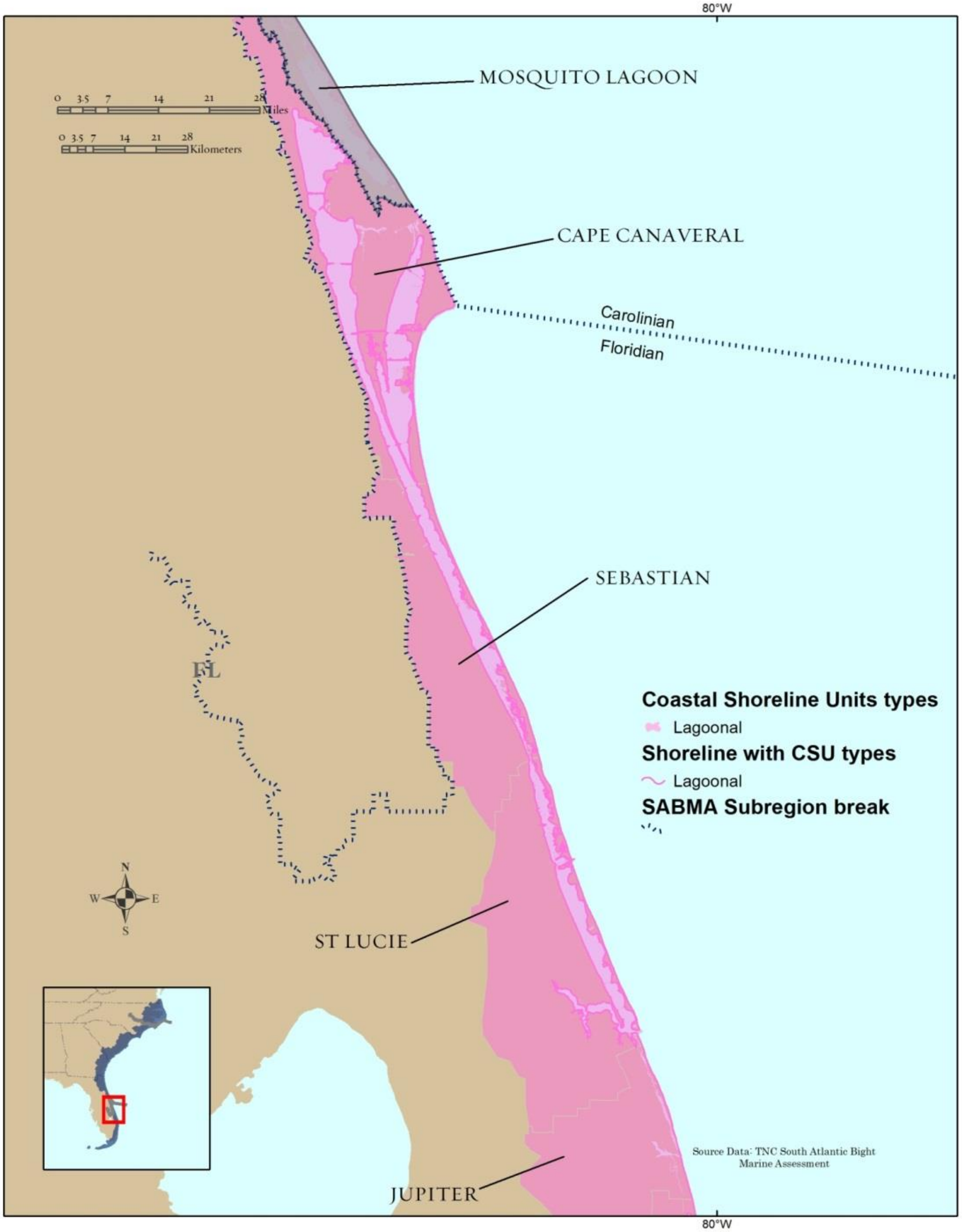

Figure 2.23. Coastal Shoreline Units in the northern portion of the Floridian subregion

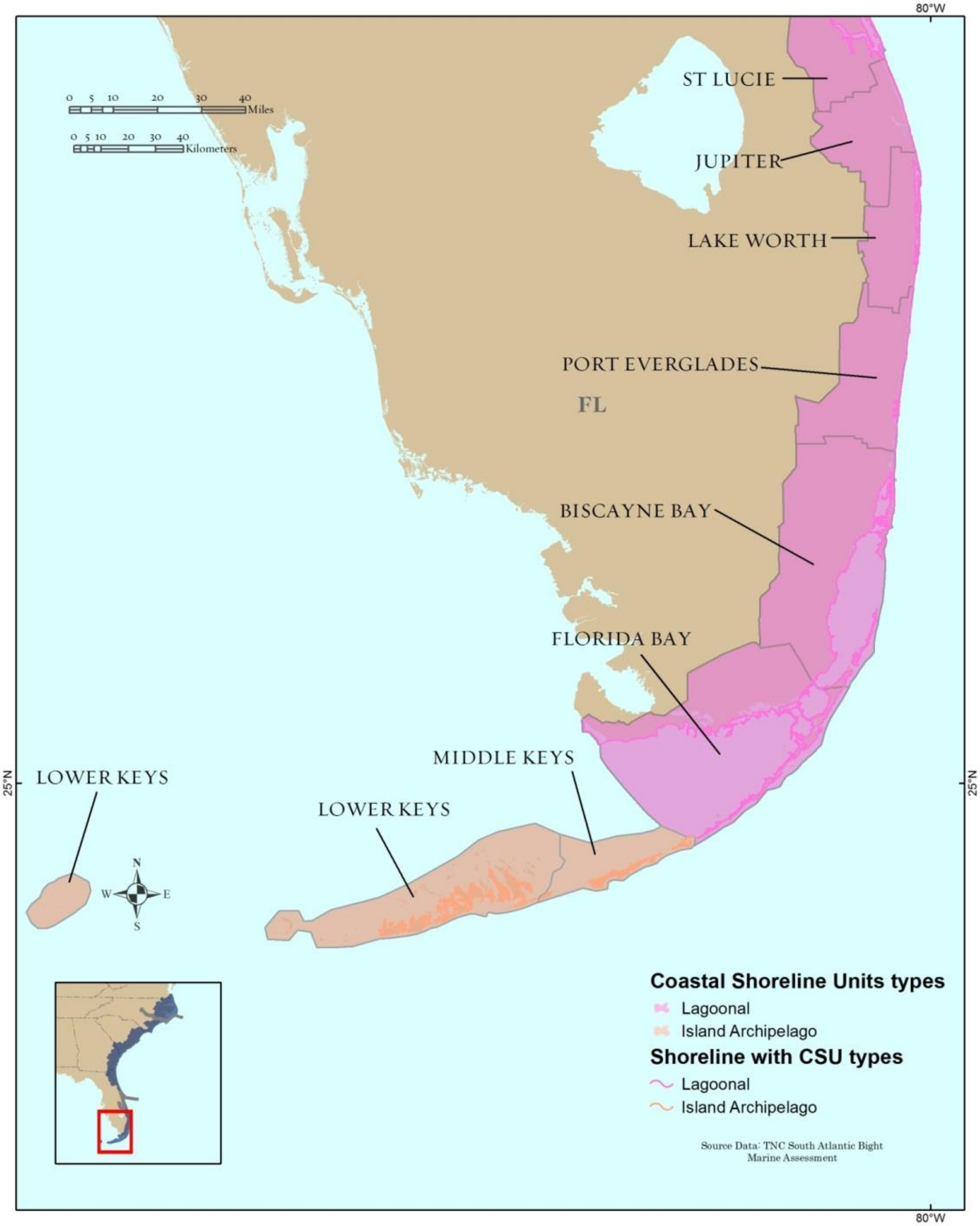

Figure 2.24. Coastal Shoreline Units in the southern portion of the Floridian subregion

Maps, Analysis, and Areas of Importance

Each Coastal Shoreline Unit (CSU) was characterized by summarizing a variety of natural features with presumed relevance for supporting productivity and biodiversity in order to identify patterns by subregion and by estuary type. Characterized attributes included size, habitat diversity, select species populations, and watershed condition.

Size

Size is an important CSU parameter because many other variables are likely to correlate with it. Size of each CSU was characterized by shoreline length, coastal watershed land area, and open water area. When combined, the latter two represent total CSU area. Table 2.5 provides an overview of these variables across the project area, including the largest CSU, smallest CSU, average and total.

Shoreline: The total shoreline distance based on the Environmental Sensitivity Index (ESI) is 45,992 km (28,578 mi), which includes estuarine and ocean shoreline. The average shoreline length does not vary considerably when compared across CSU types. Coastal riverine CSUs have the longest average shoreline (1,329 km) and Piedmont riverine CSUs the smallest (1,031 km). However, there is significant variation within some individual CSU types. In particular, the lagoonal type includes both the longest (Florida Bay; 3,000 km), and shortest (Lake Worth Lagoon; 272 km) shorelines in the project area. There is limited variation in average shoreline length between subregions. The mid-Atlantic has the longest average shoreline (1,856 km), dominated by the Pamlico Sound and Albemarle Sound with respective shorelines of 2,970 km and 2,377 km. The Carolinian and Floridian average 1,082 km and 1,075 km, respectively.

Terrestrial Land Area: The coastal watersheds associated with the CSUs equate to a total land area of 8,190,076 hectares (31,622 mi^2) with an average CSU watershed size of 210,002 ha (811 mi^2). There is variation in watershed size when comparing CSU types. The Piedmont riverine CSUs average 407,074 ha, a result of the wider land area that drains into these Piedmont river systems. On the other end of the spectrum, the island archipelago CSUs average only 10,575 ha, dominated by the Florida Keys. Coastal riverine and lagoonal CSU types were close to the project area average. The subregion averages decreased from north to south: mid-Atlantic (409,323 ha), Carolinian (221,675 ha) and Floridian (82,326 ha). The presence of the island archipelago CSUs and the breakdown of the southern Florida lagoons into subunits accounts for much of the difference.

Open Water Area: Open waters include subtidal submerged lands, rivers, and freshwater lakes within the CSU boundary. Total area of open water is 1,906,917 ha (7,363 mi^2) or approximately 20% of the total CSU area. The island archipelago (115,220 ha)) and lagoon (66,489 ha)) CSU types have the greatest extent of submerged lands and associated open water. Similarly, the mid-Atlantic (173,992 ha) and Floridian (63,026 ha) subregions which have a higher percentage of these CSU types have a much greater open water extent then the Carolinian (16,946 ha).

Total CSU Area: When the terrestrial and submerged lands are combined, the total area encompassed within the SABMA CSUs is over 10 million hectares (38,610 mi^2) with an average of 258,897 hectares (1,000 mi^2) per CSU. Piedmont riverine CSUs have the largest average area at 431,221 ha, followed by coastal riverine (253,468 ha), lagoonal (193,852 ha) and island archipelago (125,795 ha) (Figure 2.25).

Table 2.5. Overview of CSU size variables

	Shoreline (km)	Total CSU Area (ha)	Terrestrial Area (ha)
Largest	3000 (Florida Bay)	1,059,988 (Albemarle Sound)	842,761 (Albemarle Sound)
Smallest	272 (Lake Worth Lagoon)	31,638 (Mosquito Lagoon)	3,052 (Middle Keys)
Average	1179	258,897	210,002
Total	**45,992**	**10,096,993**	**8,190,076**

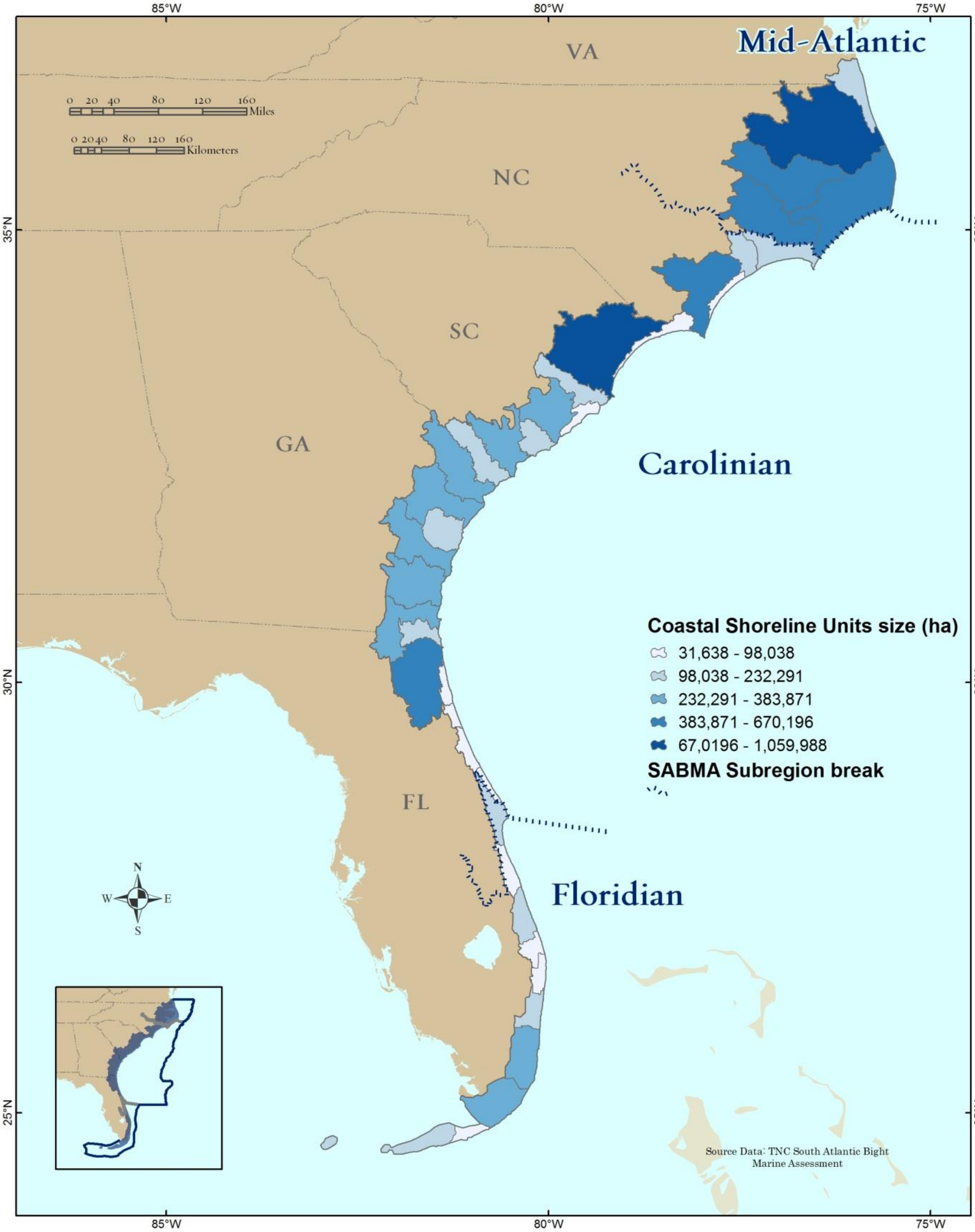

Figure 2.25. Coastal Shoreline Units ranked by total size

HABITAT DIVERSITY

The extent of targeted SABMA coastal habitats was summarized for each CSU by associating the individual habitat data with the "nearest" coastal shoreline. There are overarching habitat characteristics associated with each CSU type. Figures 2.26-2.30 provide examples of this variation, showing selected CSUs for each estuary type with associated intertidal habitat:

Pamlico Sound (Figure 2.26): A representative lagoon estuary in the mid-Atlantic subregion, Pamlico Sound is dominated by open water. Fringing salt and tidal freshwater marsh habitats are located primarily on the mainland shore. Ocean beach habitat spans the barrier islands.

Florida Bay (Figure 2.27): The largest lagoon estuary in the Floridian subregion, Florida Bay also is dominated by open water. NWI-classified limestone flats are scattered throughout the bay. Mangrove forests dominate the intertidal habitat versus the marsh systems located in the more temperate mid-Atlantic and Carolinian subregions.

Altamaha River (Figure 2.28): A representative Piedmont riverine estuary, the Altamaha River CSU extends further inland than those associated with lagoonal and coastal riverine CSUs. Significant salt marsh systems transition into tidal freshwater marsh and tidal forest moving up river.

St. Helena Sound (Figure 2.29): A representative coastal riverine system, St. Helena Sound has a complex tidal creek system that supports a large complex of salt marsh. This transitions into tidal freshwater marsh and forest habitats, though not to the same extent found in Piedmont riverine CSUs.

Lower Keys (Figure 2.30): One of two island archipelago CSUs, the Lower Keys is surrounded by open water areas with primarily limestone-based tidal flats. Mangrove swamps and rocky barren scrub-shrub habitats on limestone dominate the vegetated intertidal habitats.

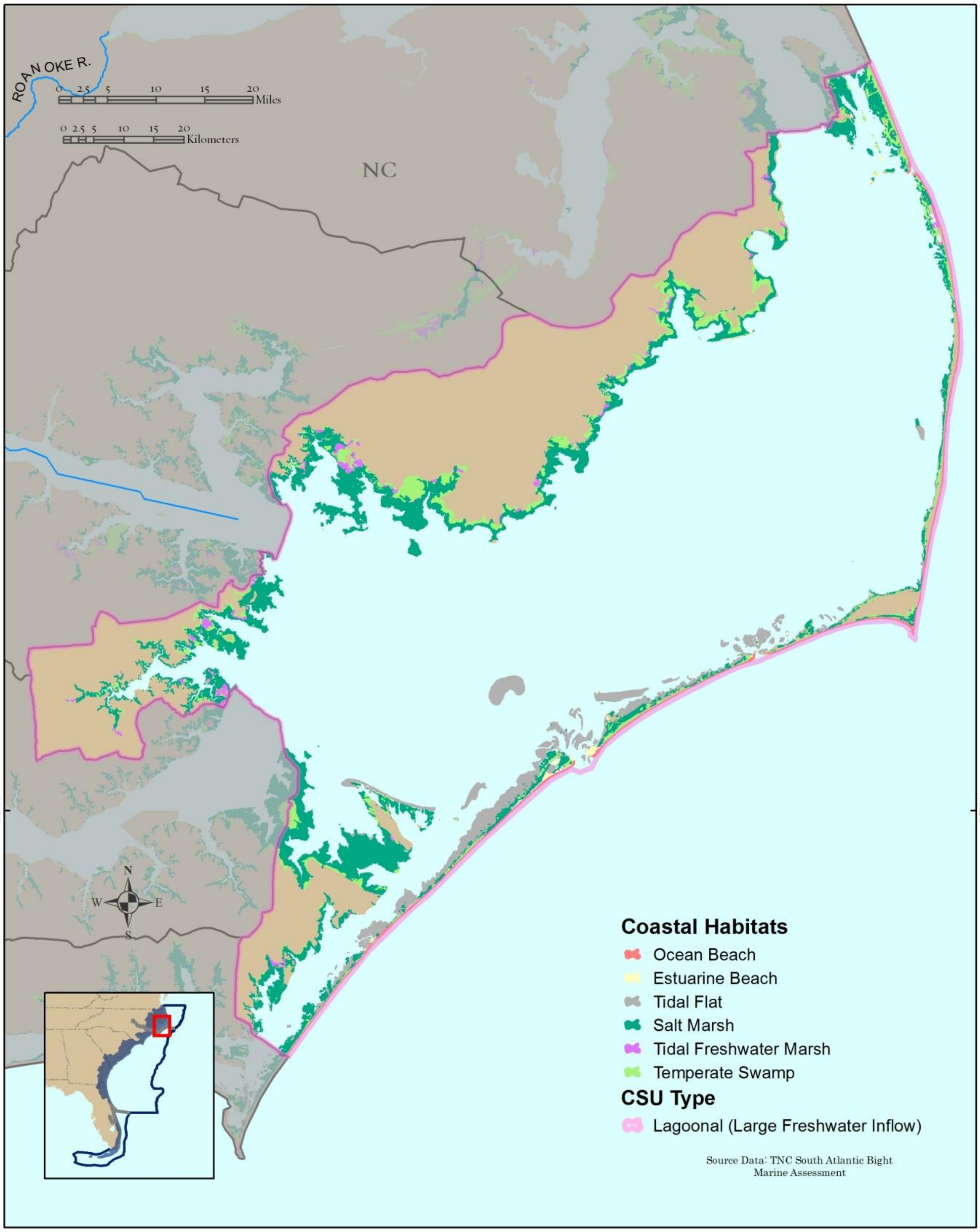

Figure 2.26. Pamlico Sound (NC) example of coastal habitats in a lagoonal estuary

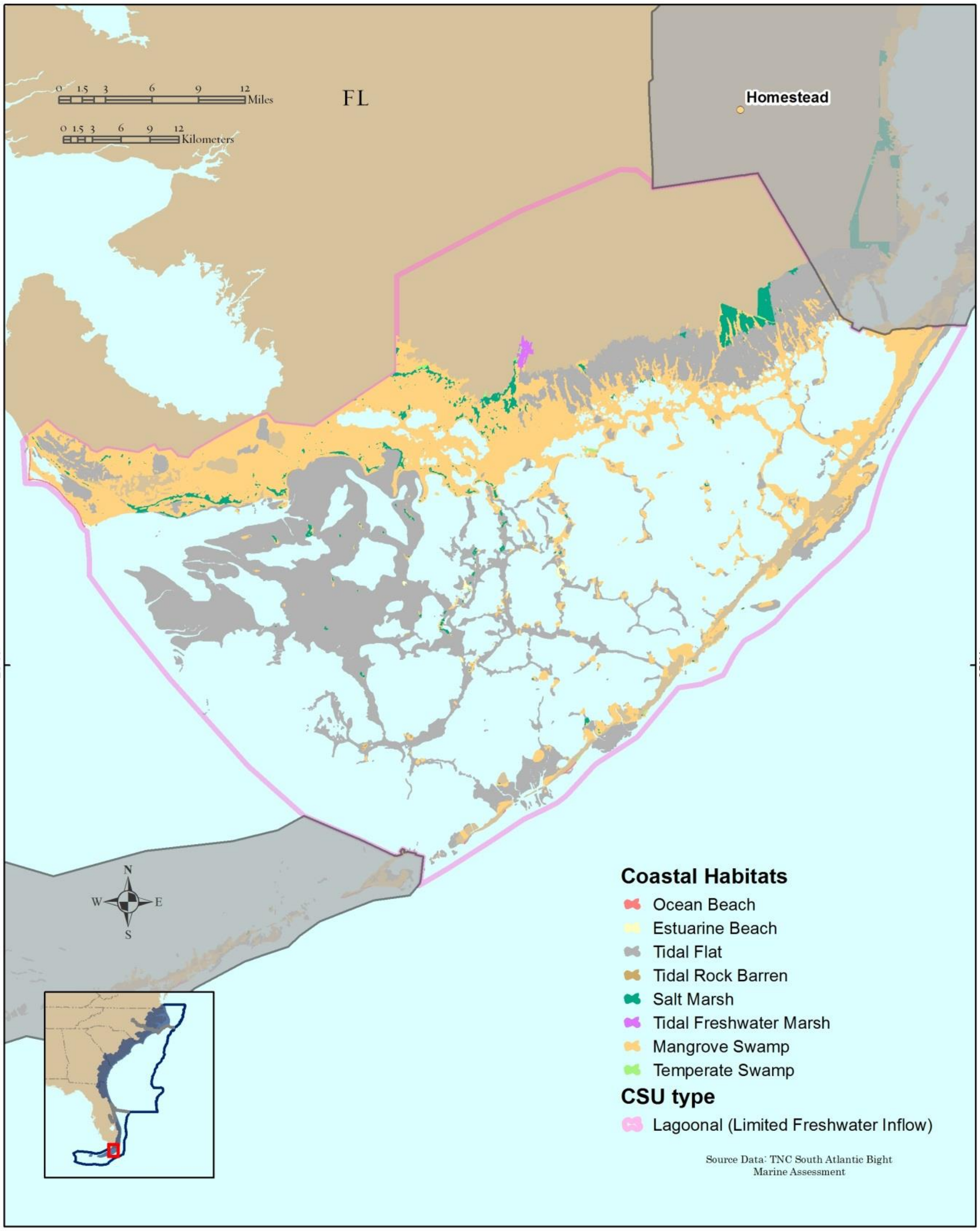

Figure 2.27. Florida Bay (FL) example of coastal habitats in a lagoonal estuary

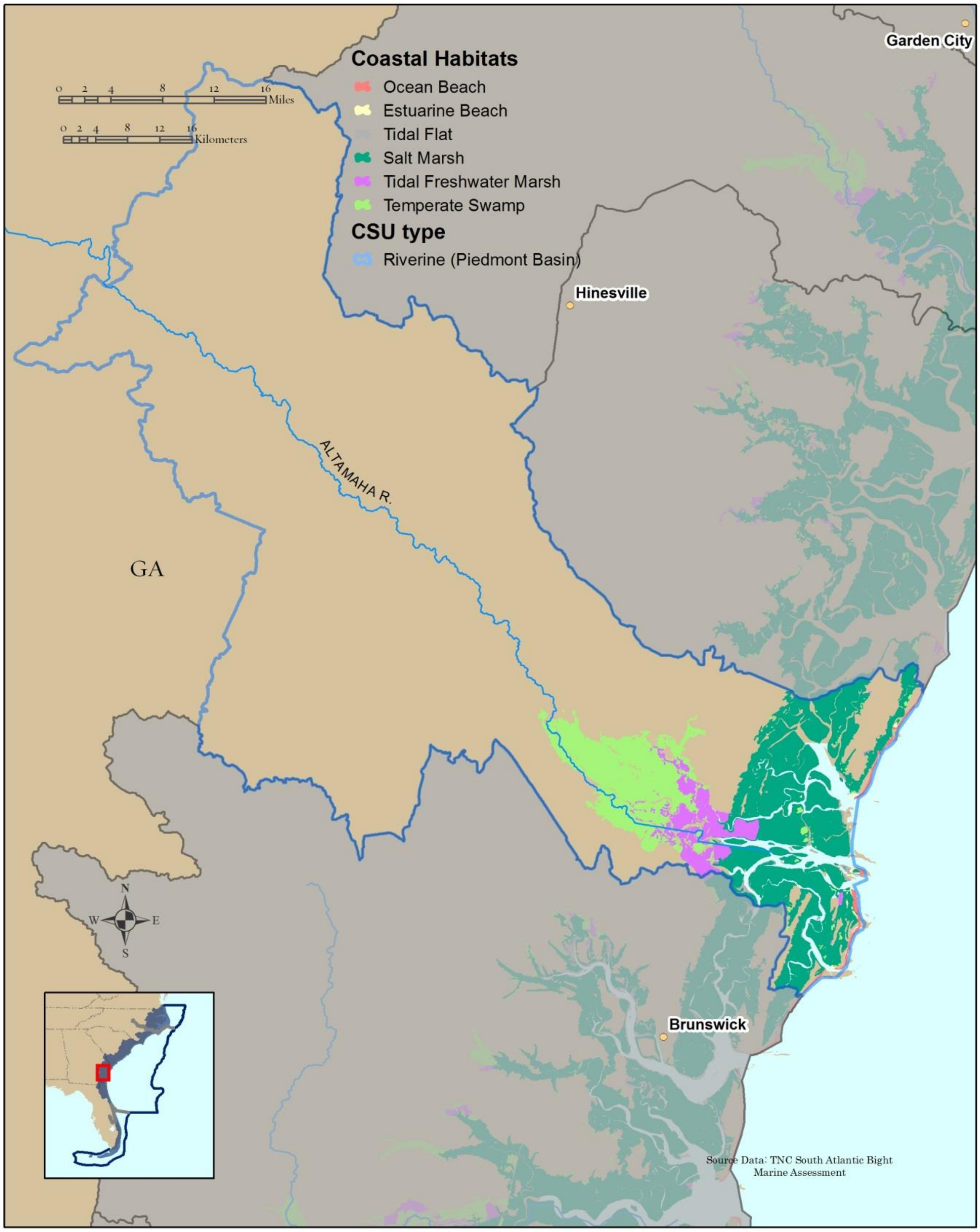

Figure 2.28. Altamaha River (GA) example of coastal habitats in a Piedmont riverine estuary

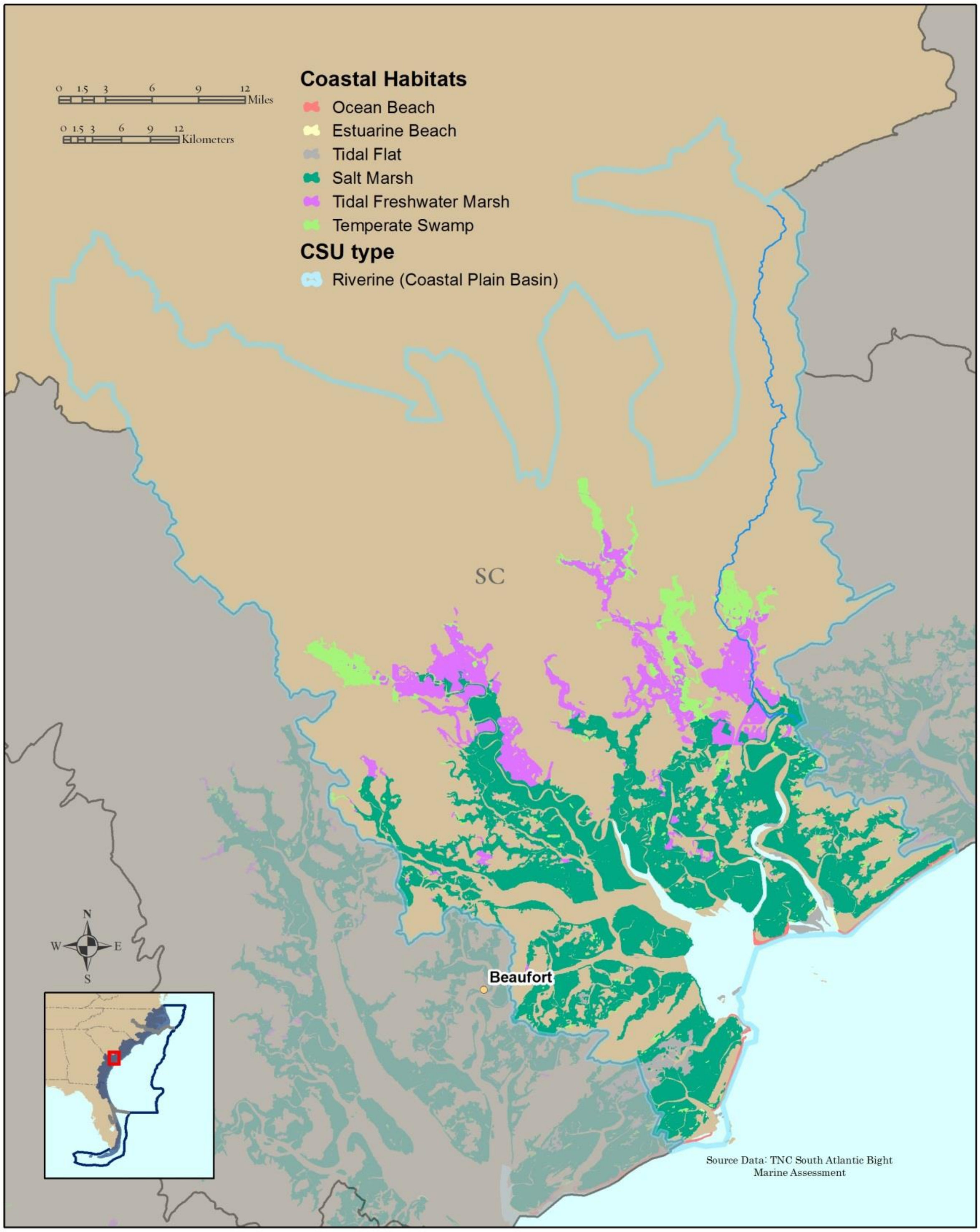

Figure 2.29. St. Helena Sound (SC) example of coastal habitats in a coastal riverine estuary

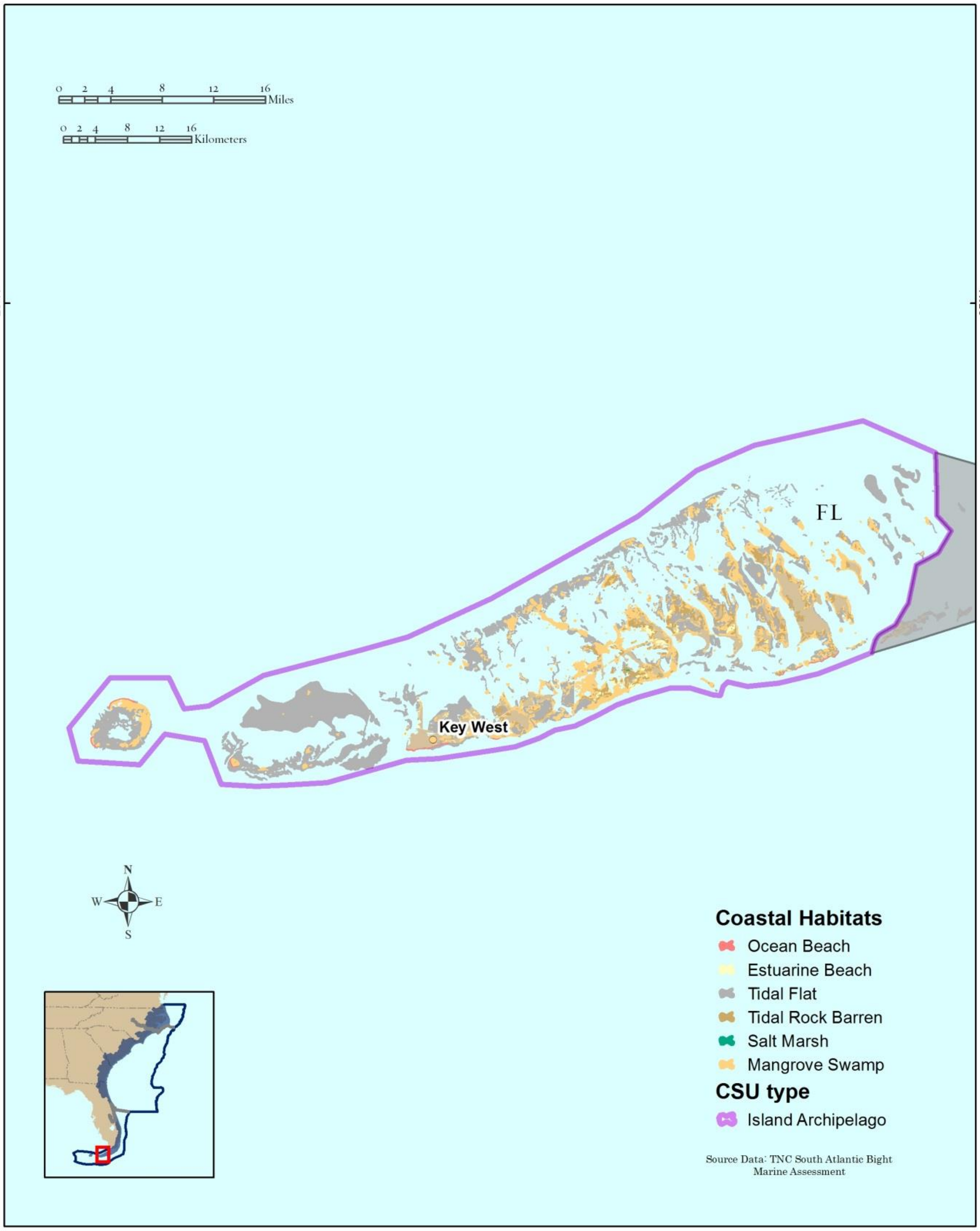

Figure 2.30. Lower Keys (FL) example of coastal habitats in an island archipelago system

Targeted Habitats and Species Groups
The following sections describe how targeted habitats and species are associated within CSUs. Associated maps represent the relative extent of habitats and species, values are distributed into five quintile groups each containing an equal number of CSUs:

SALT MARSH
(Figure 2.31) The total salt marsh extent in the South Atlantic Bight is 425,490 ha. The Carolinian subregion has the highest average salt marsh area per CSU at 14,696 ha. Nine of the top ten CSUs ranked according to hectares of salt marsh per mile of shoreline are located between Cape Romain (SC) and St. Mary's River (GA). This portion of the South Atlantic shoreline has a greater mean tidal range, between 1.5 and 2.1 m (5 and 7 feet), and relatively low coastal development which can support extensive salt marsh habitat. The Satilla River had both the highest total area (41,192 ha) and density (2,677 ha/km of shoreline) of salt marsh. Fifty percent of the top ten were coastal riverine CSUs; consequently, coastal riverine CSU types had the highest average extent (22,500 ha), almost double Piedmont riverine CSUs (12,438 ha) which are ranked. Pamlico Sound was an exception with 36,536 ha; however, the sound's extensive shoreline resulted in a significantly lower density value (1,230 ha/km). The total area of salt marsh was markedly smaller in the Floridian subregion with an average of 1,319 ha. This small acreage most likely corresponds with the presence of mangroves as the primary intertidal habitat in the subtropical Floridian subregion.

TIDAL FRESHWATER MARSH
(Figure 2.32) The total tidal freshwater marsh extent in the South Atlantic Bight is 63,796 ha (246 mi^2). With an average acreage of 4,044 ha (15.6 mi^2), Piedmont river CSUs dominated the total acreage of tidal freshwater marsh. Six of the ten highest ranked CSUs are classified as Piedmont river systems, including Winyah Bay, Santee Rivers, Savannah River, Altamaha River, Cape Fear River and Charleston Harbor. However, the greatest total area of tidal freshwater marsh is found in St. Helena Sound (10,194 ha), a coastal riverine CSU. While average acreage did not vary much between the mid-Atlantic (2,125 ha) and Carolinian (2,143 ha) subregions, there was a significant drop in the Floridian where the average is 24 ha per CSU. Similar to salt marsh habitat, this difference is linked to the prevalence of mangroves in subtropical areas.

TIDAL FOREST
(Figure 2.33) In general, the categorization of estuarine and tidally influenced freshwater forest was less consistent in NWI data across the project area. Extent numbers are most likely conservative with a total extent of 184,461 ha (712.2 mi^2). Tidal forests fall into two primary groups: cypress-tupelo swamps in the mid-Atlantic

and Carolinian and mangrove swamps in the Floridian. The variation is linked to overall climate and a movement from temperate to subtropical communities.

In the Carolinian and mid-Atlantic, tidal forests are generally larger in Piedmont riverine systems (7,241 ha). Winyah Bay had the greatest total area (28,095 ha), more than double the second ranked Currituck Sound (10,821 ha). In the Floridian, where mangrove communities dominate the intertidal area, Florida Bay had four times the total coverage of tidal forests (37,735 ha) relative to the second ranked CSU, Lower Keys (11,563 ha). Though Florida Bay is one of the largest CSUs in the Floridian subregion, this does not completely explain the difference.

TIDAL FLAT

(Figure 2.34) The total extent of tidal flats in the South Atlantic Bight is 106,534 ha (411 mi^2). Over 60% of the total tidal flat area is associated with two CSUs, Florida Bay (46,418 ha) and Lower Keys (20,635 ha). A common characteristic of CSUs ranked high for tidal flat habitat is a significant acreage of shallow open water area which increases potential for tidal flat habitat. This is confirmed by the total submerged land area for the top four ranked CSUs for tidal flats: Florida Bay (201,479 ha), Lower Keys (172,950 ha), Pamlico Sound (490,898 ha) and Biscayne Bay (81,405 ha).

ESTUARINE BEACH

(Figure 2.35) Estuarine beaches are the most limited intertidal habitat evaluated, with a total area of 2,997 ha (11.6 mi^2). Lagoonal systems averaged the largest extent of estuarine beach at 204 ha/CSU. Three of the top five ranked CSUs across the project area were lagoons in the mid-Atlantic and Floridian subregions: Pamlico Sound (576 ha), Bogue Sound (253 ha), and Florida Bay (145 ha).

OCEAN BEACH

(Figure 2.36) Throughout much of the South Atlantic project area, ocean beaches are associated with barrier islands. Pamlico Sound, which includes Cape Hatteras, has more than double the ocean beach area than any other CSU (1513 ha. Three other CSUs with significant ocean beach associated with barrier islands are Cape Romain (640 ha), Bogue Sound (636 ha), and St. Augustine Inlet (628 ha). In the case of Long Bay (694 ha) the barrier island has welded with the mainland.

SEAGRASS BEDS

(Figure 2.37) The total seagrass extent in the South Atlantic Bight is approximately 560,000 hectares (2,162 mi^2). Twenty-two of the 39 CSUs have seagrass. Those without include the coasts of South Carolina, Georgia, and northeast Florida (e.g., Nassau River, St. Johns River, St. Augustine Inlet, and Mantanzas Inlet) where conditions do not permit seagrass growth and therefore no monitoring is conducted. For all CSUs with seagrass, the average extent was 25,819 hectares (99.7 mi^2).

Seagrass bed coverage differed by shoreline type: island archipelago (205,998 ha), lagoons (360,793 ha), Piedmont rivers (1,147 ha), and coastal riverine (84 ha). Over 80% of the total seagrass acreage in the South Atlantic is associated with the four CSUs located at the southern tip of Florida: Florida Bay (186,667 ha), Lower Keys (144,996 ha), Biscayne Bay (83,279 ha), and Middle Keys (61,002 ha). In this section of the coast, seagrasses are not confined to estuaries, but extend onto the shallow Continental Shelf. Pamlico Sound contains the largest seagrass coverage north of the Floridian subregion with an extent of 42,358 ha.

SHELLFISH REEFS

(Figure 2.38) Oyster habitat has been mapped, at least partially, in 28 of the 39 CSUs that comprise the South Atlantic Bight. The most significant gaps fall in Georgia and Florida where habitat mapping has been limited to select areas. The total area of oyster reefs within the surveyed areas (Figures 2.7-2.10) is 12,811 ha (49.4 mi^2) with an average of 458 ha (1.8 mi^2) per surveyed CSU. Because the total area surveyed for oysters varies across different states and within individual CSUs, oyster reefs are described as the percentage of area surveyed that contained oysters. Across the project area 1.7% of the area surveyed was classified as oyster reef (SC, GA, FL) or shell habitat (NC).

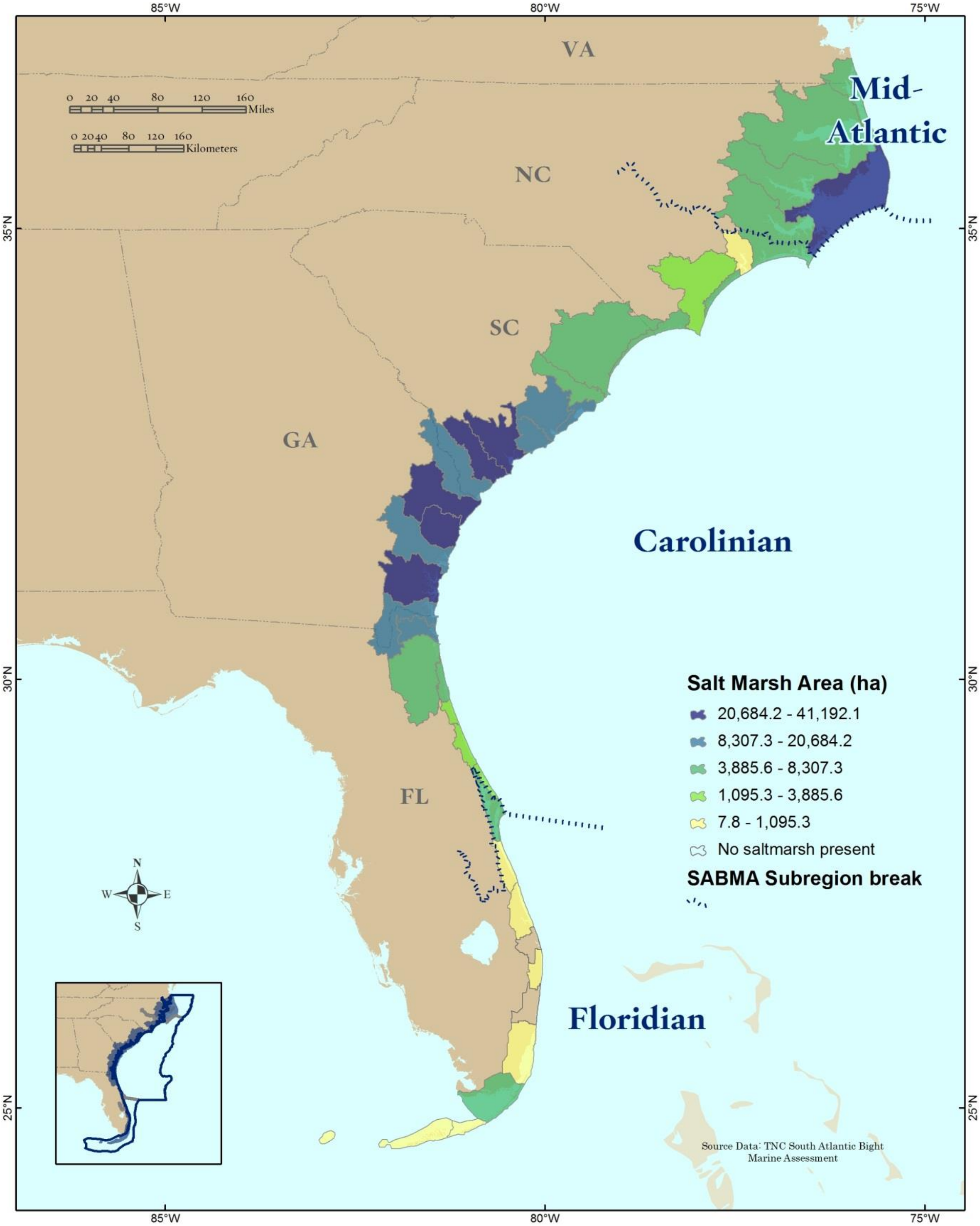

Figure 2.31. Coastal Shoreline Units ranked by salt marsh extent

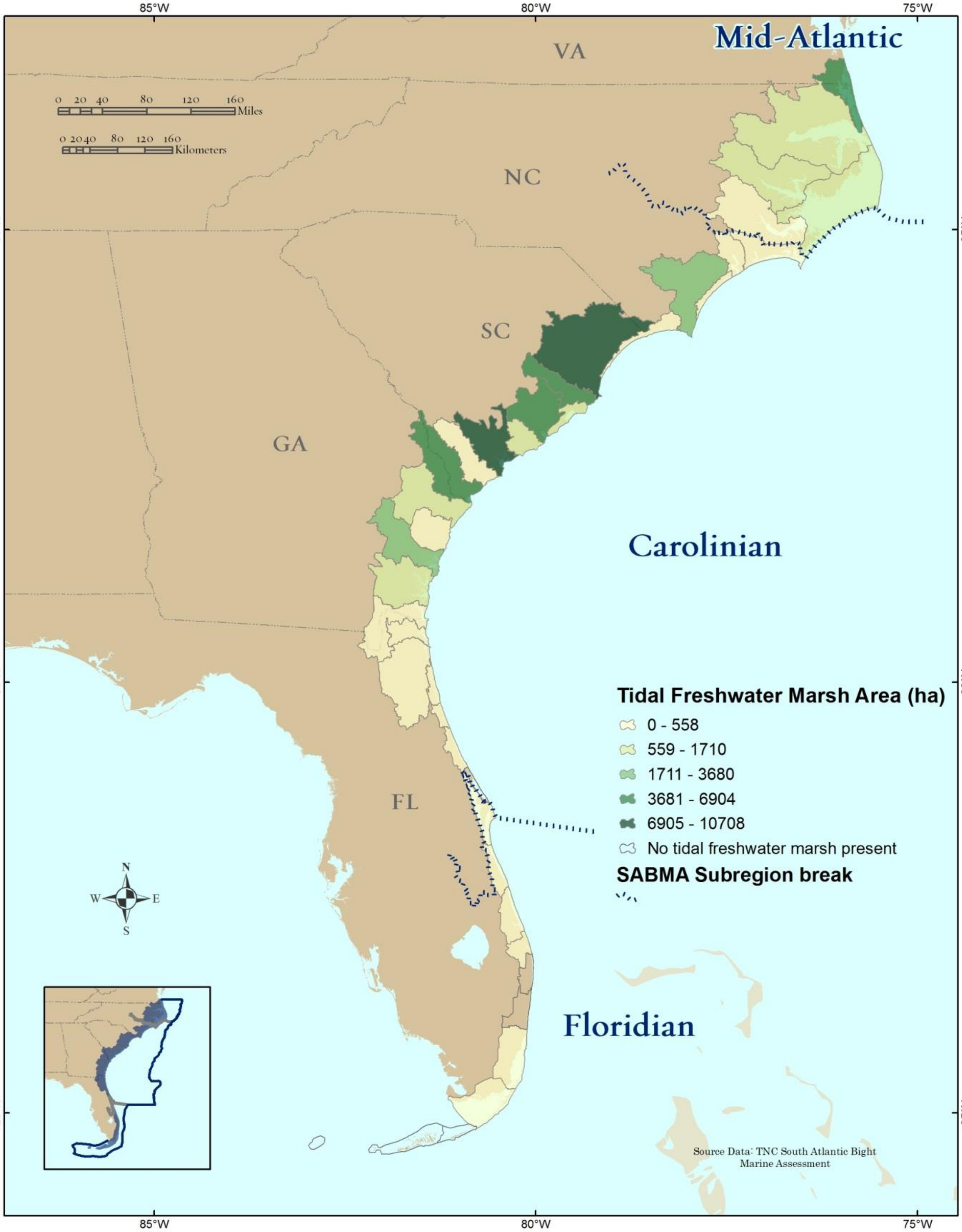

Figure 2.32. Coastal Shoreline Units ranked by tidal freshwater marsh extent

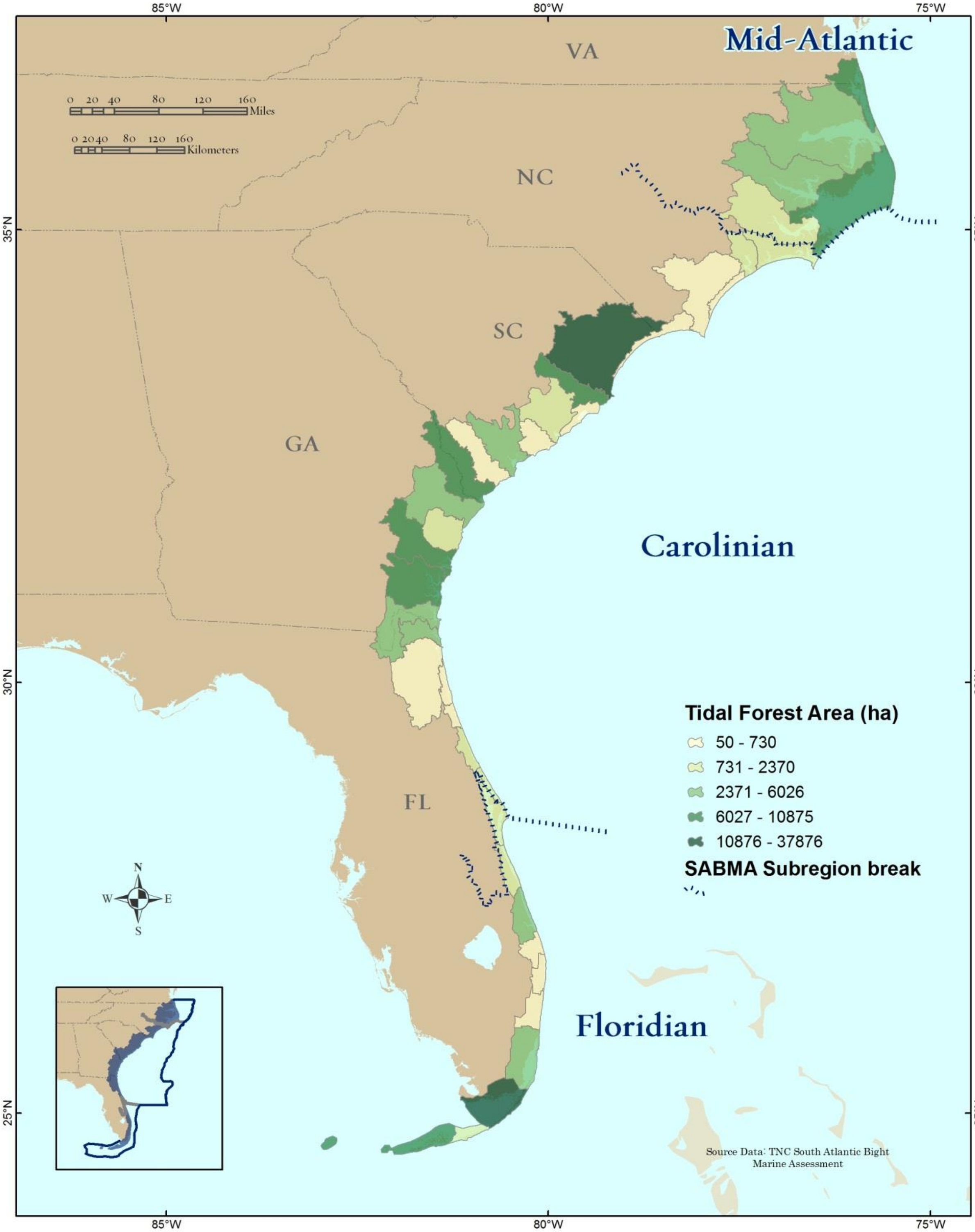

Figure 2.33. Coastal Shoreline Units ranked by tidal forest extent

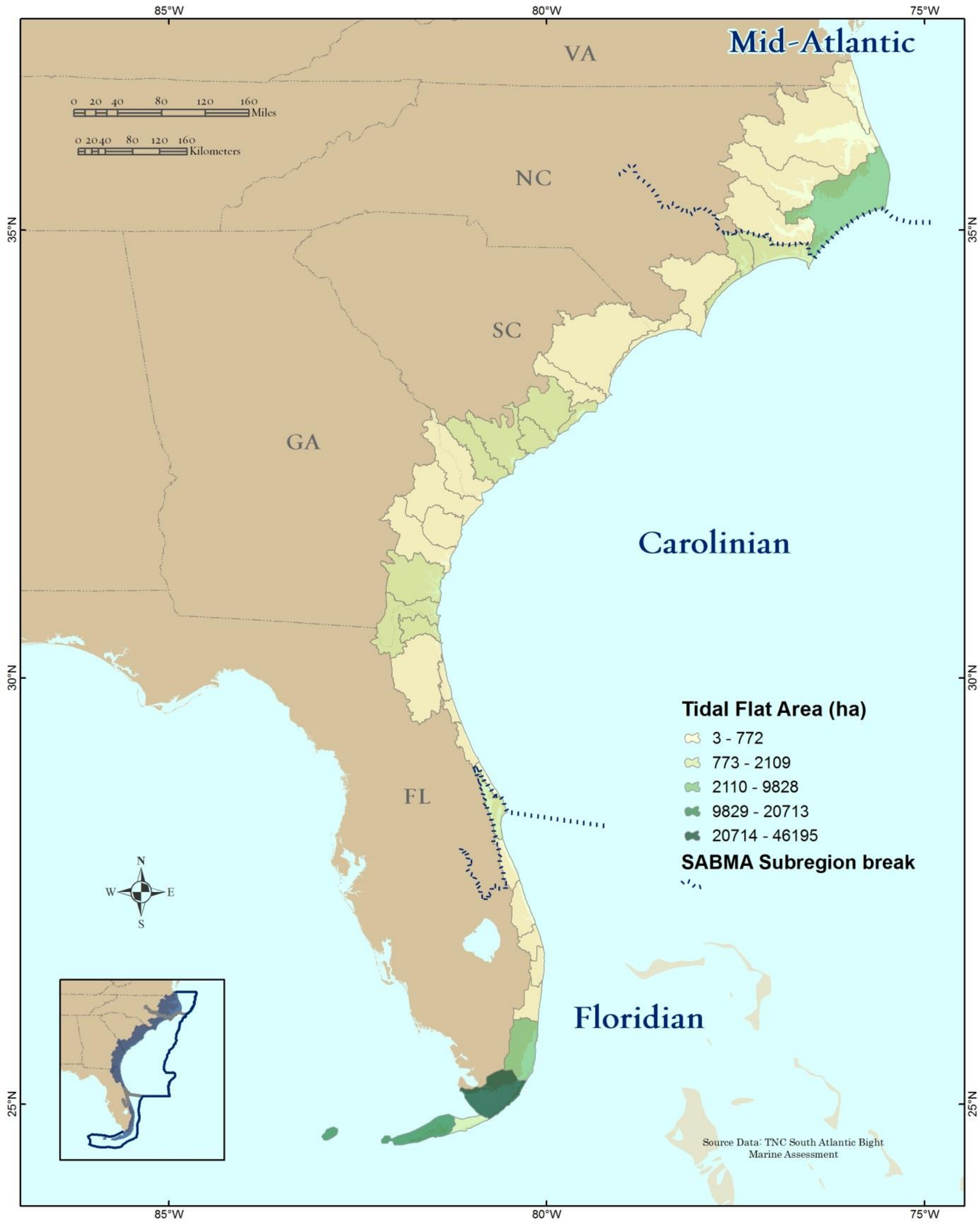

Figure 2.34. Coastal Shoreline Units ranked by tidal flat extent

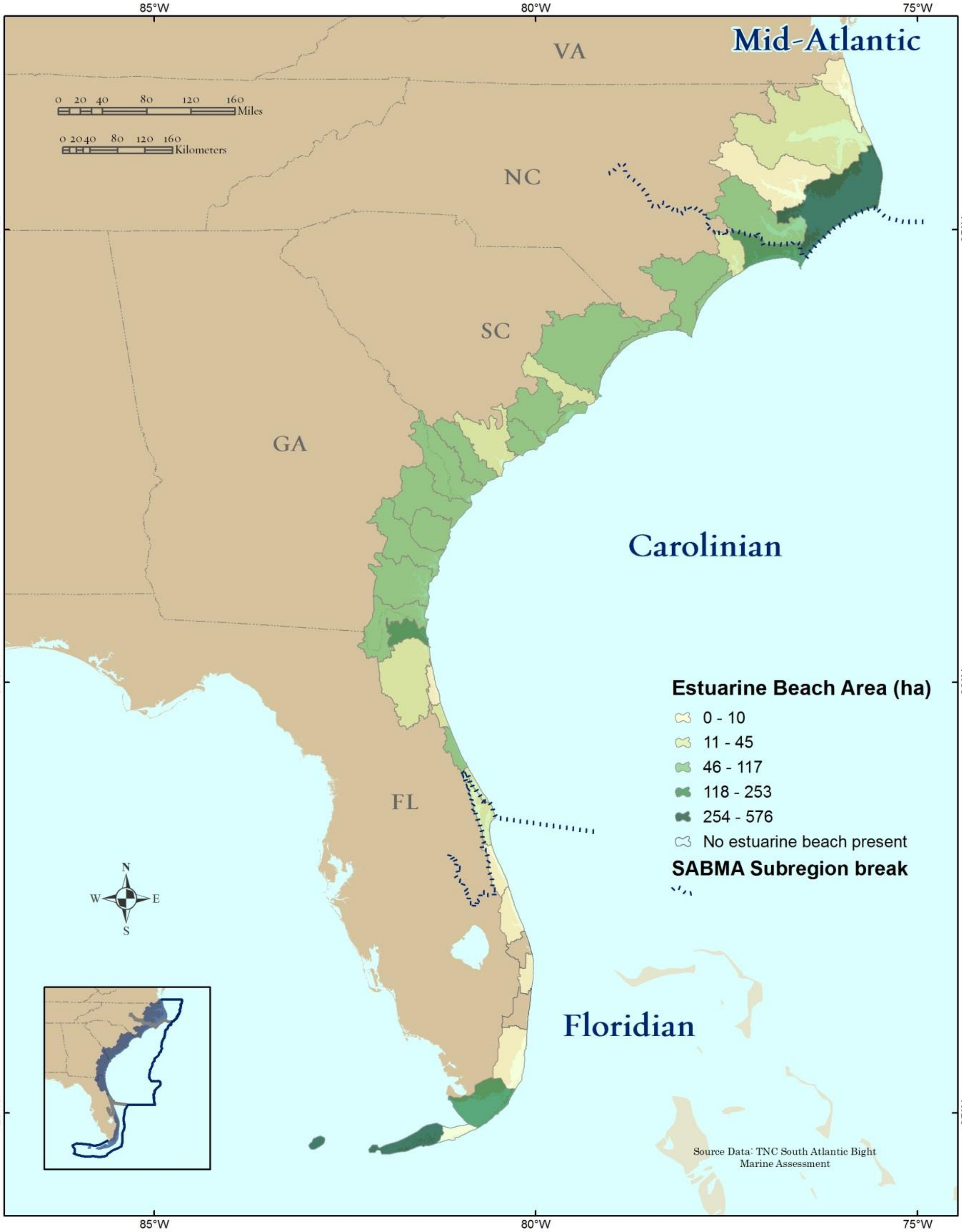

Figure 2.35. Coastal Shoreline Units ranked by estuarine beach extent

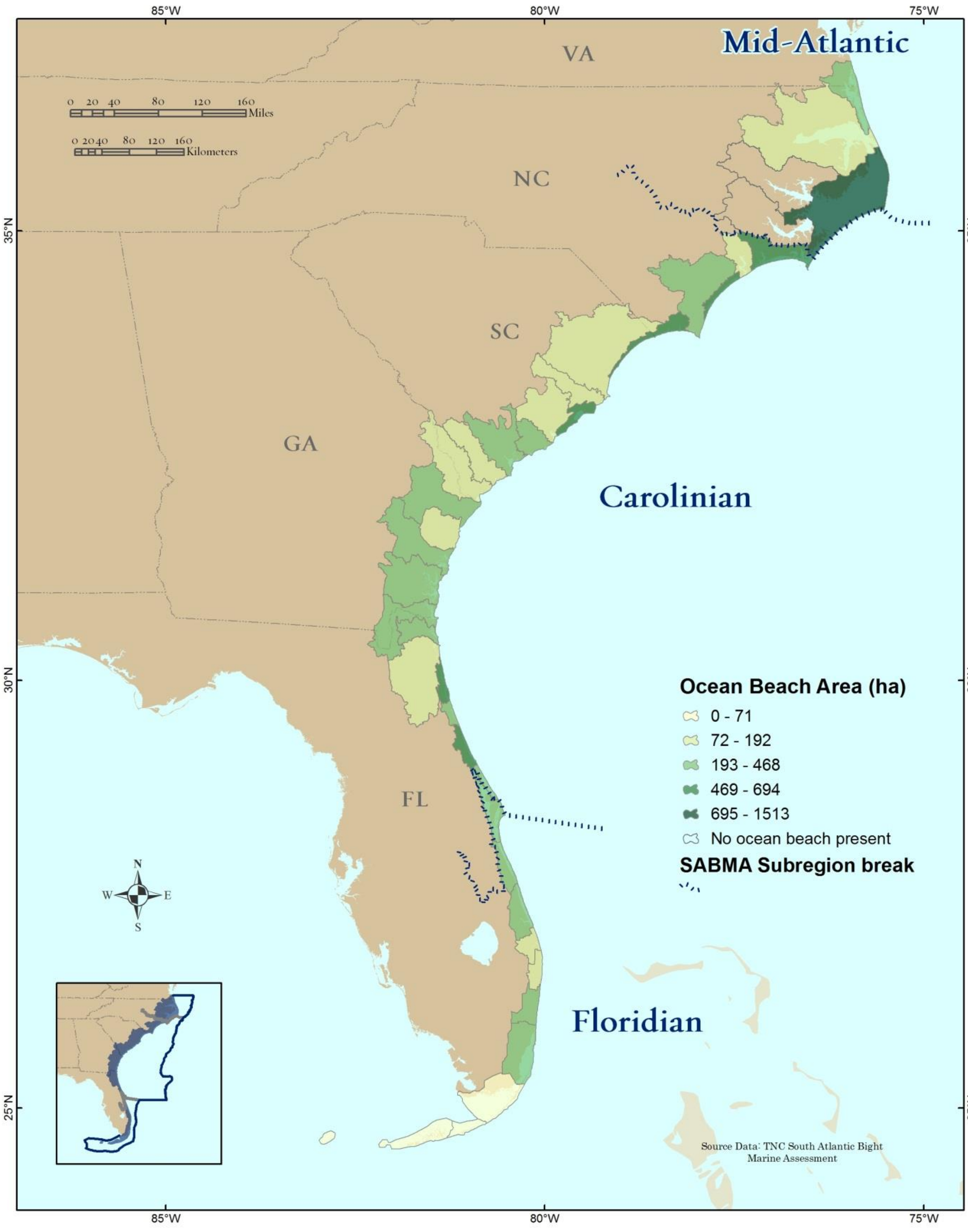

Figure 2.36. Coastal Shoreline Units ranked by ocean beach extent

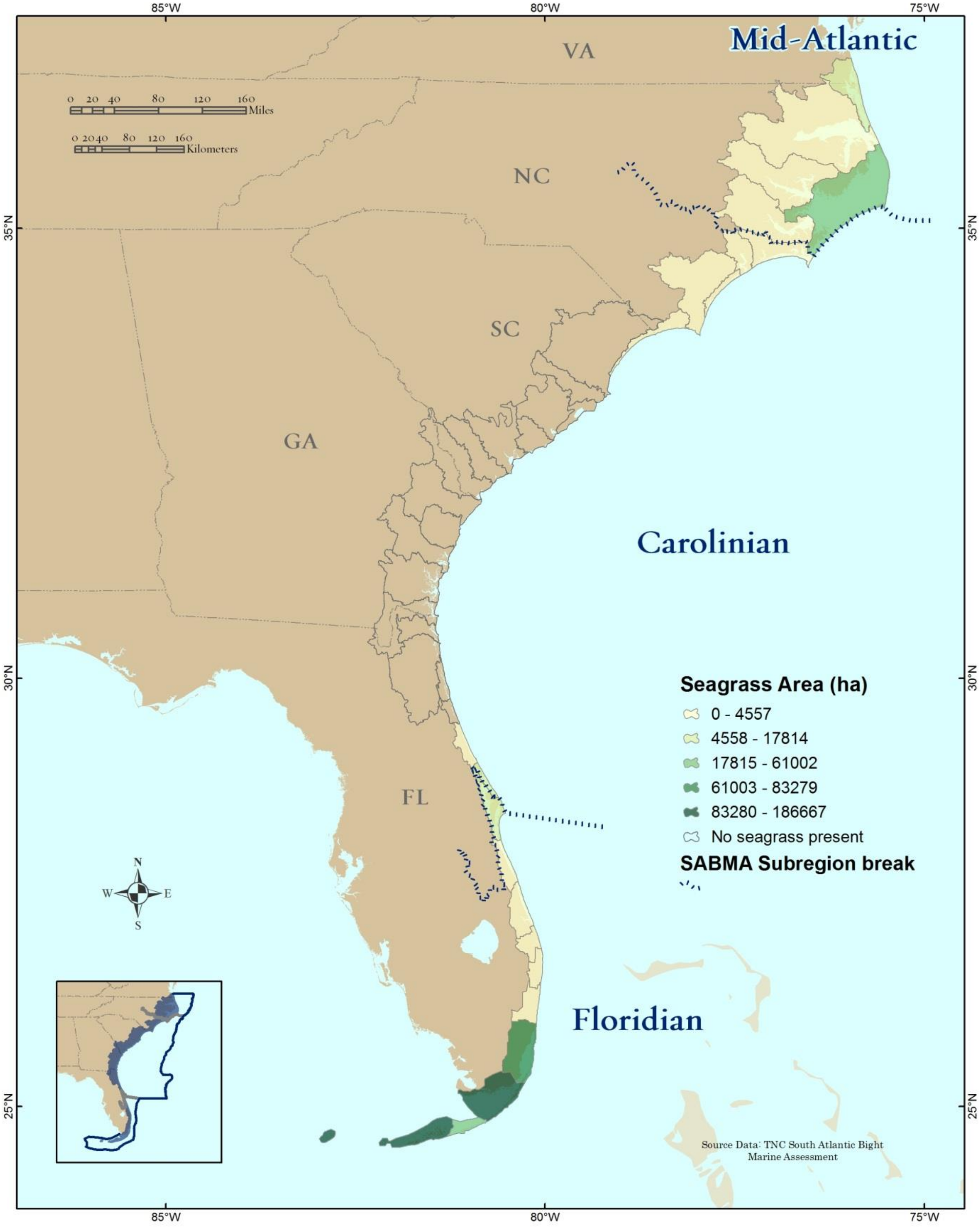

Figure 2.37. Coastal Shoreline Units ranked by seagrass extent

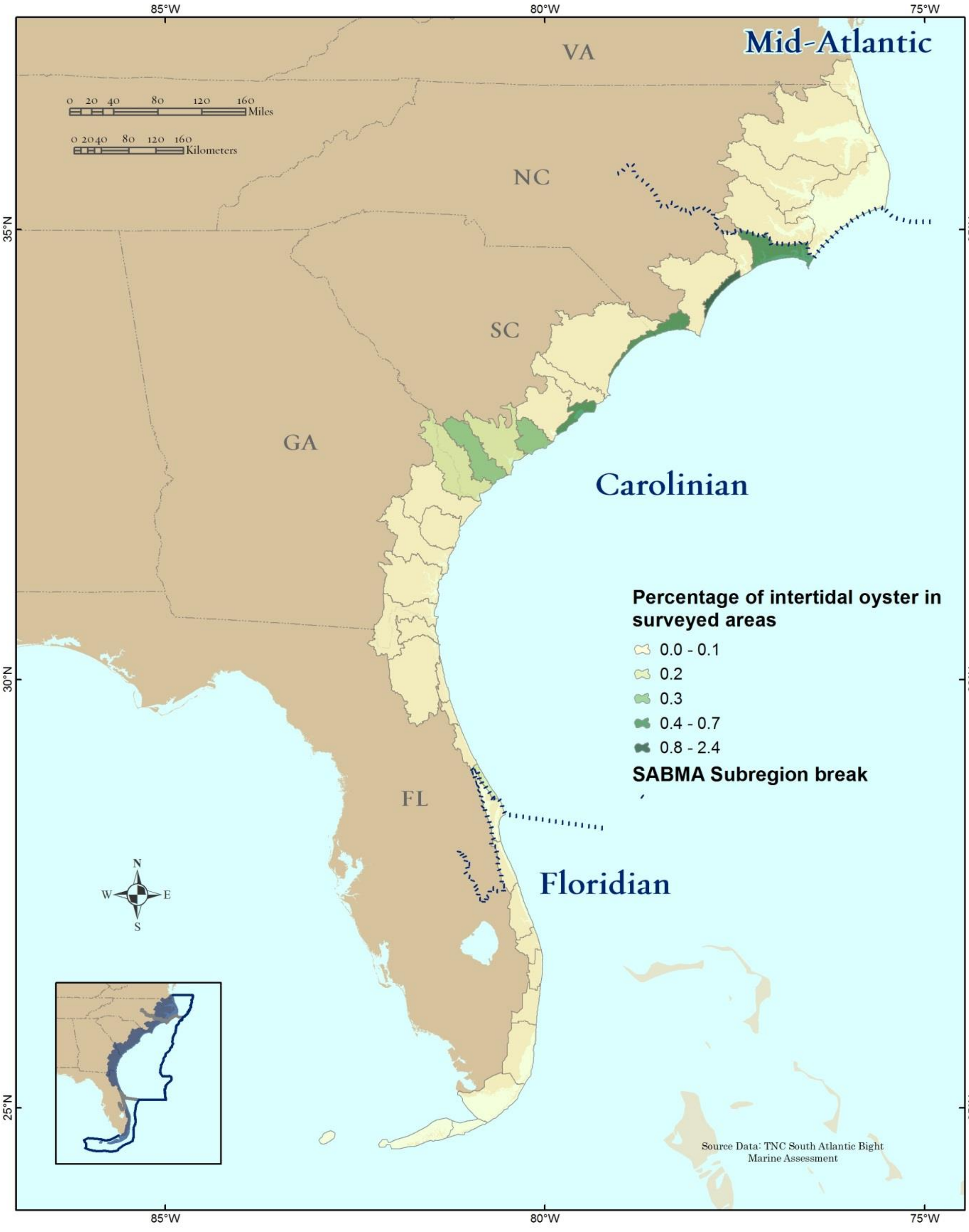

Figure 2.38. Coastal Shoreline Units ranked by density of oyster reefs within surveyed areas

Diadromous Fish

(Figure 2.39) Each river stretch was assigned to a CSU which was then quantified based on highest number of species present for any river stretch within the CSU. Significant variation among states in the size of water body that monitored for diadromous fish made specific calculations, such as average number of species per CSU river mile, inconsistent at a regional scale.

Piedmont riverine estuaries in the mid-Atlantic and Carolinian subregions dominate the list of 16 CSUs with either five or six priority species present. The Santee River system was the only CSU outside of North Carolina where all six species were present. The high concentration of CSUs with all six species present in the northern half of the assessment is related to the fact that one of the selected species (alewife) has a southern spawning boundary near the Albemarle and Pamlico Sounds – presence in CSUs further south would therefore be rare. Piedmont riverine systems have the highest numbers of species overall, while the lagoonal systems have the fewest, corresponding to the presence of spawning areas upstream in freshwater. Lagoonal systems south of the St John's River were almost completely devoid of diadromous fish.

Coastal Birds

(Figure 2.40) The two Western Hemisphere Shorebird Reserve Network sites located within the SAB are associated with three CSUs: Cape Romain, Altamaha River, and St Catherines/Sapelo Sounds.

Loggerhead Sea Turtle Nesting

(Figure 2.41) Of the 39 CSUs located in the South Atlantic Bight, 18 were identified as including loggerhead nesting beaches that fell within the top 25% by density of nests per km of beach within each genetic subpopulation area. The greatest total distance of high density nesting shoreline was in Sebastian Inlet (FL) with 45.9 km. Five CSUs had a minimum of 20 km of high density nesting shoreline: Loxahatchee River (31 km), Cape Romain (26.7 km), St. Lucie River (24.8 km), Winyah Bay (22.8 km) and St. Augustine Inlet (21.7 km). These highest-ranked CSUs contain nesting sites for the entire suite of loggerhead sub-populations.

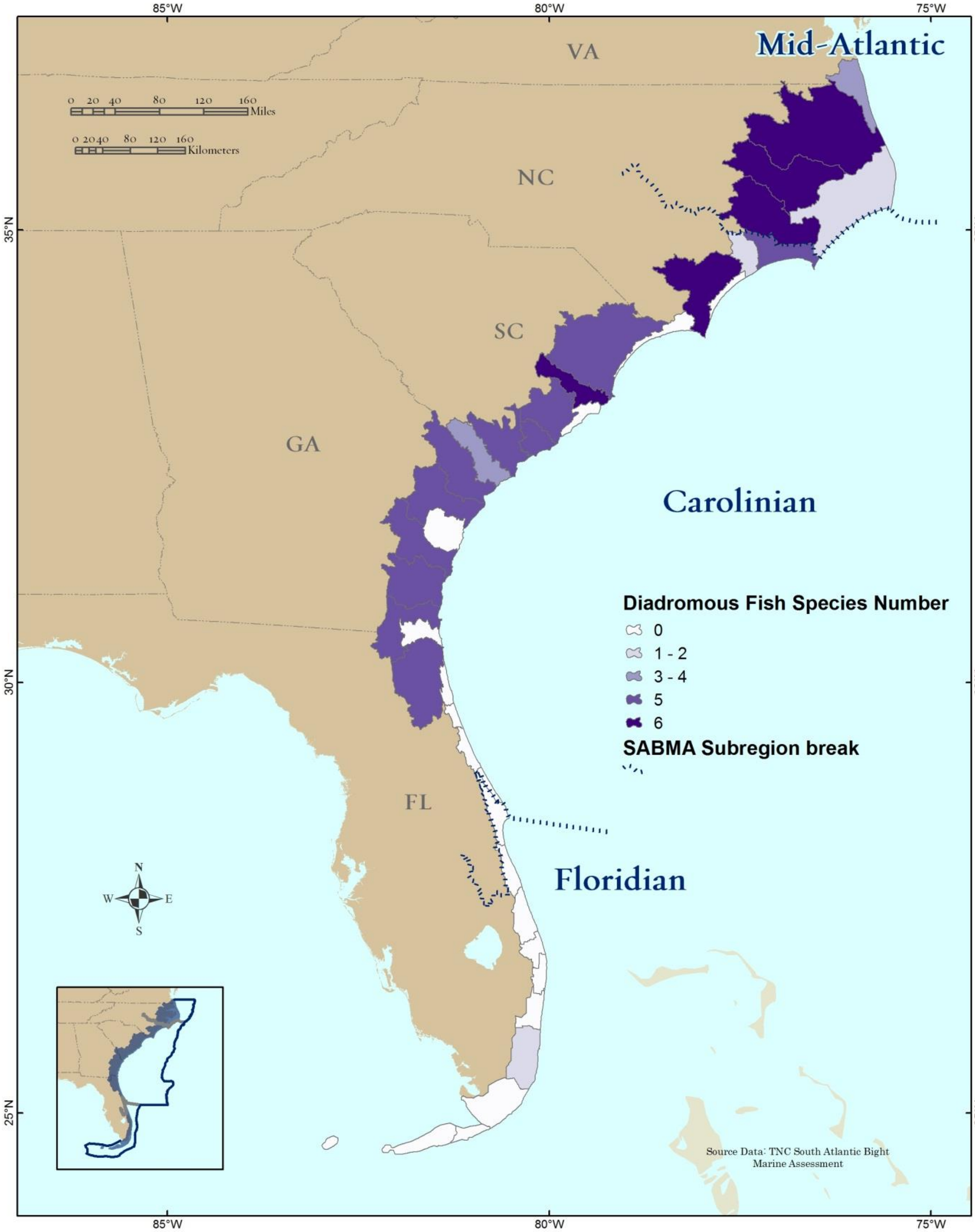

Figure 2.39. Coastal shoreline units ranked by number of priority diadromous fish species found within primary river systems

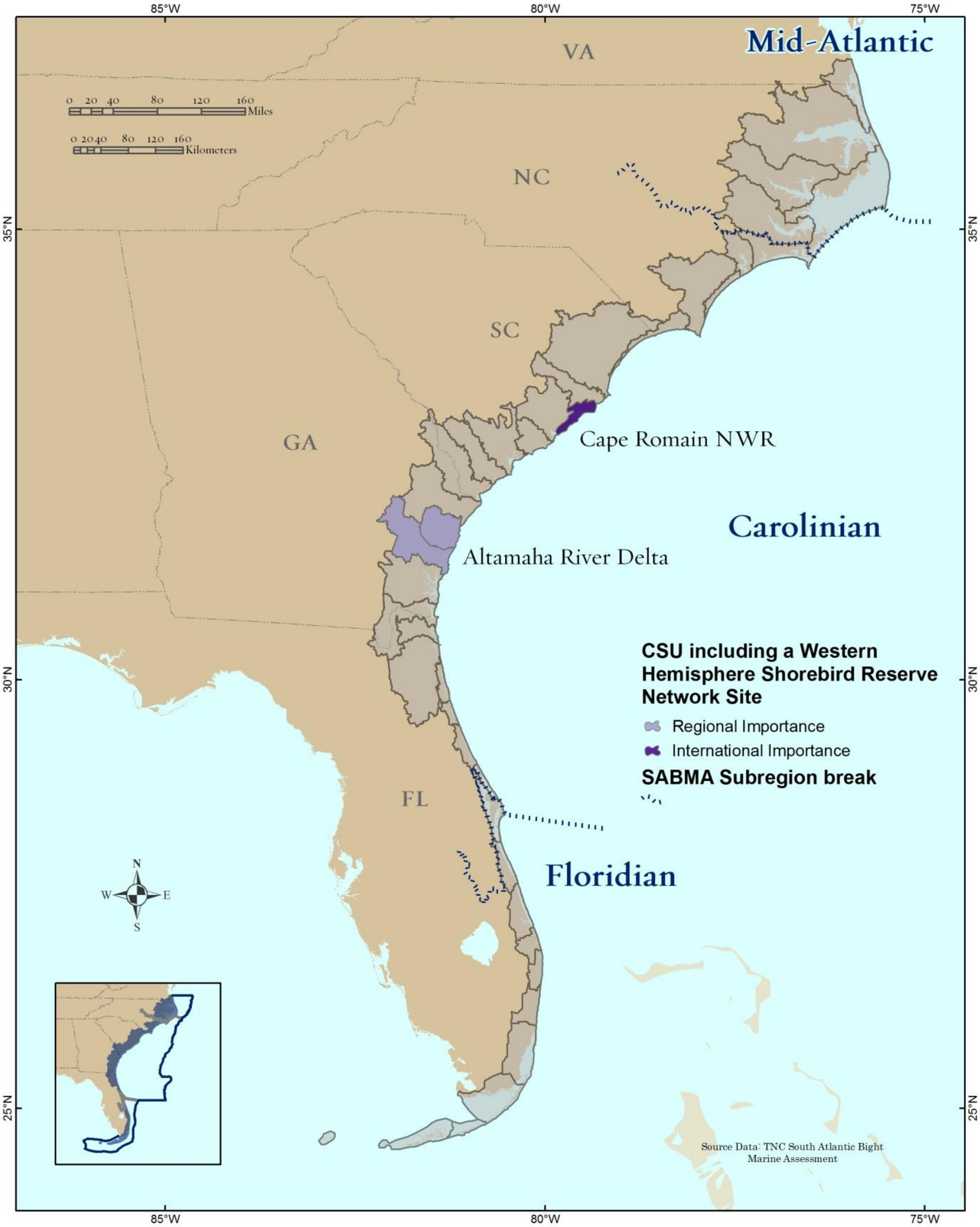

Figure 2.40. Coastal shoreline units coded with presence of Western Hemisphere Shorebird Network sites

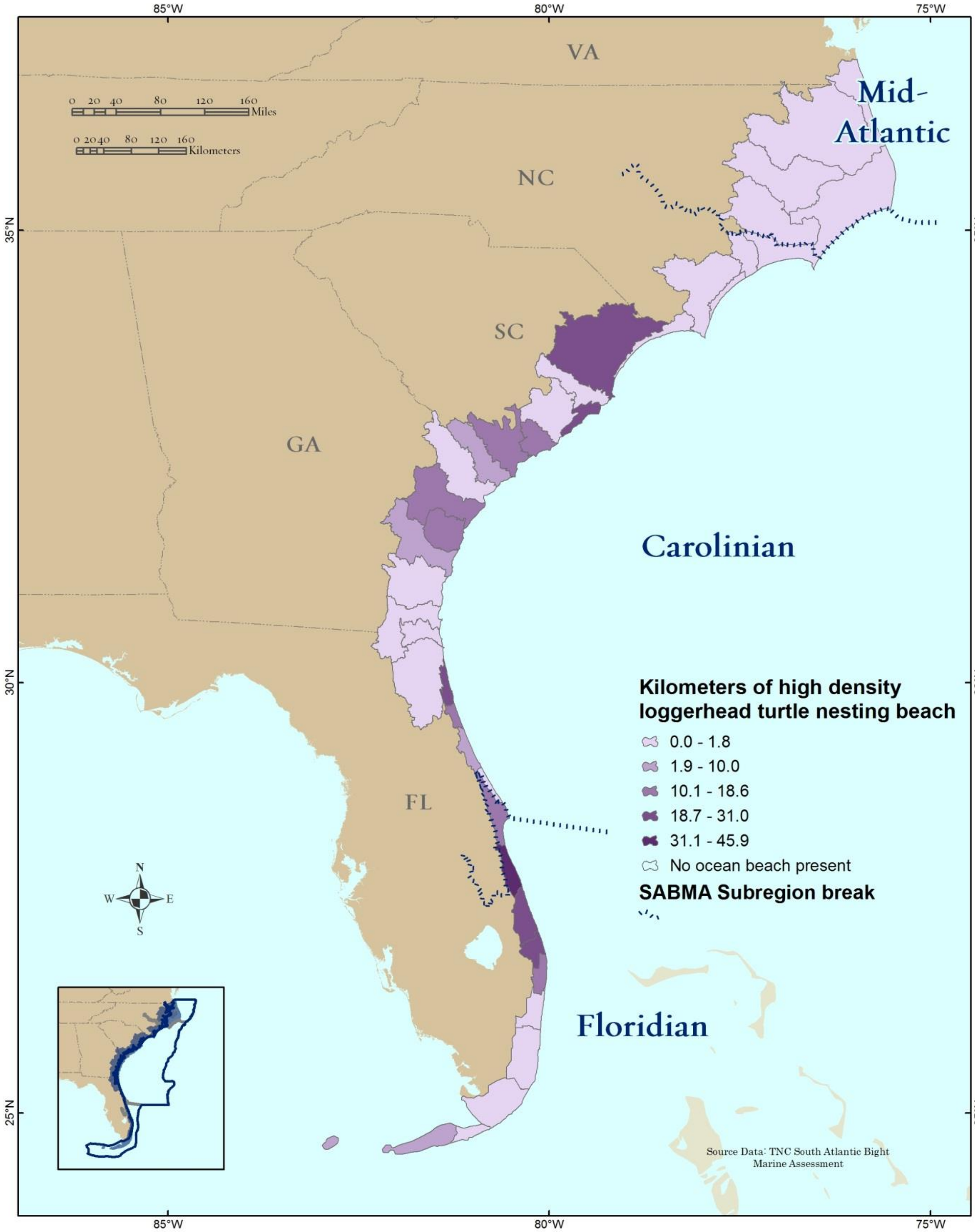

Figure 2.41. Coastal Shoreline Units ranked by kilometers of high density loggerhead turtle nesting beach

Coastal Condition

Land use and conservation level varies greatly across Coastal Shoreline Units in the South Atlantic. This variation is often more closely linked with historical use and distance from population centers than the hydrographic and ecological characteristics that define CSU types. Land cover (Figure 2.37) and shoreline attributes were associated with CSU watersheds to better understand estuarine condition. For land cover characteristics, both the total area and percent land coverage were calculated for each CSU.

SECURED LANDS

(Figure 2.42) There are a total of 1,452,365 ha (5,608 mi^2) of secured lands within the project area, averaging 37,240 ha (143.8 mi^2) per CSU. The CSUs associated with higher protected land percentages often include significant state and federal protected lands, for example, Florida Bay (91.4%; 97,710 ha) and Everglades National Park or Cape Romain (55.9%; 26,799 ha) and the Francis Marion National Forest. Lower percentages of protected land are located near larger urban population centers and ports.

Table 2.6. Coastal Shoreline Units with the highest and lowest percentage of secured lands

Most Protected Lands (>30%)			Least Protected Lands (<10%)		
CSU Name	%	Area (ha)	CSU Name	%	Area (ha)
Florida Bay	91.4%	97,710	Lake Worth Lagoon	2.2%	1,411
Lower Keys	62.2%	11,254	Port Royal Sound	4.3%	8,710
Cape Romain	55.9%	26,799	Satilla River	4.9%	16,929
Pamlico Sound	39.2%	70,315	Winyah Bay	5.0%	41,334
Mosquito Lagoon	50.6%	8,083	Port Everglades	5.4%	5,579
Cape Canaveral	49.1%	34,190	Stono/N Edisto Rivers	5.5%	6,017
Loxahatchee River	47.1%	34,788	Savannah River	7.1%	25,989
Bogue Sound	35.6%	52,664	Tar River	7.4%	35,658
Ossabaw Wassaw Sounds	34.7%	121,596	SE NC Estuaries	7.7%	2,834
Santee Rivers	33.8%	59,872	Long Bay	8.5%	7,875
			Neuse River	9.9%	42,293

AGRICULTURAL LANDS

(Figure 2.43) There are a total of 1,066,955 ha (4120 mi^2) of agricultural lands within the project area, averaging 27,358 ha (105.6 mi^2) per CSU. Five of the eight CSUs with agricultural land percentages over 15% are found in the Mid-Atlantic Region – Tar River (33.4%), Currituck Sound (30.4%), Albemarle Sound (29.2%), Neuse River (24.4%) and Pamlico Sound (20.0%).

Table 2.7. Coastal Shoreline Units with the highest and lowest percentage of agricultural lands

Most Agricultural Lands CSU Watersheds (>15%)			Least Agricultural Lands CSU Watersheds (<2%)		
CSU Name	%	Area (ha)	CSU Name	%	Area (ha)
Tar River	33.4%	161,356	Middle Keys	0%	0
Currituck Sound	30.4%	34,507	Lower Keys	0%	7
Albemarle Sound	29.2%	246,083	Mantanzas Inlet	0.4%	124
St. Lucie River	25.3%	29,927	St. Catherines/ Sapelo Sounds	0.5%	895
Neuse River	24.4%	104,410	St. Augustine Inlet	0.6%	292
Pamlico Sound	20.0%	35,838	Florida Bay	0.9%	910
Sebastian Inlet	18.8%	14,373	Mosquito Lagoon	1.2%	193
Winyah Bay	17.6%	144,574	Ponce Inlet	1.7%	1,050
			Satilla River	1.9%	6,475

DEVELOPED LANDS

(Figure 2.44) Percent of developed lands varies widely within individual CSU watersheds, ranging from 2.1 to 90.6%. There is a total of 1,121,797 ha (4,331 mi^2) of developed lands within the project area, averaging 28,764 ha (111 mi^2) per CSU. The Floridian subregion contains the highest developed lands percentages in the South Atlantic project area.

Table 2.8. Coastal Shoreline Units with the highest and lowest percentage of developed lands

Most Developed CSU Watersheds (>30%)			Least Developed CSU Watersheds (<5%)		
CSU Name	**%**	**Area (ha)**	**CSU Name**	**%**	**Area (ha)**
Port Everglades	90.6%	94,448	Santee Rivers	2.1%	3,793
Lake Worth Lagoon	89.4%	58,003	Florida Bay	3.0%	3,155
Biscayne Bay	60.3%	113,281	St. Helena Sound	3.7%	9,646
Middle Keys	59.0%	1,800	Pamlico Sound	4.2%	7,549
St. Lucie River	46.8%	55,453			
Ponce Inlet	45.0%	27,934			
Sebastian Inlet	40.6%	31,017			
SE NC Estuaries	32.7%	12,130			
Cape Canaveral	31.1%	21,649			
Mantanzas Inlet	30.5%	9,784			

IMPERVIOUS SURFACE AREA

(Figure 2.45) There are a total of 316,916 ha (1,224 mi^2) of impervious area, averaging 8,126 ha (31.4 mi^2) per CSU. For the most part, CSUs with the highest density of impervious surface corresponded closely with developed lands. In fact, nine of the ten CSUs with the highest percentage of developed land and imperviousness were the same. The exception was Mantanzas Inlet, which ranked tenth for developed lands (30.5%) but was replaced by the Lower Keys when evaluating imperviousness (11.1%). Thirty of the 39 CSUs in the SAB had impervious values under 10% of the total watershed. Areas with low impervious surface percentages were located along the South Carolina and Georgia coastlines, between Winyah Bay and St. Simons, and around the Albemarle-Pamlico Sound in North Carolina.

Table 2.9. Coastal Shoreline Units with the highest and lowest percentage of impervious cover

Most "Impervious" CSU Watersheds (>8%)			Least "Impervious" CSU Watersheds (<1.5%)		
CSU Name	**%**	**Area (ha)**	**CSU Name**	**%**	**Area (ha)**
Port Everglades	35.4	36,852	Santee Rivers	0.3	497
Lake Worth Lagoon	34.2	22,224	St Helena Sound	0.4	1,153
Biscayne Bay	25.6	48,033	Albemarle Sound	0.8	6,634
Middle Keys	24.2	739	Pamlico Sound	0.9	1,553
Ponce Inlet	13.5	8,403	St Catherines/ Sapelo Sounds	0.9	1,602
St Lucie River	12.2	14,484	Altamaha River	1.0	3,052
Sebastian Inlet	11.6	8,867	Florida Bay	1.0	1,075
Lower Keys	11.1	2,017	Stono North Edisto Rivers	1.2	1,293
Cape Canaveral	10.4	7,211	Tar River	1.2	5,960
SE NC Estuaries	8.8	3,260	Satilla River	1.3	4,604
Loxahatchee River	8.0	5,934	Winyah Bay	1.3	11,042

HARDENED SHORELINE

(Figure 2.46) A significant proportion of the shoreline of the South Atlantic Bight region is man-made or altered by human structures of various kinds. The average proportion of man-made shoreline per CSU across the region is 13%, representing over 5,000 total shoreline kilometers (3,107 mi). There are marked differences in the proportion of man-made shoreline across CSUs, ranging from a high of 75% in Port Everglades to a low of 0% for the Santee Rivers. Not surprisingly, the more industrialized and populated Floridian subregion has the highest average percentage of hardened shoreline at 34%.

Table 2.10. Coastal Shoreline Units with the highest and lowest percentage of hardened shoreline

Most Hardened Shoreline (>25%)			Least Hardened Shoreline (<2%)		
CSU Name	**%**	**Distance (km)**	**CSU Name**	**%**	**Distance (km)**
Port Everglades	75.7%	704	Santee Rivers	0.0%	0
Lake Worth Lagoon	70.2%	191	Nassau River	0.8%	7
Middle Keys	38.9%	142	Cape Romain	0.9%	11
Mantanzas Inlet	33.2%	78	St Catherines/Sapelo Sounds	1.3%	23
Loxahatchee River	31.1%	86	Altamaha River	1.5%	14
St. Lucie River	29.8%	212	St Helena Sound	1.5%	29
Biscayne Bay	26.5%	462	Cape Fear River	1.9%	36
Cape Canaveral	26.5%	271			

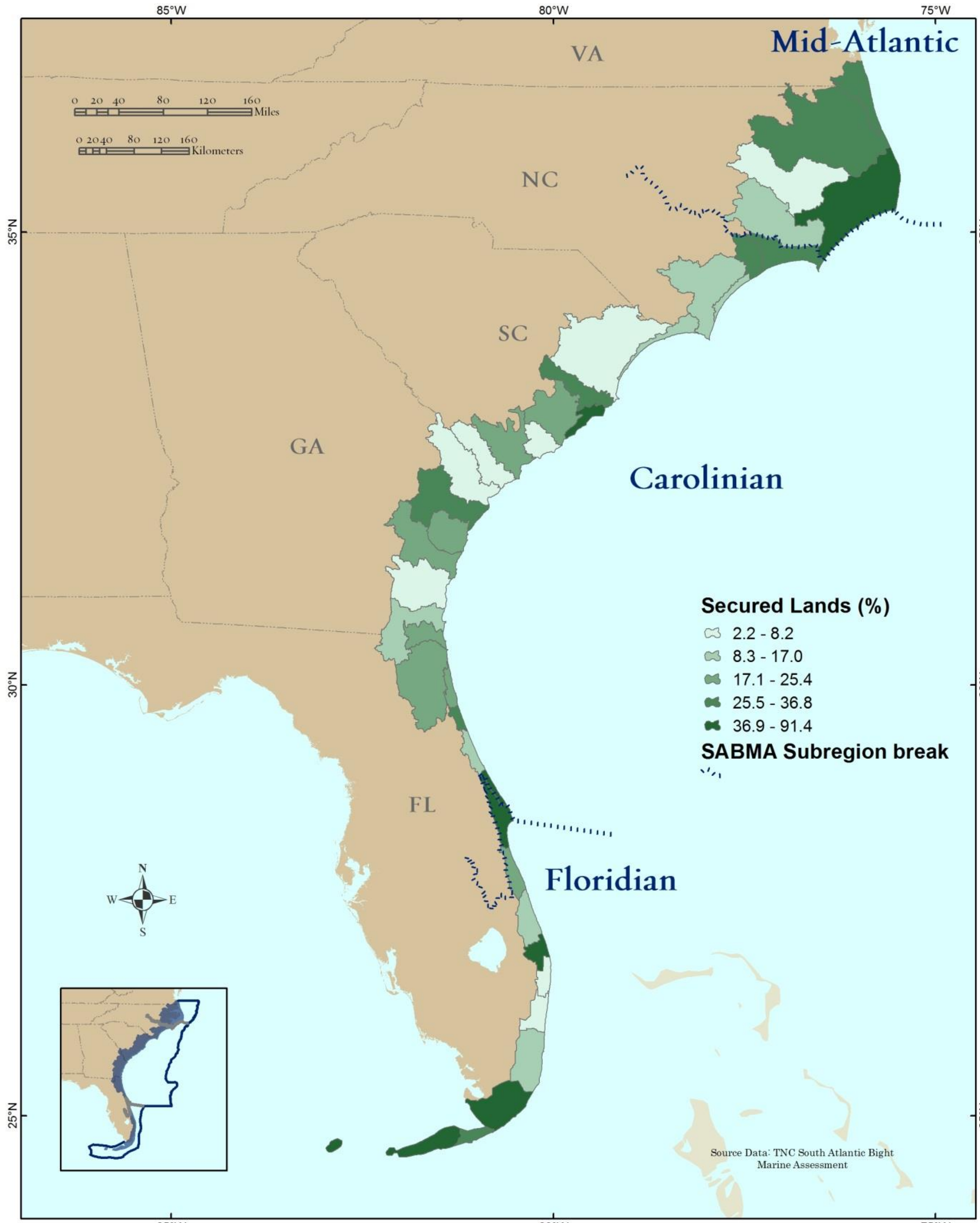

Figure 2.42. Coastal Shoreline Units ranked by the presented of secured (protected) lands

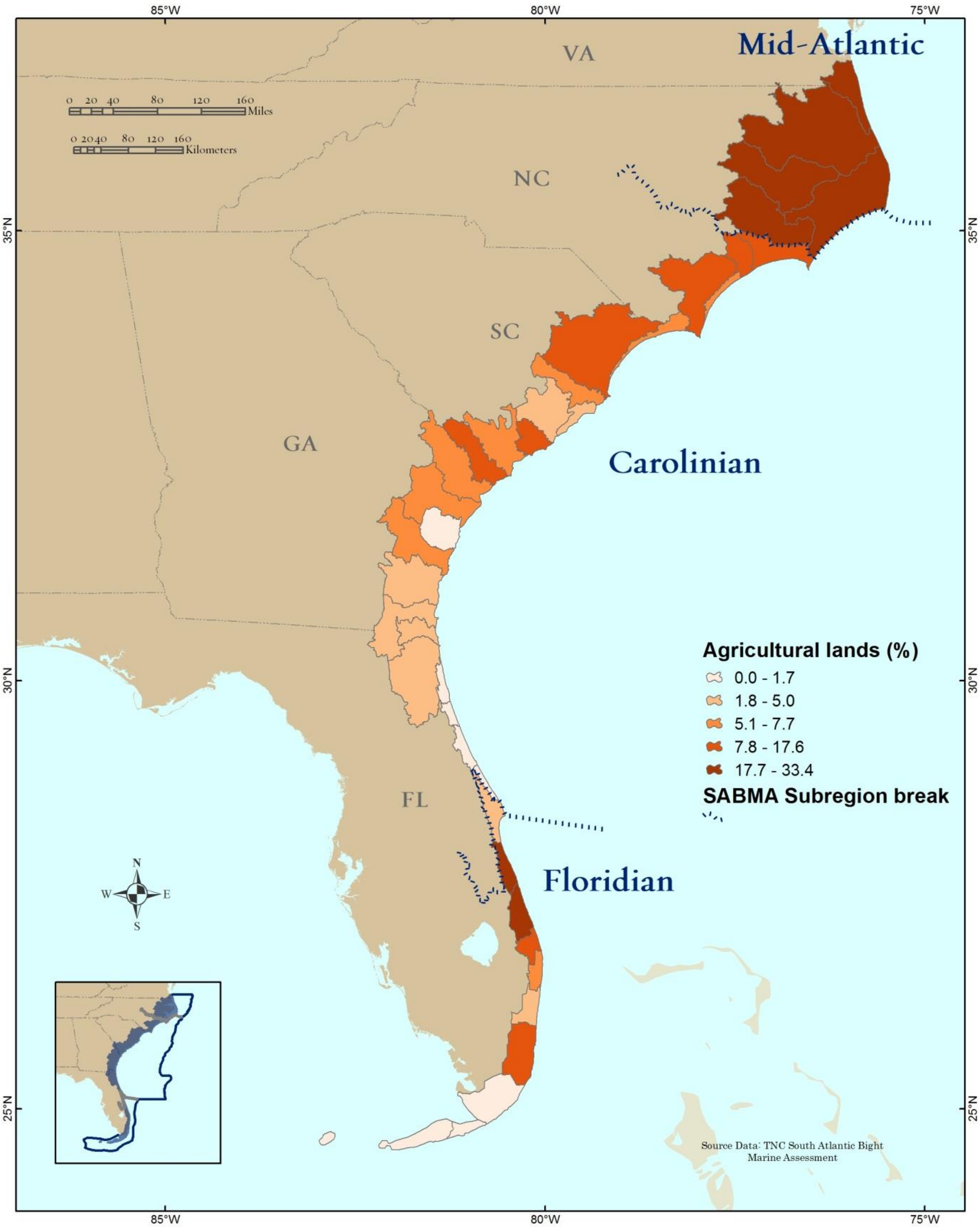

Figure 2.43. Coastal Shoreline Units ranked by percent of agricultural lands

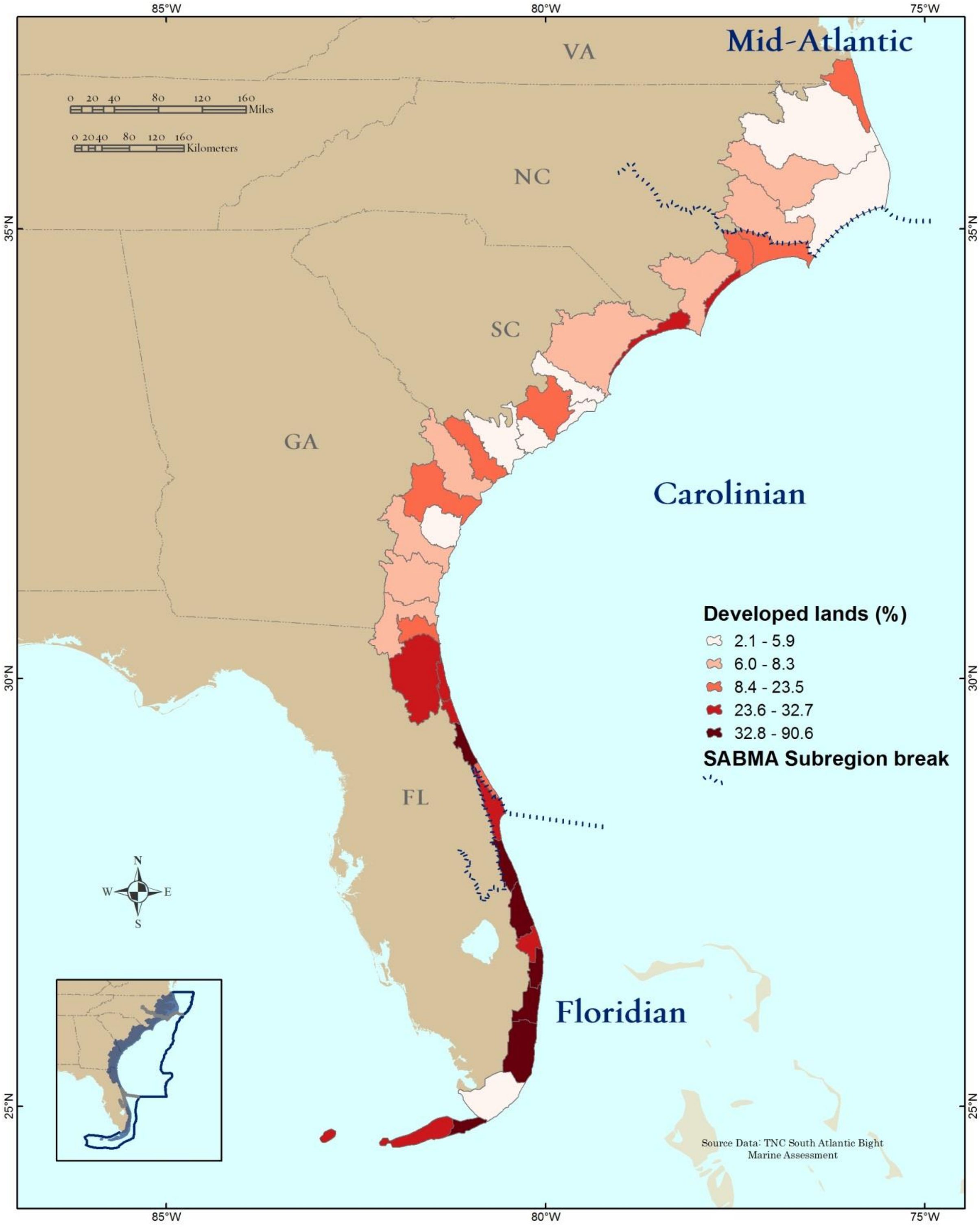

Figure 2.44. Coastal Shoreline Units ranked by percentage of developed lands

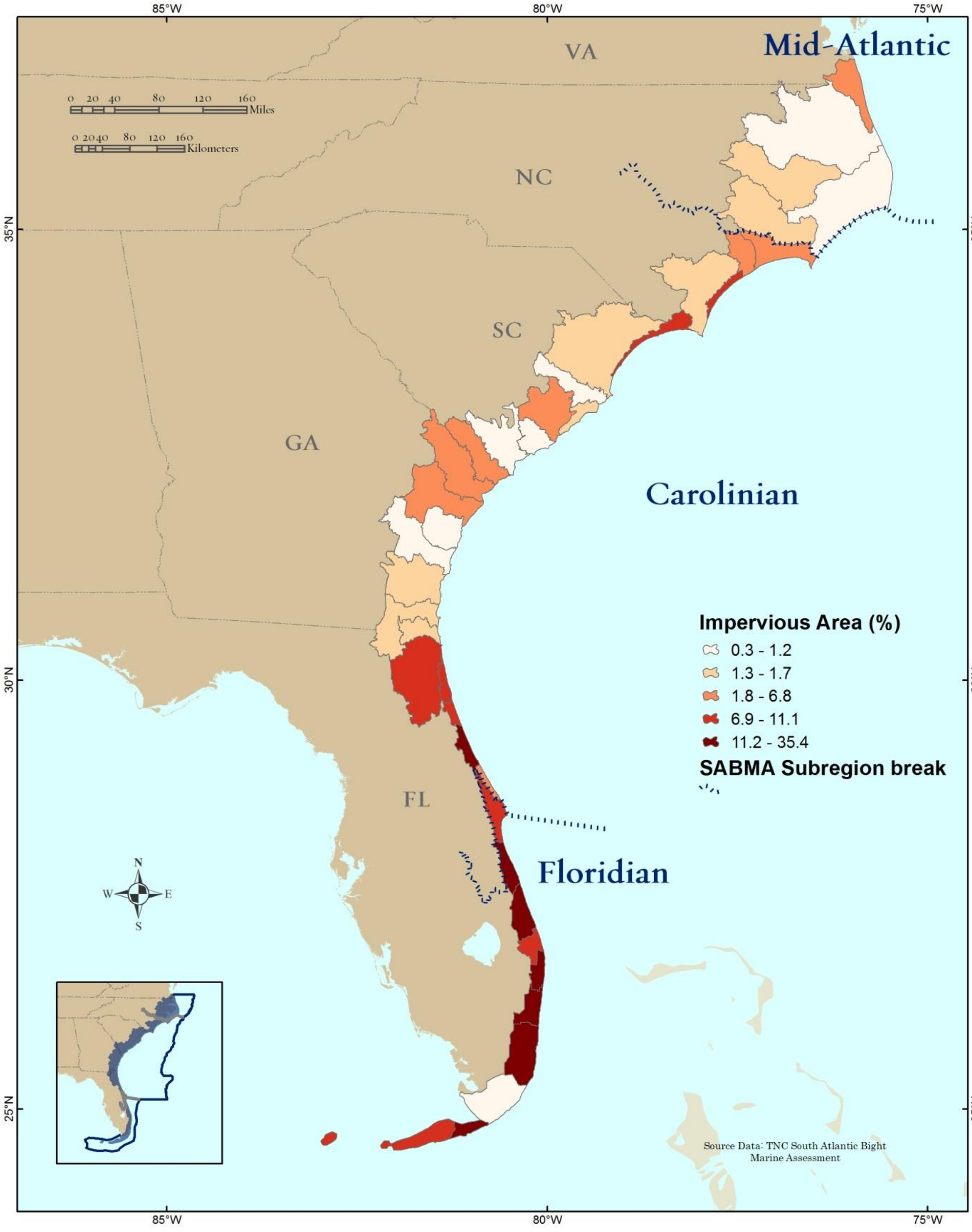

Figure 2.45. Coastal Shoreline Units ranked by percent impervious surface

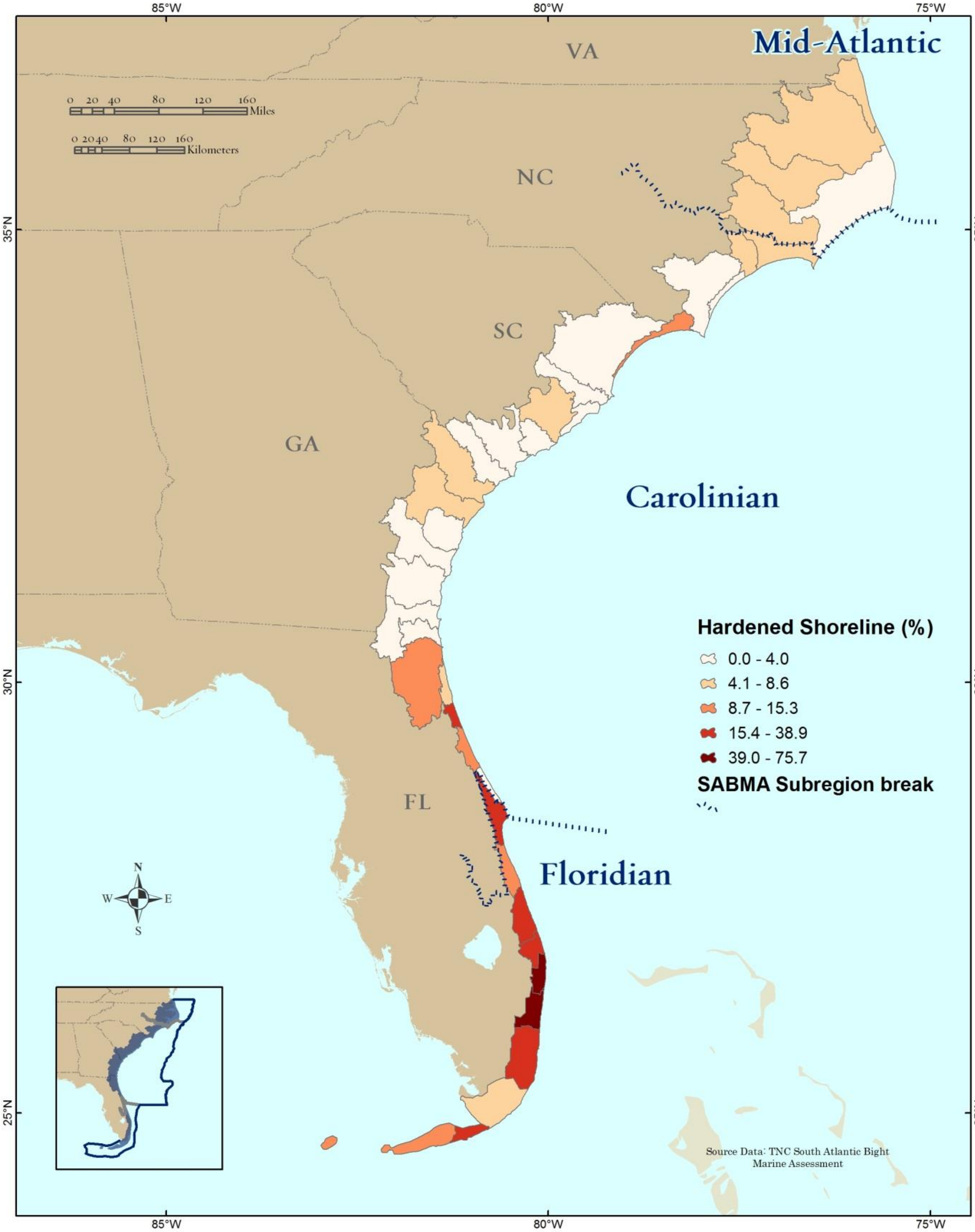

Figure 2.46. Coastal Shoreline Units ranked by percent hardened shoreline

Human Interactions and Other Threats

The coast is a dynamic place – daily tides, seasonal storms, and long term climate variation all interact to form a constantly changing landscape. What is now the Continental Shelf edge was once the shoreline. The productivity and diversity of the South Atlantic's coastal systems in the face of these long- and short-term changes speaks to the adaptability and resilience of many of the plants and animals now using these habitats. Today, however, these systems are facing pressure from a variety of sources, both from land and in the water. This section provides an overview of many of the human impacts, threats and risks to targeted coastal habitats and species in the SAB.

Coastal Development and Shoreline Stabilization

Between 1980 and 2006, the coastal counties of the Southeast coast region showed the largest rate of population increase (79%) of any coastal region in the conterminous United States: an increase in population density from 186 to 332 persons/square mile (Kildow et al. 2009; EPA 2012). Development can lead to direct destruction of coastal habitats, and it can also bring increased inputs of nutrients and toxins, alterations of tidal flow, and overland freshwater input, all of which can impact estuarine and nearshore systems.

Shoreline stabilization is one way that development can impact coastal systems. Shoreline armoring of all types (e.g., groins, bulkheading, rip rap) can cause direct loss of habitat, most often impacting adjacent properties (Nordstrom et al. 2003). An associated impact is the inability of wetlands to migrate with changes in ocean processes and sea level rise. It is estimated that 30% of the shoreline in the Nuese River Estuary (NC) has been stabilized with hardened structure (Corbett et al. 2008).

Pollution and Eutrophication

Estuaries normally receive nutrients from natural sources in their watersheds (e.g., wetlands) and from the ocean. However, population growth and related activities have increased nutrient inputs above natural levels (CENR 2003), which often results in an increase in the rate of supply of organic matter in an ecosystem, known as eutrophication (Nixon 1995). An over-supply of organic matter can produce undesirable effects, including elevated levels of chlorophyll *a*, low dissolved oxygen, extensive macroalgae, loss of seagrass, and harmful algal blooms (Bricker et al. 1999; CENR 2003). Nitrogen is the most common driver of estuarine eutrophication, coming from a variety of point (e.g., treatment plants, industrial sources) and non-point sources (e.g., septic systems, agricultural runoff, combined sewage overflows) (CENR 2003).

The South Atlantic region has relatively few highly eutrophic estuaries; the exceptions are Pamlico/Pungo Rivers, Neuse River, New River and St. John's River (Bricker et al. 1999). This status corresponds with the results from the *National Coastal Condition Report IV* (EPA 2012) which rated the overall coastal condition for the coastal waters of the Southeast region as fair based on indicators such as chlorophyll *a*, nitrogen and dissolved oxygen. While overall indicators show limited signs of eutrophication, Bricker et al. (1999) did note that the Southeast is facing increasing impacts from harmful algal blooms. Continued population growth in the region has the potential to further impact coastal systems and should be monitored.

Altered Sediment Regimes

Barrier islands, sand shoals, and riverine deltas are geologically unstable and therefore likely to be impacted directly and indirectly by engineering that alters natural sediment supplies. Human activities can diminish sand sources. For example, channel dredging can impact shorelines as sediments accumulate in the deeper channels rather than near the adjacent shores. Similarly, nearshore sand mining can starve beaches of their natural sand supply in an attempt to nourish other beaches. The result can be the total loss of some beaches, or some beaches may become more transitory as they erode at increased rates (Riggs and Ames 2003).

Within estuaries, alteration of sediment dynamics by creating and maintaining inlets can impact tidal amplitude, residence time, temperature, and salinity. Sediment pollution is also a direct threat to shellfish populations as resuspended sediments and siltation events can harm shellfish gills, interrupt feeding, and decrease recruitment success (Kennedy et al. 1996).

Altered Freshwater Regime

Human activities have altered the freshwater inflow to most estuaries in the continental U.S. (Dynesius and Nilsson 1994). These activities include dams, impoundments, ground and surface water withdrawals, and channelization. The southeast region has some highly-altered systems, such as the Savannah and Santee with five dams each (Dynesius and Nilsson 1994). It also has some of the few remaining unimpounded coastal plain rivers, including the Waccamaw, Edisto, Ogeechee, and Satilla (Dame et al. 2000).

Altered freshwater regimes affect the timing, quantity and rate that freshwater enters estuarine systems which can directly influence salinity and circulation patterns. These changes can lead to shifts in wetland communities, in particular limiting the habitats available for tidal freshwater communities. Increased salinity can stress shellfish communities, leading to higher direct mortality or increases in susceptibility to disease and predators (Kennedy et al. 1996). In addition, impoundments and dams can limit movement of species, including diadromous fish, between spawning, nursery, and adult habitats.

Physical Destruction and Overharvest

A variety of activities beyond coastal development can lead to the direct destruction of coastal habitats. Prop scarring from boats can impact seagrass beds, particularly in Florida Bay and around the Florida Keys (SFNRC 2008). Small and large scale dredging projects can directly destroy seagrass beds and bottom communities. Restrictions on timing of dredging are in place in many locations to limit impacts on sea turtles which can get caught in dredge machines.

Another direct impact to coastal resources is overharvest and associated fishing activities, including dragging, dredging, and boat wakes. In the case of oyster reefs, overharvest can both deplete populations and reduce the ecosystem services (e.g., water quality, shoreline protection, fish refugia) provided by these complex structural habitats. Recent data show oyster landings on the U.S. East Coast at a mere 2% of historic highs (Eastern Oyster Biological Review Team 2007).

Invasive Species and Disease

New exotic marine species can have major impacts on marine and coastal systems through competition with native species, predation (e.g., green crabs on clams), or actual habitat impacts. By the time they are detected, marine invasive species are virtually impossible to eradicate. The ecological consequences of recent marine invasions in this region are uncertain. Global shipping and aquaculture are the main vectors for introduction of exotic marine species and marine disease invasions.

Within coastal wetlands systems, a variety of invasive exotic species are also having an impact in the South Atlantic region. In salt marshes, the European genotype of common reed (*Phragmites australis*) is an aggressive competitor capable of forming dense monocultures that crowd out native salt-tolerant plant communities (Whetstone 2009; Meyerson et al. 2008). While in mangrove swamps, invasion by exotic species such as Brazilian pepper-tree (*Schinus terebinthifolius*) is replacing the native species and altering ecosystem services (Gioeli and Langeland 2009).

Seagrass “wasting disease” decimated many eelgrass beds in the last century. Parasites, diseases, and harmful invasive parasites are prevalent in filter-feeding bivalves, especially oysters and hard clams. Though less prevalent in the warmer water intertidal oyster reefs common in the Southeast, the protozoans Dermo (*Perkinsus marinus*) and MSX (*Haplosporidium nelsoni*) are prevalent in the Northeast and mid-Atlantic (Kennedy et al. 1996).

Climate Change and Sea Level Rise

Extreme precipitation events, warming sea surface temperatures, and accelerated sea level rise due to global climate change are likely to disrupt a variety of coastal habitats and species. An estimated 99% of the losses of estuarine emergent wetlands (primarily in the Gulf of Mexico) between 2004 and 2009 were attributed to effects from coastal storms, land subsidence, sea level rise, or other ocean processes (Dahl and Stedman 2013). Coastal habitats will likely be increasingly stressed by climate change impacts that have resulted from sea level rise and coastal storms of increasing frequency and intensity (Field et al. 2007; Riggs and Ames 2003).

Though sea level rise and storm frequency are generally the primary climate change impacts associated with coastal systems, changes in water temperatures and pH should also be considered. As nearshore waters warm with climate change, communities and populations may shift; this is particularly true at the ecoregion transition zones around Cape Hatteras and Cape Canaveral. In addition, lower ocean pH due to elevated global CO_2 concentrations (ocean acidification) may inhibit biochemical processes that bivalves rely on for shell development (Beesley et al. 2008).

Management and Conservation

Regulatory Authorities

Management of coastal systems and species involves a myriad of state and federal agencies whose jurisdictions and authorities overlap in complex ways. Most states have further delegated authority for certain management activities, such as zoning and permitting of development, to individual coastal communities. Many of the core federal and state regulatory authorities are described below; however, this is not a comprehensive list. Focus was placed on broader authorities that impact coastal systems and habitats rather than more species-focused regulations.

One unifying federal program is the Coastal Zone Management Act of 1972 (CZMA) which provides federal funding to each state to carry out research and outreach that may facilitate or enhance regulation but is not directly regulatory itself. Regulatory authority for specific activities within the coastal zone is still most often administered separately by different municipal, state, and federal agencies. The overall program objectives of the CZMA are to "preserve, protect, develop, and where possible, to restore or enhance the resources of the nation's coastal zone." All the states in this region participate in the voluntary Coastal Zone Management Program, and have federally-approved management plans including regulatory authorities to protect and conserve coastal resources. Depending on the state, regulatory controls are exercised by a single state coastal agency or by a network of environmental, wildlife, and conservation agencies.

Marine and estuarine vegetated wetlands (e.g., tidal salt marsh, tidal freshwater marsh and tidal forest) have been afforded protection by various state and federal coastal regulatory measures including federal protection under Section 404 of the Clean Water Act (Dahl 2000). The U.S. Army Corps of Engineers and the Environmental Protection Agency jointly administer Section 404, a program to regulate the discharge of dredged or fill material into waters of the United States. Waters of the United States are defined to include navigable waters and their tributaries and associated wetlands. Section 404 permits are reviewed and issued based on the premise that no discharge of dredged or fill material should be permitted if there is a practicable alternative that would be less damaging to aquatic resources or if significant degradation would occur to the nation's waters.

In addition to federal regulations, all of the South Atlantic states have laws and regulations in place concerning dredge and fill material and placement. Any kind of dredge or filling activity without an appropriate permit can face steep fines, and depending on the extent of the activity, possible criminal charges. General regulations also exist in all four states' coastal programs for any kind of construction of infrastructure in wetlands, including piers, docks, bulkheads, and riprap revetments. These regulations are in place to prevent degradation of critical coastal habitats. For example, in South Carolina, a private dock cannot be built in saltwater tidelands if the property does not have at least 75 ft. of marsh front. This regulation is to protect salt marsh from becoming fragmented.

The extent and type of home rule authority granted to local governments varies considerably from state to state; in most states land use controls including zoning and land development permitting are exercised by local and/or county governments. Some states have delegated additional authorities to municipalities and other units of government for other management activities that concern coastal resources, such as shellfish management, harbor management, and wetland management.

Both the CWA and CZMA include sections focused on non-point source pollution. The CWA Section 319 Nonpoint Source Management Program, established in 1987, provides states grant money to support implementation of approved state nonpoint source management programs. Grant funded activities can include technical assistance, education, training, technology transfer, demonstration projects and monitoring to assess the success of specific nonpoint source implementation projects. In 1990, the Coastal Zone Act Reauthorization Amendments (CZARA) included creation of the Coastal Nonpoint Pollution Control Program (Section 6217) to address nonpoint pollution problems in coastal waters. Section 6217 requires states with approved CZM programs to develop Coastal Nonpoint Pollution Control Programs describing how they will implement nonpoint source pollution controls. The program is administered jointly by NOAA and the EPA and has been challenged by limited funding. As of 2008, 34 states and territories participate in this program.

The Harmful Algal Bloom and Hypoxia Research and Control Act of 1998 (HABHRCA; P.L. 105-383) recognized that human activities contribute to the impairments caused by harmful algal blooms (HABs) and hypoxia within the watersheds of our nation's estuarine and coastal waters. To facilitate an enhanced national effort to address these problems, the statute called for national assessments of the causes and consequences of HABs and coastal hypoxia, in addition to a region-specific assessment of the causes and consequences of hypoxia in the northern Gulf of Mexico and an action plan to address those Gulf-specific problems (CENR 2003).

Current Conservation Efforts

Conservation efforts for coastal zone ecosystems, habitats, and species are as many and varied as the regulatory jurisdictions that govern them and are too numerous to summarize here. Most have a specific geographic focus, and aim to link land-based activities with the health of the coast and the values of the human communities that border them.

A notable feature of coastal zone conservation is the frequent reliance on public-private partnerships and programs such as the National Estuary Program (EPA) and the National Estuarine Research Reserve Program (NOAA) which are designed to engage stakeholders and foster broad partnerships and are often paralleled by complementary private organizations. The National Estuary Program (NEP) was created under the Clean Water Act and administered by the U.S. Environmental Protection Agency (EPA) to "protect and restore the water quality and ecological integrity of estuaries of national significance." Albemarle-Pamlico Sounds (NC) and Indian River Lagoon (FL) are the two designated NEP sites in the South Atlantic region. Each NEP is required to create and execute a Comprehensive Conservation and Management Plan (CCMP), a long-term plan that contains detailed activities intended to address water quality, habitat, and living resources problems in its estuarine watershed.

The National Estuarine Research Reserves System (NERRS), which falls under the jurisdiction of the CZMA, was created to "conduct long-term research, environmental monitoring, and education and stewardship" in select estuarine systems. The reserve system is a partnership program between NOAA and coastal states. Each reserve is overseen by a lead state agency or university, with involvement from local partners. There are five NERRS sites in the South Atlantic: North Carolina (comprised of Currituck Banks, Rachel Carson, Masonboro Island and Zeke's Island), North Inlet (SC), ACE Basin

(SC), Sapelo Island (GA), and Guana Tolomato Matanzas (FL).

Another focus of conservation efforts in coastal systems is on the restoration of critical habitats, including wetlands, shellfish and seagrass. Shellfish restoration activities provide one example of how a variety of regulatory entities in coastal programs interact. The NOAA Restoration Center is a primary provider of funding for shellfish restoration projects and activities, especially for oysters and hard clams. These programs are augmented by state programs for certain conservation activities, such as shell management for restoration in the Carolinas, and private non-profit efforts. Shellfish restoration funding often requires protection from harvesting, which is most often accomplished by siting projects in areas closed due to poor water quality. A combined focus on restoration and conservation has led to the concept of protected spawning sanctuaries in some areas. The U.S. Department of Agriculture Natural Resources Conservation Service is one funder for oyster restoration, especially in the context of expanded aquaculture operations that provide restoration benefits.

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CHAPTER
3

SEAFLOOR HABITATS

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Introduction

Effective marine resource management and conservation begins with knowing the types, amounts, and spatial distribution of resources (Walker and Gilliam 2013).

The seafloor habitats of the South Atlantic Bight are the foundation of the region's extensive biodiversity. Sandy habitats on the Continental Shelf sustain important fishery species such as tilefish, flounder, scallops, and penaeid shrimp. Rocky outcrops that punctuate the shelf provide substrate for a wealth of sponges, corals, and algae. Like coral reefs, these "live" rocky reefs support varied assemblages of mollusks and crustaceans, and sustain economically valuable fisheries of snapper, grouper, grunt, and porgy. South of Cape Canaveral, a drowned coral reef creates a ridge system parallel to the shoreline of Florida where shallow water coral reefs harbor a myriad of reef species. The Florida reef tract encompasses 6,000 patch reefs and coral ridge formations, the only system of shallow reef-building corals in the continental U.S. Seaward of the shelf, the Continental Slope is interrupted by the relatively flat Blake Plateau that separates the inshore slope from the deep offshore Blake Escarpment that plunges to 3,000 m (9,842 ft) at its base. The rock outcrops of the Blake Plateau are colonized by deep-sea sponges and corals, and in some places the corals have formed significant mound and ridge systems up to 150 m (492 ft) tall. These coral mounds support associated sponges, other cnidarians, mollusks, polychaetes, crustaceans, echinoderms, and fishes (adapted from Fautin et al. 2010).

The distributions and life histories of seafloor organisms are related to the physical environment. Individual species are sensitive to variations in light, depth, sediment size, temperature, salinity, and other abiotic factors. They may be attached to hard substrates, embedded in soft sediment, or freely moving. For example, filter feeders, abundant in shallow sandy sediment, strain suspended matter directly from the water column, while deposit feeders that rely on settling detritus are most abundant in fine-grained mud. Natural rock substrate and reefs are often colonized by algae, sponges, corals, and bryozoans, which in turn support a large diversity of fish (SAFMC 1998). Mobile species such as sea stars, crabs, snails and demersal fish search the seafloor for prey.

Extensive surveys of the benthic invertebrate communities of the South Atlantic Continental Shelf suggest that these habitats are teeming with life. Surveys have found an average of 3,000 individual organisms per square meter with a range of 275 to 23,650 individuals per square meter (Wenner et al. 1983; Wenner et al. 1984; Hyland et al. 2006; Fraser and Sedberry 2008; Cooksey et al. 2010). Samples taken in Gray's Reef National Marine Sanctuary found the density of individual organisms per square meter to range from 4,958 (inner shelf) to 5,901 (mid-shelf) to 1,550 (outer shelf; Hyland et al.2006).

The taxonomic diversity of invertebrate species in the South Atlantic Continental Shelf region is estimated at 2,434 species, with mollusks (698 spp.), crustaceans (696), annelids (400) and cnidarians (362) making up the majority of the taxa (Fautin et al.2010). Cooksey et al. (2010) found a total of 462 benthic taxa on the shelf exclusive of estuaries, with polychaetes and crustaceans representing the majority of the taxa. The fauna of the oceanic region is poorly known because of the difficulty of sampling. However, the rock outcrops of the Blake Plateau are colonized by a wide variety of deep-sea sponges and corals, with many other associated invertebrates and fishes (Ross and Nizinski 2007).

The South Atlantic Bight supports an estimated 1,200 fish species including an extensive and diverse demersal fish fauna (Fautin et al. 2010). Fin fish associated with reef and rock substrate habitats have been well studied in the region (Sedberry et al. 2006; Rowe and Sedberry 2006; Schobernd and Sedberry 2009) and systematically sampled for over 30 years by the Marine Resources Monitoring Assessment and Prediction program (MARMAP, Reichert 2009), whose mission is to determine distribution, relative abundance, and critical habitat of economically and ecologically important fishes of the South Atlantic. Prevalent and abundant in the region, especially on hard substrate, are: bank sea bass, black sea bass, gag, gray triggerfish, knobbed porgy, red grouper, red porgy, red snapper, sand perch, scamp, scup, spottail pinfish, spotted moray, tomtate, vermilion snapper, and white grunt (Sedberry and Van Dolah 1984; Wenner and Sedberry 1989; Van Dolah et al. 2011).

This report provides the results of The Nature Conservancy's three-year effort to define the types, amounts, and spatial distribution of seafloor habitats across the South Atlantic Bight using the most recent information on bathymetry, seafloor topography, sediment grain size, and hardbottom. This project is not the first to map the seafloor of the South Atlantic. The challenge of mapping seafloor habitats has produced an extensive body of research both within the South Atlantic and in other marine regions (Table 3.1). We were grateful that many of the authors of previous classifications agreed to participate on the steering committee to review and guide this project, allowing us to integrate and upgrade a substantial body of existing work with additional data and newer mapping techniques.

There is no agreed-upon approach for classifying seafloor habitats, although many have been proposed (see reviews in National Estuarine Research Reserve System 2000 and Lund and Wilbur 2007). In the United States, the Coastal and Marine Ecological Classification Standard (CMECS) has been adopted as a federal standard for classifying and describing coastal and marine ecological systems (FGDC 2012). CMECS is not a list of habitat types but a language for describing components of the seafloor at various scales using a consistent vocabulary. This flexible approach allows features mapped at a variety of scales to be crosswalked to CMECS. For readers interested in how our results relate to CMECS we include a complete crosswalk in Appendix 1. Methods for crosswalking mapped seafloor features to CMECS were developed for the Northwest Atlantic Marine Ecoregional Assessment (Anderson et al. 2010) which used the same mapping protocols as this project (Weaver et al. 2013).

Our goal was to build on the considerable sampling, mapping, and classification work completed by others for many parts of the South Atlantic to produce a regional map of seafloor habitats using consistent and repeatable methods. Many organizations freely contributed data to this effort, and a team of scientists familiar with the seafloor of the South Atlantic Bight served as a scientific review committee (Box 3.1). Comments on the methods and preliminary results were collected via meetings, webinars, individual phone calls, and written responses. Each dataset and derived product was carefully reviewed, but a full accuracy assessment was not completed and cross-validation using independent datasets is ongoing. The assessment was developed to guide conservation decisions and aid in marine spatial planning. We anticipate that updated reports will be produced as the research matures.

Box 3.1. Seafloor Habitats Technical Team Members

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Geography of the Study Area

The South Atlantic Bight marine region, as the SABMA project defines it, extends southward from North Carolina's James River to the Florida Keys. Seaward it encompasses the continental shelf, the shelf-slope break, and the deepwater plateaus and terraces that reach to the Blake Escarpment, 5000 m (3.1 mi) below sea level (Figure 3.1). The large, 37,550,000 hectare (145,000 mi^2) region divides naturally into three sub-regions that include all of the Carolinian and the Floridian regions (Spalding et al. 2007), and part of the Virginian region. For planning purposes, The Conservancy calls the latter the "mid-Atlantic Bight" (Figure 3.1).

<u>The mid-Atlantic Bight.</u> This analysis addresses the southern end of the mid-Atlantic Bight/Virginian ecoregion, starting at the James River in Virginia and running south to Cape Hatteras. The region is centered on the 105-km (65-mile) wide Continental Shelf running from the Virginia/North Carolina coastline to the shelf-slope break. The shelf averages 25 m (82 ft) in depth, growing deeper eastward until it reaches 100 m (328 ft) at the shelf edge and then drops to 1,000 m (3,281 ft) at the steep escarpment and deep canyons of the slope break.

The coastal edge of the region is dominated by large estuaries like Pamlico Sound which contains a huge expanse of sea grass and tidal marsh. Not all of the mid-Atlantic Bight is covered by this study; the Chesapeake Bay and Delaware Bay estuaries, for example, are in this region but outside the extent of the South Atlantic Bight.

The Carolinian Region forms the central portion of the study area. The west side is dominated by the large shallow Continental Shelf, 64 to 137 km (40 to 85 miles) wide and 5 to 100 m (16 to 328 ft) deep. It is underlain in places by a hard limestone pavement where corals and other species form diverse colonies. At the shelf edge, the slope drops to 200 m (650 ft) and flattens out into two wide plateaus: the smaller and shallower Charleston Bump at a depth of 200-600 m (650-1,970 ft), and the larger Blake Plateau at 600-750 m (1,970-2,460 ft) depth. The Blake Plateau covers almost 518 km^2 (200 mi^2) and is flanked on its eastern side by the Blake Escarpment, a steep slope that drops to 5,000 m (3.1 mi) in depth. The escarpment and its two deepwater spurs (Blake Spur and McAlinden Spur) mark the eastern edge of the ecoregion. The southernmost end of the region is marked by Florida's cape Canaveral, and the deepwater zone is bounded by the exclusive economic zone (EEZ), a zone prescribed by the United Nations Convention on the Law of the Sea over which a state has special rights over the exploration and use of marine resources, including energy production from water and wind.

The Floridian Region extending from Cape Canaveral to the Keys is a narrow linear region of terraces and coral reefs. The shallow Continental Shelf is a relatively modest feature constricted to 11.3 km (7 mi) at its narrowest and about 64.3 km (40 mi) at it is widest. The shelf-break drops to 200 m (656 ft) in depth and is then broken up by relatively flat terraces: the Miami Terrace, the Pourtales Terrace, and the Tortuga Terrace reaching a depth of 750 m (2,460 ft).

Table 3.1. A review of literature on seafloor classifications and approaches that informed our methods

Physical/ Biological	Ecological Associations	Species	Data Type/ Comments	Example References
temperature	community composition	benthic macro-invertebrates		Theroux & Wigley 1998
substrate	soft sediment	demersal fish	sampling; correlational analyses done separately for each group	Wenner 1983 Miller & Richards 1980 Vandolah 1984
		benthic macro-		Hyland et al. 2006 Cooksey et al. 2010
	hardbottom	demersal fish, benthic macro-invertebrates	trawl samples, benthic grabs/submersible transects	Wenner et al. 1980 Van Dolah et al. 2011 Sedberry et al. 2006 Reichert et al. 2009 Wenner & Sudbury 1989 Quattrini & Ross 2006
	coral reef	demersal fish, benthic macro-invertebrates	bottom trawls samples	Chiappone & Sullivan 1994 SAFMC 1998
habitat complexity	species abundance community composition	demersal fish	video transects	Anderson & Yoklavich 2007
	species diversity	benthic macro-invertebrates	benthic grabs, photographs, fine-scale sediment heterogeneity	Kostylev et al. 2001 Serrano & Preciado 2007 Etter & Grassle 1992
			literature review	Levin et al. 2001
	species richness & total abundance	demersal fish	visual surveys	Charton & Perez Ruzafa 1998
depth	organism density & community composition	benthic macro-invertebrates & demersal fish	benthic grabs; correlational analyses done separately for each group	Stevenson et al. 2004
Combination				
depth + temperature + substrate	species assemblages & abundance, benthic 'seascapes'	demersal fish abiotic	bottom trawl; single species assessments, abiotic sampling	Mahon et al. 1998 DeLong & Collie 2004 CLF/WWF 2006

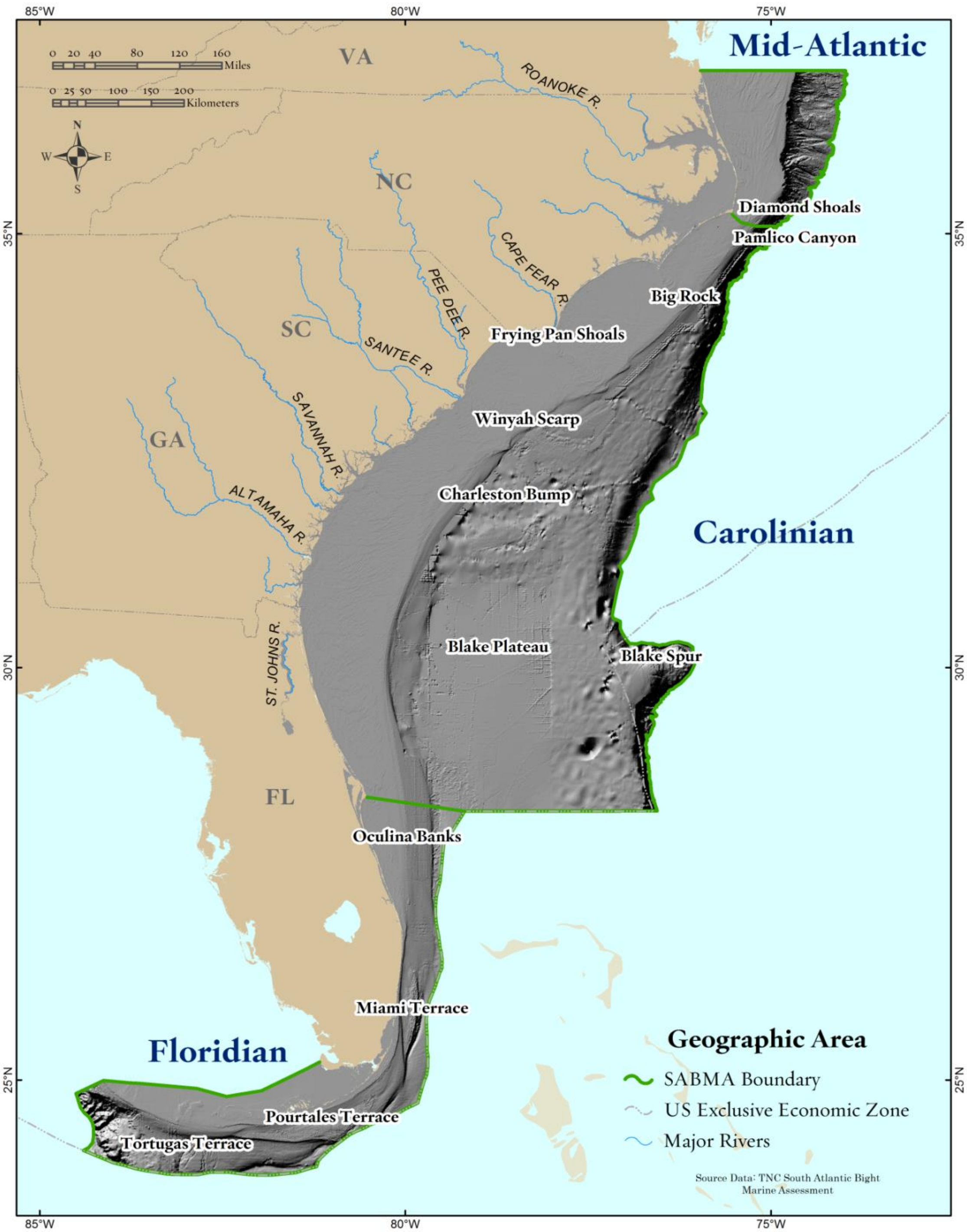


Figure 3.1. Geography and subregions of the South Atlantic Bight marine region

Methods and Results

We characterized the seafloor using three geophysical variables that define its structure: bathymetry (depth), seabed forms (topography), and substrate (texture and hardness). These factors are relatively stable over time and space, and have been shown to correlate with the distribution and abundance of demersal fish and benthic organisms (Table 3.1). They change at slower rates than water column conditions such as temperature and salinity, collectively forming the enduring physical template of the seafloor. For each variable we created a spatially comprehensive dataset using the highest quality data that was regionally available. The individual and combined datasets were used to create a mapping framework (Ecological Marine Units) to explore how the biota of the region corresponded to the physical environment.

Data on each physical factor were compiled from many sources; the techniques used to create a comprehensive map are discussed below. There was a dramatic difference in the density of information available for the Continental Shelf versus the oceanic region eastward of the shelf-slope break. Consequently, there was often a difference in data resolution (coarser in the deepwater areas) and in the number of data points available for confirming patterns between these two areas. Our approach was to use the best available data for the shelf and the best available for the deepwater region even if this created a lack of consistency between the two sections.

Bathymetry

Seafloor depth affects the temperature, pressure, light availability, circulation patterns, and chemistry of benthic environments, and it can be a limiting factor for many species. To characterize depth across the whole study region, we compiled millions of depth sounding points and then interpolated them to form a continuous grid. Our primary data source was the National Geophysical Data Center's (NGDC) Coastal Relief Model (CRM) depth soundings. The soundings were from hydrographic surveys completed between 1851 and 1965, and from survey data acquired digitally on National Ocean Service (NOS 2008) survey vessels since 1965 that are stored in the NOS Hydrographic Database. We interpolated the bathymetry directly from the 4.7 million sounding points, after evaluating CRM's bathymetric surface model and finding data inconsistencies that would not support the accurate derivation of slope. To create a single bathymetry grid for the entire region, we merged the re-interpolated grid with an existing high-quality grid for the estuaries and a coarser scale grid for oceanic areas not covered by the data points.

Mapping Methods

Our bathymetry map was created from three datasets: in estuaries we used the NGDC CRM, in the oceanic section of the Carolinian we used the General Bathymetric Chart of the Oceans (GEBCO), and for the remainder of the region we used a re-interpolated grid created from NGDC's depth soundings (Figure 3.2). For the re-interpolation, we prepared the CRM soundings dataset by paring down the original set of 8.4 million points to include only the points collected after the 1950s. This reduced the data point total to 4.7 million, covering the entirety of the mid-Atlantic and Floridian regions and the Continental Shelf area of the Carolinian region (excluding the estuaries, Figure 3.2). We interpolated the points in ArcGIS 10 using kriging to create a continuous surface. We tested a variety of cell sizes and search radii on samples of the dataset and decided on a spherical model, with a cell size of 90 m^2 and a search radius of 36 cells. After each test run, we created a slope grid from the products and visually assessed it for obvious data artifacts. Some problems in the slope grid were caused by a false six-decimal precision in the sounding depth. To correct for this, we rounded the sounding values to one decimal place which eliminated many of the false slopes. When we were satisfied with the results of the test areas, we created a map for the whole region by dividing the geography into six smaller overlapping subsets and combined the successful runs into one bathymetry grid for the region. In offshore areas, we conducted a density analysis on the raw points in order to determine which areas we needed to fill in with data from the GEBCO grid. We used the modeled NGDC CRM in all estuaries.

We created a seamless regional dataset by adding oceanic and estuary data to the newly interpolated offshore bathymetry grid. In the oceanic portion of the Carolinian region (east of the Continental Shelf) that was outside the range of the CRM points, we obtained 810 m^2-resolution data from the GEBCO. The resolution of the dataset was purportedly at 90 m^2; however, a slope grid created for this area revealed that each area of nine by nine grid cells had the same depth value across all of the cells, indicating that the resolution of the grid was actually 810 m^2. To create a smooth grid we aggregated the grid up from 90 m^2 cells to 810 m^2 cells and resampled the aggregated 810 m^2 grid back to 90 m^2 cells, averaging the values. We then calculated a focal mean for the new 90 m^2 grid to smooth out the values, resulting in an approximate 90 m^2 grid. We filled in all estuaries with the NGDC CRM. We merged these two datasets with the newly interpolated bathymetry grid to create one 90 m bathymetry grid for the whole region.

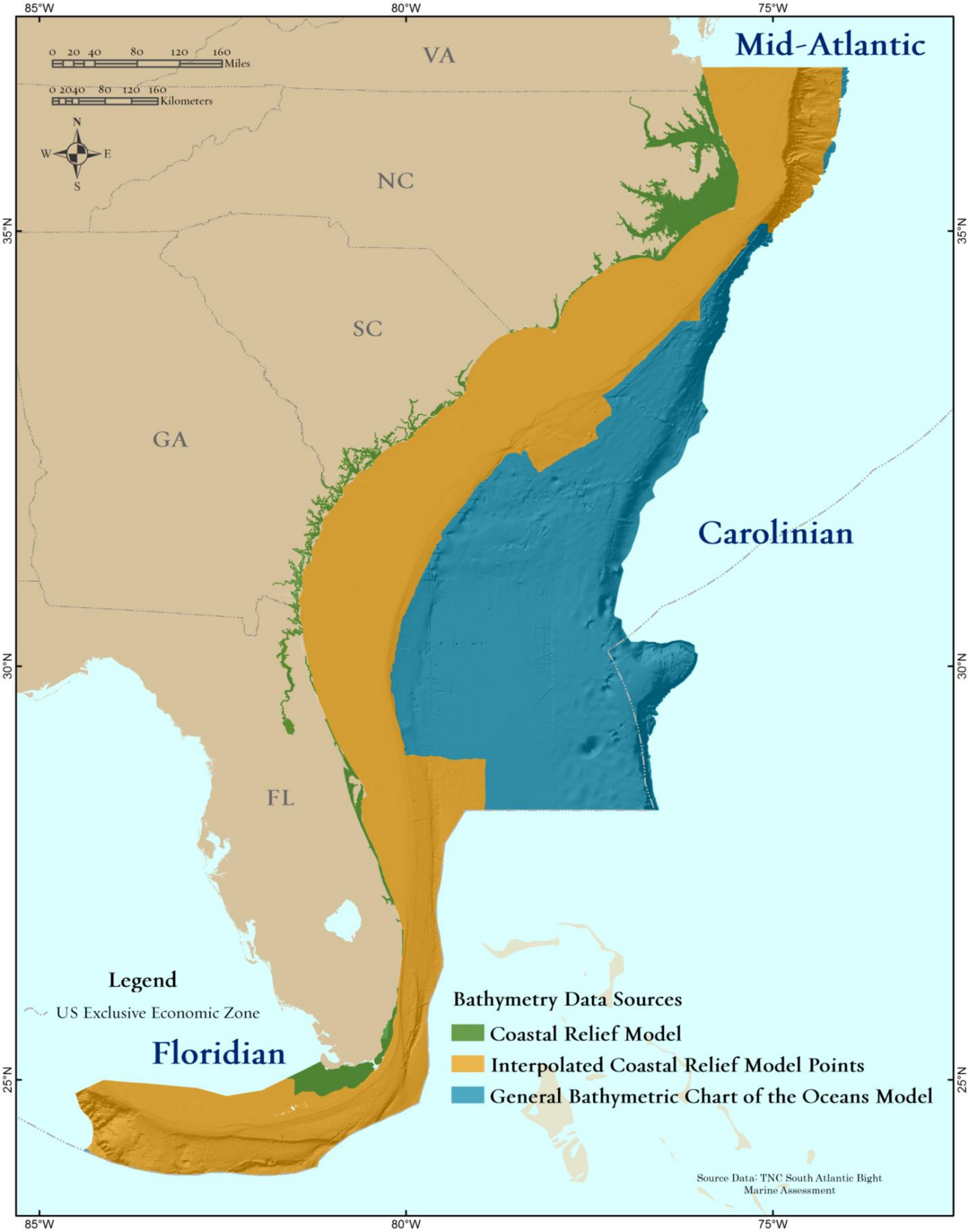


Figure 3.2. Distribution of the three source datasets used for creating the bathymetry grid

Bathymetry Zones

Demersal fish and invertebrate communities typically occur within a particular bathymetry range. Fish such as lookdown, menhaden, and black sea bass are typically found in shallow water (less than 30 m (98 ft) deep). In contrast, fish such as the scaleless dragonfish, duckbill eel, and lightfish thrive in depths over 600 m (1,968 ft). Over the past fifty years, researchers have identified a number of different depth zones that correspond to changes in species composition or ecological processes Table 3.2). Some schemes are based on specific habitats such as rock substrates or soft sediments (Table 3.2, rows 6-10), and others are characterized by the distribution of benthic invertebrates, particularly corals, that have also been well studied with respect to depth (Table 3.2, rows 11-15). The Continental Shelf is much better studied than the deeper oceanic habitat. Deepwater corals (e.g., *Lophelia pertusa* and *Enallopsammia profunda*) have been the subject of several inventories (Ross and Nizinski 2007) but most deepwater seafloor habitats are poorly surveyed. For example, Blake and Grassle (1994) reported that of the 1,202 invertebrate species they collected on the Blake Plateau beyond the 600 m depth line, 43% were new to science.

Depth zones can also be characterized by dominant ecological process. The inner shelf is controlled by tidal currents, river runoff, local wind, and seasonal atmospheric changes. The mid shelf zone is dominated by winds but also influenced by the Gulf Stream. Stratification of the mid shelf water column changes seasonally with mixed conditions generally characterizing fall and winter, and vertical stratification prevailing during spring and summer (SAFMC 2009). Strong stratification allows the upwelled waters near the seafloor to advance closer to shore, while at the same time facilitating offshore spreading of lower salinity water in the surface layer. The outer shelf, terminating at the steep shelf-slope break, is controlled primarily by the Gulf Stream. Recognizing these differences, CMECS (FGDC 2012) bases their benthic depth zone modifier on ecological processes (Appendix 1). The modifier was developed to describe general “zones in which surf or ocean swell influences bottom communities, lower limits of vegetation, and overall photic ability and temperature” at a global scale. This modifier was not specifically developed to describe regional patterns of biodiversity; however, the zones are similar to those derived from biotic patterns (Table 3.2):

- Infralittoral: shallow (0-5 m)
- Infralittoral: deep (5-30 m)
- Circalittoral (30-200 m)
- Mesobenthic (200-1,000 m)
- Bathybenthic (1,000-4,000 m)
- Abyssalbenthic (4,000-6,000 m)
- Hadalbenthic (>6,000 m)

IDENTIFYING BATHYMETRY ZONES FOR SABMA

To identify biologically relevant depth zones for the South Atlantic region, we examined two recent depth zone proposals (Table 3.2, rows 2-3): the CMECS process-based classification and the depth zones recommended by the South Atlantic Fisheries Independent Management (SAFIM) group (Williams and Carmichael 2009). We combined these two proposals into one set of depth thresholds (30, 70, 140, 200, 600, and 1,000 meters) and evaluated how well these thresholds separated different fish communities by examining the species–depth relationships in the following four regional datasets:

Collections by the Exploratory Fishing Vessels Oregon, Silver Bay, Combat, and Pelican (USFWS, Bullis and Thompson 1965): Trawl and dredge surveys from the late 1950s in the southwestern North Atlantic. (4,792 samples in SABMA; 513 spp.; depth range 3 to 8,284 m; years 1956 – 1960; FL,GA,SC,NC)

Marine Resources Monitoring Assessment and Prediction: Isaacs-Kidd Midwater Trawl 1979 (Reichert 2010) (1,053 samples in SABMA; 16,825 records; 529 spp.; depth range 9 to 686 m; years 1973-1980; FL,GA,SC,NC).

Marine Resources Monitoring Assessment and Prediction: Chevron Trap data (MARMAP, Reichert 2009): Chevron trap data (7,885 samples in SABMA; hardbottom only; 24 spp.; depth range 15 to 101 m; years 1989-2012; GA,SC,NC).

National Marine Fisheries Service (NMFS 2009): Spring and fall bottom trawl surveys. (4,712 samples in SABMA; 560 spp.; depth range 6 to 1,160 m; years 1968 – 2006; SC, NC)

The USFWS Exploratory Vessels report, our base dataset, was the most geographically and bathymetrically extensive, covering North Carolina (1,407 samples), South Carolina (460 samples), Georgia (460 samples) and Florida (2,771 samples), and ranging in depth from 3 to 8,284 m. The aim of the regional exploratory program was to inventory fishery resources in the western Atlantic; it included a gross faunal survey with identifications performed by many different taxonomic specialists. The standard gear for bottom exploration was 40 foot shrimp trawls, but a large variety of commercial type fishing equipment was used: shrimp trawls, fish trawls, midwater trawls, scallop and clam dredges, seines and lampara nets, longlines, and handlines. Material was also collected at night-light dip-netting stations. Specific cruise objectives varied from general reconnaissance of unknown and unexplored areas to detailed commercial evaluations of a range of food or scrap fish.

The NMFS and MARMAP datasets were amenable to detailed quantitative analysis, while the USFWS dataset was not. The NMFS data is based on trawl surveys performed over a 40-year period, but was only available for the mid-Atlantic Bight and a portion of the northern Carolinian region. The MARMAP trawl data were collected by offshore surveys in the 1970s that collected a few hundred species; the data set is comparable to the NEFSC survey conducted by MARMAP in the South Atlantic. The MARMAP trap data also come from a long term sampling program that uses chevron traps to sample hardbottom substrates often under-sampled in the trawl surveys. We used the information from these surveys to augment the USFWS study and analyzed each independently to determine relevant depth zones.

For the NMFS and MARMAP trap datasets we performed exploratory quantitative analysis to determine species-depth thresholds. First, we clustered the sample data into groups based on species composition, and then we used a classification tree to identify the depth zones that best separated the groups from each other. For the cluster analysis, we performed hierarchical clustering on each individual dataset (flexible beta, beta = -0.25) using both presence/absence data (Jaccard distance matrix) and abundance data (Bray Curtis distance matrix) for individual species. An additional divisive partitioning analysis (TWINSPAN) was performed on the NMFS trawl data to obtain a more thorough sorting of the presence/absence data as the initial identification of twenty clusters assigned 96% of the data to a single one.

To identify depth zones, all samples were assigned to their respective cluster group and attributed with the depth at which the sample was taken. A classification tree analysis was then run with each cluster group as the response variable and sampling depth as the predictor variable. The MARMAP and NMFS data were analyzed separately and the resulting depth thresholds were compared using all five runs (Table 3.3). There was considerable consistency across the runs: the first split averaged 34.6 m across all the datasets and the second split averaged 20.2 m. The NMFS data had a third split at 68 m, and the TWINSPAN analysis identified a deep water split at 213 m in its initial three breaks. The results provided evidence to support the SAFIM workshop proposal of breaks at 30 m and 70 m, and for the CMECS process-based thresholds of 30 m and 200 m.

Using the USFWS vessel data augmented by the other three datasets we next examined individual species distribution patterns to determine whether we could identify sets of species that were typical of each zone. For this analysis, we organized the survey data by the potential depth zones then calculated the percent of each species' distribution found across each zone (Table 3.4). Most proposed zones each had at least 17-152 species found mainly in the zone (i.e., had more than two-thirds of their sampled locations in the zone): 0-30 m (99 species), 30-70 m (71 species), 70-200 m (40 species), 200-600 m (152 species), and 600-1,000 m (17 species). The exception was the 70-140 m zone which had only two "restricted" species: saddle bass and big-eyed frogfish. Therefore, we dropped the 140 m threshold, collapsing it into the broader 70-200 m zone. The other exception was the 1,000+ m zone for which we had very few samples and only 11 species detected, none of them restricted to the zone. Because there was no information to support or dispute the 1,000 meter threshold, we retained the threshold to match the CMECS process-based classification. Ultimately, we recognized six depth zones that were similar to the SAFIM zones and match or nest within CMECS thresholds (Figures 3.3-3.6).

Table 3.2. Comparison of depth zones used in recent studies

		Depth (meters)															
Depth Zones	**Source**	**0-10**	**10-20**	**20-30**	**30-40**	**40-50**	**50-60**	**60-70**	**70-80**	**80-90**	**90-100**	**100-150**	**150-200**	**200-250**	**250-300**	**300-350**	**350-600**
SABMA-TNC	Combat/Oregon/ Silver Bay/Pelican NMFS/MARMAP data	**Infralittoral**		**0-30**			**Shallow Circalittoral 30-70**					**Deep Circalittoral 70-200**			**Shallow Mesobenthic 200-600**		**Deep Meso 600-1000**
SAFIM Workshop	Williams & Carmichael 2009		**0-30**				**30-70**				**70-140**				**>140**		
CMECS depth modifiers	FGDC 2012		**0-30 Infralittoral**						**30-200 Circalittoral**							**200-1000 Mesobenthic**	
Process based	SAFMC 2009	**0-20 IS**		**20-40 Mid shelf**			**41-75 OS**										
Fisheries zone	SAFMC 2009	**<18 coastal**			**18-55 open shelf**						**55-183 Shelf edge**						
Live bottom	SC DNR Website 2014		**15-31 Blackfish**			**31-55 Snapper**			**55-110 Shelf edge**				**110-183 Lower shelf**				
Live bottom/sponge - coral habitats	Miller and Richards 1980	**<18**			**18-55**						**55-183**						
Fish in Sponge - coral habitat	Wenner 1983 (M&R 79)	**<18 nearshore**			**18-55 open shelf**						**55-183 offshore**						
Demersal fish - live bottom	Sedberry and Van Dolah 1984		**16-22 IS**	**25-38 MS**			**47-67 OS**										
Demersal fish - sand	Wenner et al. 1980		**11-22**		**26-41**							**70-155**			**254-338**		
Hardbottom	Deaton et al. 2010			**20-40**							**50-200 outer shelf reefs**					**>250**	
Sponge - coral habitat	Wenner 1983 cluster groups			**18-29**		**37-44, 42-46**											
Florida offshore reefs	SAFMC 2009	**5-8 inner**	**9-15 mid**	**18-30 outer**													
Deepwater & Black corals	SAFMC 2009									**65-103 Black Corals**						**350-500**	**>600**
Oculina colonies	SAFMC 2009			**3-50 solitary colonies**						**70-100 contiguous**							
Patch reef Elkhorn	SAFMC 2009I	**0-15**															

Table 3.3. Comparison of depth thresholds for the five classification groups and two data sources. Our goal was to determine if the data supported any of the thresholds proposed in the literature (Table 3.2), particularly those from CMECS or the SAFIM workshop. In our analysis the first split at about 15 m (row 1) was ignored because it was based primarily on differences in species abundances not composition. Rows 2 and 3 suggested a faunal change somewhere around 24-41 m (avg. 32 m) which roughly matched the zones proposed by several of the studies and supported the idea of a transition zone around 30 m. The two deeper splits were close enough to proposed SAFM and CMECS splits that they could be rounded to 70 m and 200 m respectably.

NMFS Data			MARMAP Data				
TWINSPAN Presence/ Absence	Cluster Presence/ Absence	Cluster Abundance	Cluster Presence Absence	Cluster Abundance	Avg.	Simplified	Final
		-14 m		-16.5 m	-15.3 m	-	-
-22 m	-23 m	-23 m	-25.5 m	-28.5 m	-24.4 m	-32 m	-30 m
-41 m	-38 m		-42.5 m		-40.5 m		
	-68 m	-68 m			-68 m	-68 m	-70 m
-213 m					-213 m	-213 m	-200 m

Table 3.4. Common fish by bathymetry zones based on USFWS vessel data. For each species the table shows the total number caught followed by the proportion of the total found in each depth zone. This table shows species with more than 5 individuals and >66% of their locations in one depth zone. The last two columns indicate whether the patterns in the NOAA, MARMAP trap (MM Trap) and MARMAP trawl (MM Trawl) data agree with the vessel data.

Scientific Name	Common Name	Total	0-30 m	30-70 m	70-200 m	200-600 m	600-1000 m	1000+	NMFS	MM Trap	MM Trawl
Selene vomer	Lookdown	13	1.00						Agree		Agree
Chloroscombrus chrysurus	Atlantic Bumper	10	1.00						Agree		Agree
Sphyraena borealis	Northern Sennet	9	1.00						Agree		Agree
Vomer setapinnis	Moonfish	8	1.00								
Astroscopus y-graceum	Southern Stargazer	5	1.00								
Bagre marinus	Gafftopsail Catfish	5	1.00						Agree		
Paralichthys lethostigma	Southern Flounder	5	1.00						Agree		Agree
Opisthonema oglinum	Atlantic Thread Herring	33	0.97	0.03					Agree		Agree
Peprilus paru	Harvestfish	19	0.95	0.05							
Cynoscion regalis	Atlantic Weakfish	24	0.92	0.08					Agree		Agree
Menticirrhus saxatilis	Northern Kingfish	9	0.89	0.11					Agree		Agree
Symphurus plagiusa	Blackcheek Tonguefish	9	0.89	0.11					Agree		Agree
Galeichthys felis	Sea catfish	8	0.88	0.13							
Larimus fasciatus	Banded Drum	8	0.88	0.13					Agree		Agree
Torpedo andersoni	Florida Torpedo	7	0.86			0.14					
Scophthalmus aquosus	Windowpane	20	0.85	0.15					Agree		Agree
Orthopristis chrysoptera	Pigfish	19	0.84	0.16					Agree		Agree
Chaetodipterus faber	Atlantic Spadefish	30	0.83	0.17					Agree		Agree
Rypticus saponaceus	Greater Soapfish	5	0.80	0.20							
Stenotomus chrysops	Scup	19	0.79	0.21					Agree	Agree	Agree
Pomatomus saltatrix	Bluefish	28	0.79	0.14		0.07			Agree		Agree

Table 3.4 continued. Common fish by bathymetry zones based on USFWS vessel data. For each species the table shows the total number caught followed by the proportion of the total found in each depth zone. This table shows species with more than 5 individuals and >66% of their locations in one depth zone. The last two columns indicate whether the patterns in the NOAA, MARMAP trap (MM Trap) and MARMAP trawl (MM Trawl) data agree with the vessel data.

Scientific Name	Common Name	Total	0-30 m	30-70 m	70-200 m	200-600 m	600-1000 m	1000+	NMFS	MM Trap	MM Trawl
Scomberomorus maculatus	Spanish Mackerel	18	0.78	0.17		0.06			Agree		Agree
Micropogon undulatus	Atlantic Croaker	48	0.75	0.21	0.04						
Sphoeroides maculatus	Northern Puffer	16	0.75	0.13	0.06	0.06			Agree	Agree	Agree
Seriola zonata	Banded Rudderfish	14	0.71	0.14		0.14			Agree		Agree
Leiostomus xanthurus	Spot	46	0.70	0.11	0.11	0.04		0.04	Agree		Agree
Paralichthys dentatus	Summer Flounder	36	0.69	0.25				0.06	Agree		Agree
Alectis ciliaris	African pompano	19	0.68	0.21	0.05	0.05					
Raja eglanteria	Clearnose Skate	28	0.68	0.21	0.11				Agree		Agree
Ogcocephalus radiatus	Polka-dot batfish	8		1.00							
Balistes carolinensis	Grey trigger fish	7		1.00							
Apogon maculatus	Flamefish	5		1.00					Disagree		
Mycteroperca bonaci	Black Grouper	5		1.00					Agree		
Bathystoma rimator	Tom-tate	10	0.10	0.90							
Eucinostomus argenteus	Spotfin Mojarra	6	0.17	0.83					Disagree		Disagree
Fistularia petimba	Red Cornetfish	6		0.83	0.17				Agree		Agree
Prionotus ophryas	Bandtail Searobin	6		0.83	0.17				Agree		Agree
Equetus lanceolatus	Jackknife-Fish	23	0.17	0.83					Agree		Agree
Chaetodon sedentarius	Reef Butterflyfish	15	0.13	0.80	0.07				Agree		Agree
Holocanthus isabelita	Blue angelfish	10	0.10	0.80		0.10					
Apogon pseudomaculatus	Twospot Cardinalfish	5	0.20	0.80					Agree		Agree
Chromis enchrysura	Yellowtail Reeffish	5	0.20	0.80							Agree

Table 3.4 continued. Common fish by bathymetry zones based on USFWS vessel data. For each species the table shows the total number caught followed by the proportion of the total found in each depth zone. This table shows species with more than 5 individuals and >66% of their locations in one depth zone. The last two columns indicate whether the patterns in the NOAA, MARMAP trap (MM Trap) and MARMAP trawl (MM Trawl) data agree with the vessel data.

Scientific Name	Common Name	Total	0-30 m	30-70 m	70-200 m	200-600 m	600-1000 m	1000+	NMFS	MM Trap	MM Trawl
Lutjanus campechanus	Northern Red Snapper	14	0.14	0.79		0.07				Agree	
Sphoeroides spengleri	Bandtail Puffer	17	0.18	0.76		0.06			Agree		Agree
Sphoeroides dorsalis	Marbled Puffer	24	0.08	0.75	0.17				Agree		Agree
Trachurus lathami	Rough Scad	14	0.21	0.71		0.07			Disagree		Disagree
Lepophidium jeannae	Mottled Cusk-Eel	7		0.71	0.29				Disagree		Disagree
Psenes regulus	Spotted Driftfish	7	0.14	0.71	0.14						
Rhomboplites aurorubens	Vermilion Snapper	65	0.22	0.69	0.06	0.03			Agree	Agree	Agree
Trachinocephalus myops	Snakefish	34	0.26	0.68	0.03	0.03			Agree		Agree
Ancylopsetta dilecta	Three-Eye flounder	7			0.86	0.14			Agree		Agree
Antennarius radiosus	Big-eyed frogfish	6		0.17	0.83				Agree		
Pronotogrammus spp.	Bass (unidentified)	5		0.20	0.80						
Prionotus alatus	Spiny searobin	13			0.77	0.15	0.08		Agree		Agree
Zenopsis ocellata	John Dory	13	0.08		0.77	0.15					
Macroramphosus scolopax	Longspine snipefish	14	0.07	0.21	0.71						Agree
Chaetodon aya	Bank butterflyfish	10	0.10	0.10	0.70	0.10			Agree		
Laemonema barbatulum	Smallscale mora	41				1.00			Agree		Agree
Peristedion gracile	Slender searobin	20				1.00			Disagree		Disagree
Parasudis truculenta	Longnose greeneye	13				1.00			Agree		
Foetorepus agassizii	Spotfin dragonet	10				1.00					

Table 3.4 continued. Common fish by bathymetry zones based on USFWS vessel data. For each species the table shows the total number caught followed by the proportion of the total found in each depth zone. This table shows species with more than 5 individuals and >66% of their locations in one depth zone. The last two columns indicate whether the patterns in the NOAA, MARMAP trap (MM Trap) and MARMAP trawl (MM Trawl) data agree with the vessel data.

Scientific Name	Common Name	Total	0-30 m	30-70 m	70-200 m	200-600 m	600-1000 m	1000+	NMFS	MM Trap	MM Trawl
Urophycis chesteri	Longfin hake	9				1.00			Agree		
Argyropelecus affinis	Slender hatchetfish	7				1.00					
Nezumia aequalis	Common Atlantic grenadier	6				1.00					
Chascanopsetta lugubris	Pelican flounder	5				1.00					
Chlorophthalmus chalybeius	Greeneye	28				0.96	0.04				
Helicolenus dactylopterus	Blackbelly rosefish	48		0.02	0.02	0.96			Agree		Agree
Zenion hololepis	Dwarf dory	22				0.95	0.05				Agree
Chaunax pictus	Pink frogmouth	110	0.01	0.01		0.94	0.05				
Galeus arae	Roughtail catshark	47	0.04			0.94	0.02				
Gadella maraldi	Common gadela	14			0.07	0.93					
Polymetme corythaeola	Rendezvous fish	9				0.89	0.11				
Lophiomus sp.	Goosefish (unidentified)	19		0.05	0.11	0.84					
Diapterus spp.	Mojarra	11		0.09	0.09	0.82					
Sternoptyx diaphana	Diaphanous hatchetfish	16			0.06	0.81	0.13				
Glossanodon pygmaeus	Pygmy argentine	8			0.25	0.75					Disagree
Peristedion miniatum	Armored searobin	7			0.29	0.71					Agree

Table 3.5. Final bathymetry zones. Species are from Bullis and Thompson (1965). Numbers in parentheses indicate the total number of species found and the number of species with >66% of their locations in one depth zone.

Depth (meters)	Depth		
		Zone	**Taxa (Examples to 350 m based on USFWS Vessel**
	0-30	Infralittoral (Nearshore Shelf and Estuaries)	<u>Fish</u>: **(215 species / 99 restricted)** lookdown, Atlantic bumper, northern sennet, moonfish, southern stargazer, gaff topsail catfish, southern flounder, American shad, Atlantic menhaden <u>Invertebrates:</u> Atlantic brief squid, blue crab, fire sponge, green sea urchin, notched sand dollar, banded sea star, penaeid shrimp
	30-70	Shallow Circalittoral (Mid Shelf)	**<u>Fish:</u> (232 species / 71 restricted)** Examples: polka-dot Batfish, grey Trigger fish, flame fish, black grouper, sharp nose puffer, flying gurnard, black-winged sea robin, tom-tate <u>Invertebrates</u>: arrow squid, Atlantic surf clam, crusting bryzoan, hydranths, sponges, and mantis shrimp
	70-200	Deep Circalittoral (Outer Shelf & Shelf Edge)	**<u>Fish:</u> (185 species /40 restricted)** yellowfin bass, jambeau, broad flounder, highfin scorpionfish, spiny flounder, three-eye flounder, big-eyed frogfish, spiny searobin <u>Invertebrates:</u> Atlantic rock crab, boreal asterias, brown rock shrimp, Cancer crab coarsehand lady crab, *Oculina*, brown-striped brittlestar
	200-600	Shallow Mesobenthic (Shelf/Slope break - Charleston Bump)	<u>Fish</u>: **(251 species /152 restricted)** offshore hake, white hake, freckled skate, deepwater dab, fourbeard rockling, goosefish, slim flounder, fawn cusk-eel, spotted hake <u>Invertebrates</u>: northern shortfin squid, Jonah crab, cancer crab, rock shrimp, squat lobsters, *Lophelia pertusa*, black corals, glass sponges
	600-1000	Deep Mesobenthic (Blake Plateau)	<u>Fish</u>: **(56 species / 17 restricted)** Cuban pygmy skate, smooth-head, scaleless dragonfish, duckbill eel, lightfish, snake mackerel <u>Invertebrates</u>: Polychaetes , deepwater corals (*Lophelia* and *Enallopsammia)*
	1000 - 5000	Bathybenthic/ Abyssal	**<u>Fish:</u> (11/0)** Not well sampled. Species with some proportion caught in this zone include: Pacific snake-eel, dusky flounder, spotted hake, dolphin

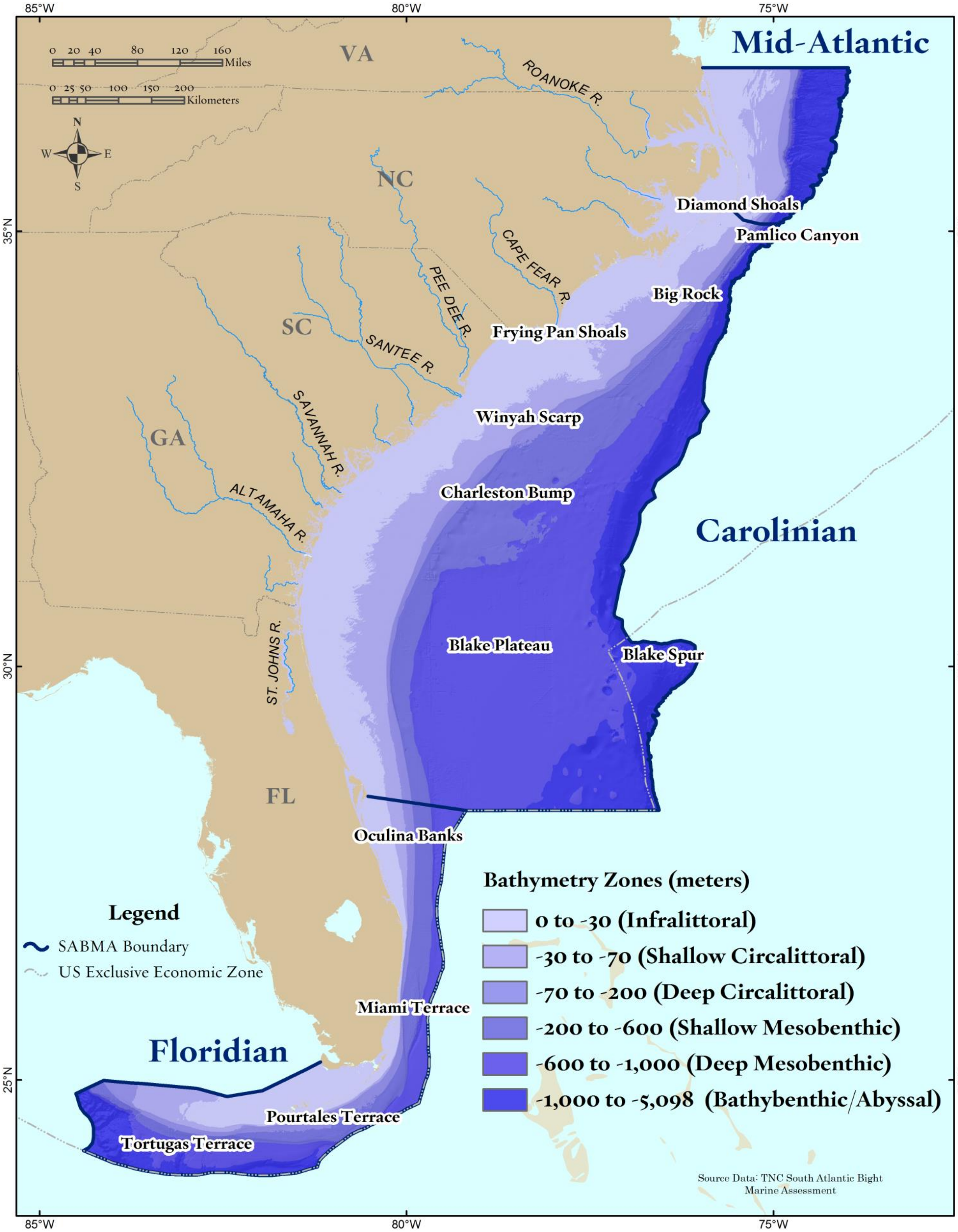


Figure 3.3. Depth zones of the South Atlantic Bight marine region. See subregional maps on following pages.

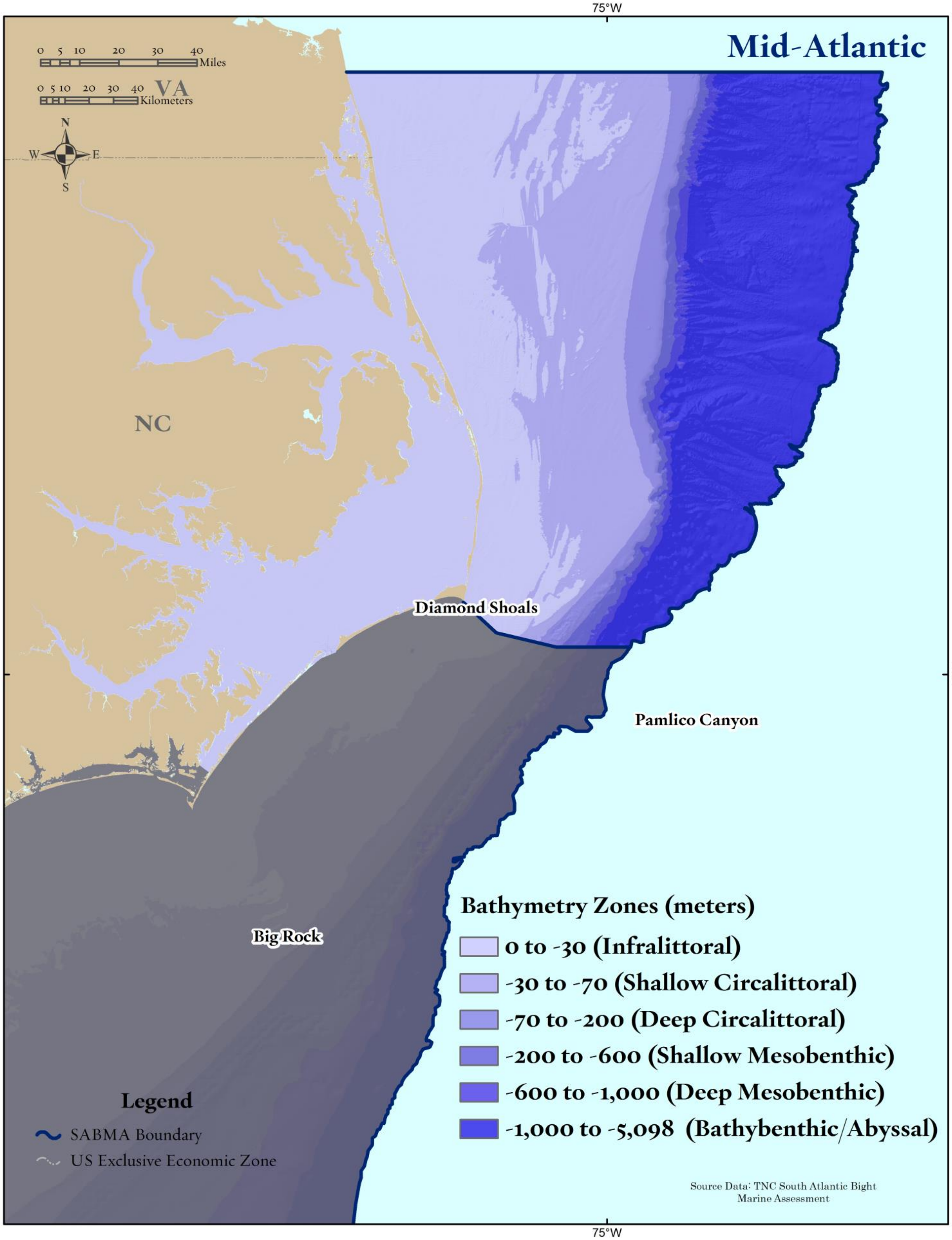


Figure 3.4. Depth zones of the mid-Atlantic subregion

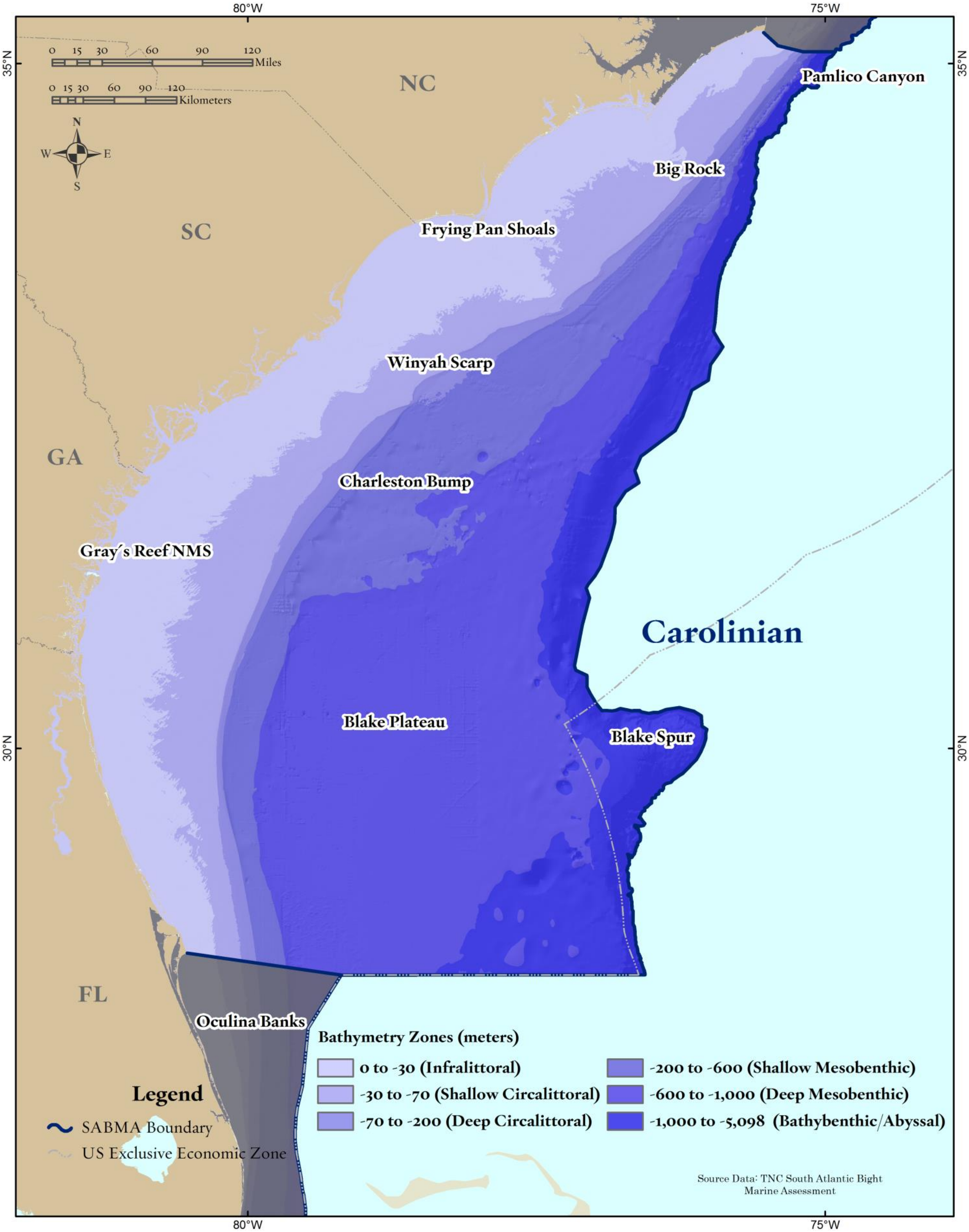


Figure 3.5. Depth zones of the Carolinian subregion

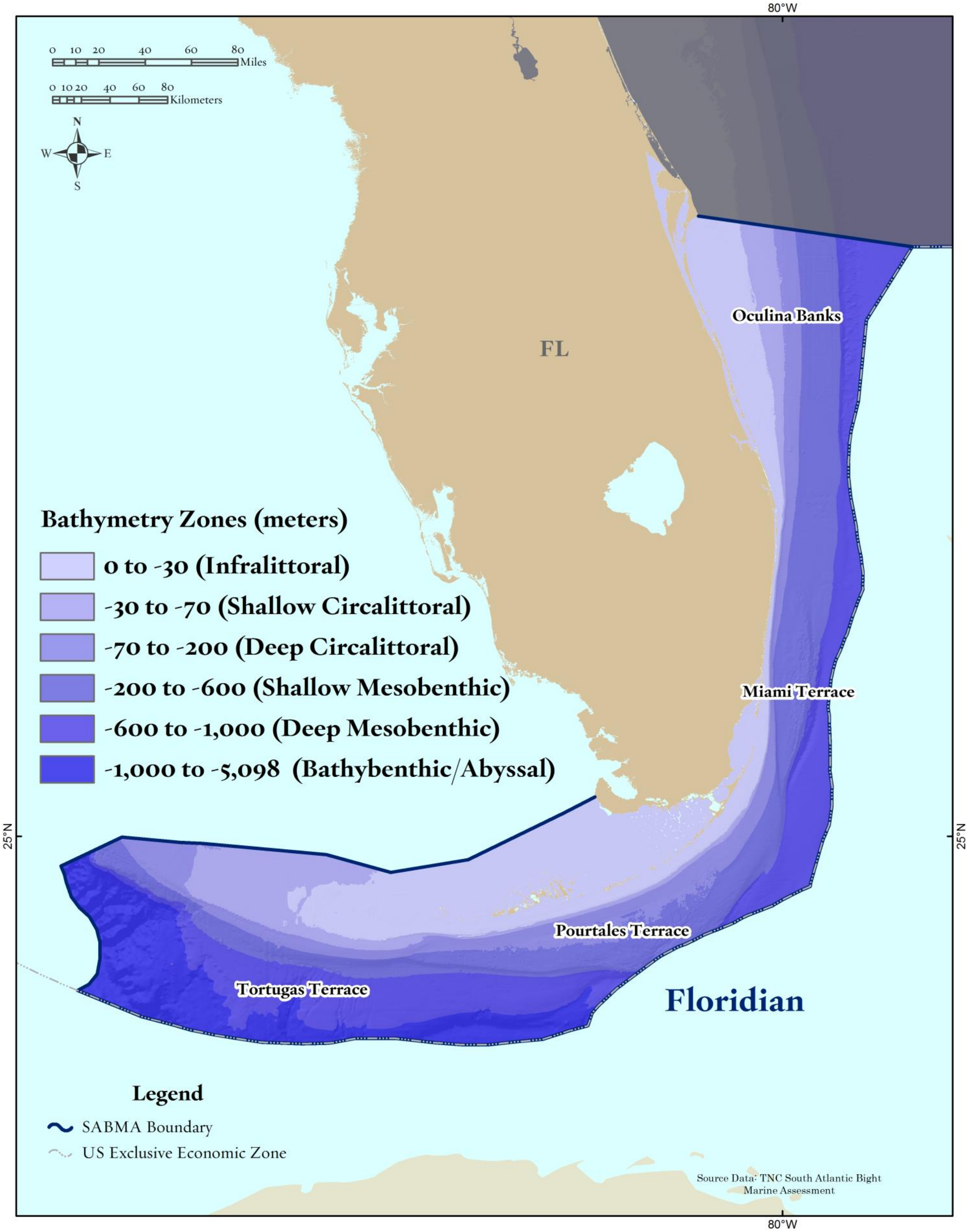


Figure 3.6. Depth zones of the Floridian subregion

Seabed Topographic Forms

Topography influences the distribution of oceanic processes and seafloor habitats. The South Atlantic seafloor is characterized by a variety of large and small scale geomorphic features. The wide, flat Continental Shelf is patterned with shoal fields, sediment waves, ridges, trenches, channels, and depressions. The oceanic region east of the shelf-slope break forms a deepwater basin marked by plateaus, terraces, canyons, slopes, and spurs. Our goal was to characterize and map seafloor topography in a systematic way relevant to the scale of distribution of seafloor organisms. The units that emerge from this analysis – the seabed forms – represent depositional and erosional environments that typically differ in fluvial processes, sediment types, and species composition (Wigley and Theroux 1981).

To develop the data layer of seabed forms, we started with the interpolated bathymetry surface, using new techniques to calculate the relative topographic position and degree of slope of each seafloor cell. From this information we described different seabed forms such as a flat surface raised above its surroundings (a shoal) or a narrow slope bottom surrounded by steep slopes (a canyon bottom). Mapping methods are described below and were based on Anderson et al. (2010) which were derived from Fels and Zobel (1995). Like the bathymetry data, cell resolution was 90 m^2 for most of the region, but 810 m^2 for the deepwater section of the Carolinian.

Relative Position

To derive relative topographic position of any given cell we evaluated the elevation differences between that cell and the surrounding cells within a specified search radius. For example, if the model cell was, on average, higher than the surrounding cells, then it was considered to be closer to the ridge top (a more positive seabed position value). Conversely, if the model cell was, on average, lower than the surrounding cells then it was considered closer to the slope bottom (a more negative seabed position value).

The relative position value was the mean of the distance-weighted elevation differences between a given point and all other model points within a specified search radius. The search radius was set at 61 cells after examining the effects of various distances to find a radius that would discern both subtle sand waves on the coastal shelf and deep canyons on the slope. Position was grouped into five classes:

CLASS NAME	Mean Elevation Difference
❖ Lowest	(< -30)
❖ Low	(-30 to -5)
❖ Mid	(-5 to 5)
❖ Upper	(5 to 30)
❖ Uppermost	(> 30)

Slope
Degree of slope was used to differentiate between steep features (slopes and canyons) and flat features (banks, shoals, depressions). Slope was calculated as the difference in elevation between two neighboring cells, expressed in degrees. After examining the distribution of slopes across the region, slopes were grouped according to the following thresholds:

MODEL SLOPE *(90 m^2 cell)*	**NAME *(Approximate actual slope*)**
❖ 0° - 0.04°	Depression (0°)
❖ 0.04° - 0.08°	Flat
❖ 0.05° - 0.8°	Gentle slope
❖ 0.8° - 8.0°	Slope
❖ > 8.0°	Steep slope (35°-45°)

The cutoffs were averaged over a 90 m^2 cell or larger and thus do not correspond exactly with slope degrees calculated at a finer scale. For example, canyon walls reported as 35°-45° slope correspond to only > 8.0° category for the 90 m cells. We combined slope and relative position to create 30 possible seabed forms which were then simplified into eleven named types from "upper flat" to "low scarp" (Table 3.6 and Table 3.7, Figures 3.7-3.10).

Each individual cell was assigned to a unique seabed form. Visually, groups of seabed forms may cluster to define larger scale forms; for example, the shelf shows a marked ridge-and-swale topography. At the shelf break, the seabed forms delineate a discontinuous series of sloped terraces that drop off into steep slopes with submarine canyons, or to the flat Blake Plateau, or deep Straits of Florida.

Relation to CMECS
The seabed topographic units are the basic building blocks of the CMECS "Geoforms" (Appendix 1). For instance, the geoform named "ridge" is composed of an upper position flat flanked by steep slopes on two sides, while the reverse geoform, "canyon" is characterized by a low position flat flanked by two steep slopes. Creating named geoforms out of the various seabed topographic forms is a step that we have not completed, but readers will recognize many characteristic geoforms on the accompanying maps because the seabed forms aggregate to produce larger recognizable features.

Table 3.6. Shelf Region: cutoffs and thresholds for the seabed forms. These forms were created using 90 meter bathymetry data.

Section	SLOPE CATEGORY (90 m)	POSITION	NAME
Shelf	Flat	Highest	Upper Flat
Shelf	Flat	High	Upper Flat
Shelf	Flat	Mid	Mid Flat
Shelf	Flat	Low	Low Flat
Shelf	Flat	Lowest	Depression
Shelf	Sloping	Highest	Upper Slope
Shelf	Sloping	High	Upper Slope
Shelf	Sloping	Mid	Mid Slope
Shelf	Sloping	Low	Low Slope
Shelf	Sloping	Lowest	Bottom Slope
Shelf	Steeply Sloping	Highest	Upper Scarp
Shelf	Steeply Sloping	High	Upper Scarp
Shelf	Steeply Sloping	Mid	Mid Scarp
Shelf	Steeply Sloping	Low	Low Scarp
Shelf	Steeply Sloping	Lowest	Low Scarp

SEABED FORM	CHARACTERISTIC GEOFORM
❖ depression	*(shelf valley channel, depression, trench)*
❖ low flat	*(valley, flat)*
❖ mid flat	*(shelf , plateau, flat terrace)*
❖ high flat	*(bank, shoal, flat)*
❖ upper slope	*(ledge, slope)*
❖ mid slope	*(slope, sediment wave)*
❖ low slope	*(fan, terrace)*
❖ slope bottom	*(slope)*
❖ upper scarp	*(ledge)*
❖ mid scarp	*(canyon, scarp, steep slopes)*
❖ lower scarp	*(canyon, trench)*

Table 3.6. Oceanic Region: cutoffs and thresholds for the seabed forms. These oceanic forms were created using 810 m bathymetry data. We tried to match the patterns found in the 90 m data used for the shelf as closely as possible, but doing so often necessitated different cutoffs due to the coarse scale of the data.

SECTION	SLOPE CATEGORIES	POSITION	NAME
Deep	Flat	Highest	Upper Flat
Deep	Flat	High	Upper Flat
Deep	Gently Sloping	Highest	Upper Flat
Deep	Flat	Mid-position	Mid Flat
Deep	Gently Sloping	Mid-position	Mid Gentle Slope
Deep	Flat	Low	Low Flat
Deep	Flat	Lowest	Low Flat
Deep	Sloping	High	Upper Slope
Deep	Sloping	Highest	Upper Slope
Deep	Sloping	Mid-position	Mid Slope
Deep	Sloping	Low	Low Slope
Deep	Sloping	Lowest	Low Slope
Deep	Sloping	Lowest	Slope Bottom
Deep	Steeply Sloping	Highest	Upper Scarp
Deep	Steeply Sloping	High	Upper Scarp
Deep	Steeply Sloping	Mid-position	Mid Scarp
Deep	Steeply Sloping	Low	Low Scarp
Deep	Steeply Sloping	Lowest	Low Scarp
Deep	Vertical	Highest	High Ledge
Deep	Vertical	High	High Ledge
Deep	Vertical	Mid-position	Mid Ledge
Deep	Vertical	Low	Canyon Bottom
Deep	Vertical	Lowest	Canyon Bottom

SEABED FORM	**CHARACTERISTIC GEOFORMS**
❖ depression	(*shelf valley channel, depressions, trenches*)
❖ low flat	*(valley, flat)*
❖ mid flat	(*shelf , plateaus, flat terraces*)
❖ mid gentle slopes	*(flat)*
❖ high flat	(*bank, shoal, flat*)
❖ upper slope	(*ledge*)
❖ mid slope	(*slope, sediment wave*)
❖ low slope	*(fan, terraces)*
❖ slope bottom	*(slope)*
❖ upper scarp	*(ledge)*
❖ mid scarp	(*canyon, steep slope*
❖ lower scarp	*(canyon, trench)*
❖ high ledge	*(ledge)*
❖ mid ledge	*(ledge)*
❖ canyon bottom	*(canyon)*

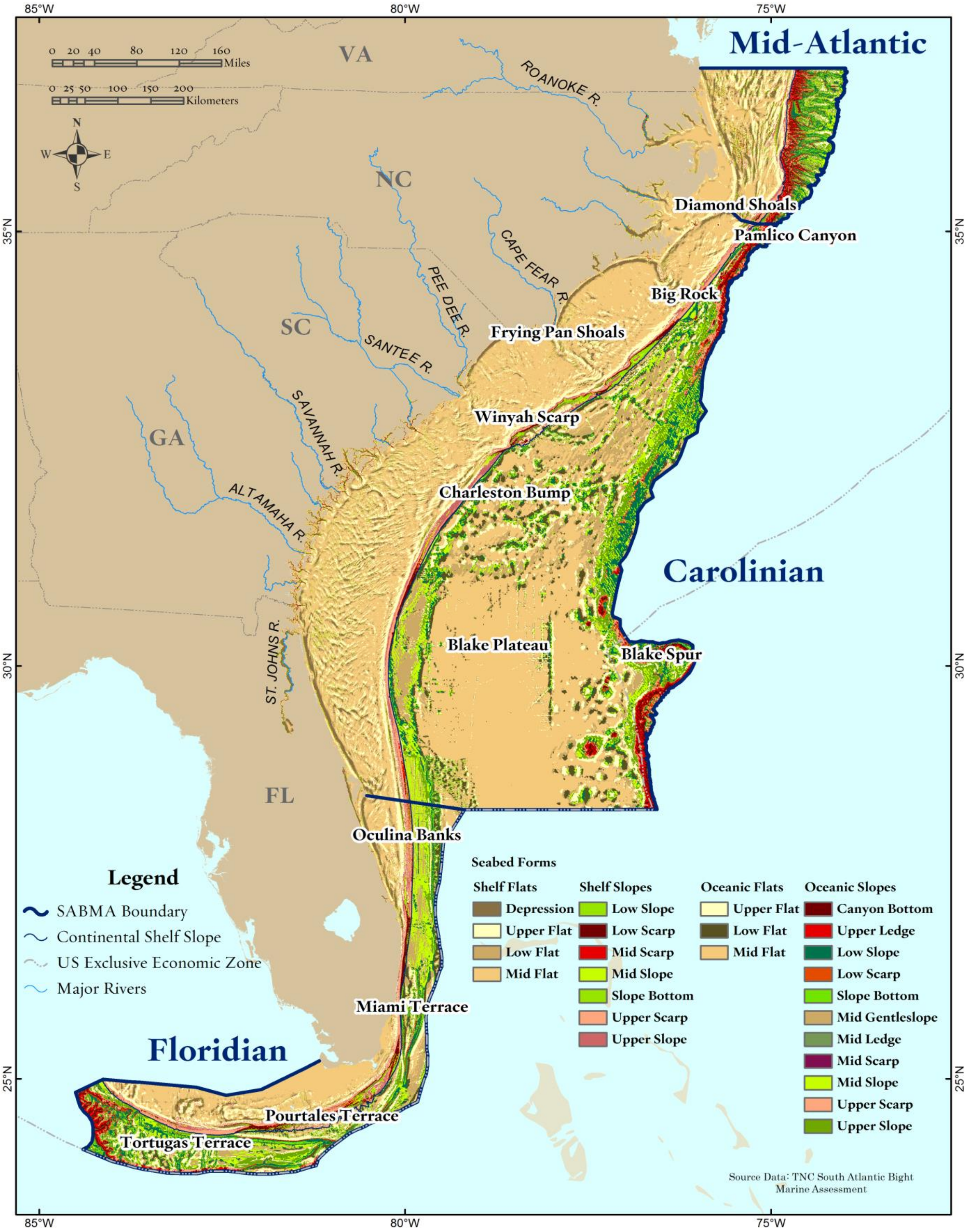


Figure 3.7. Seabed forms of the South Atlantic Bight marine region. See subregional maps on the following pages.

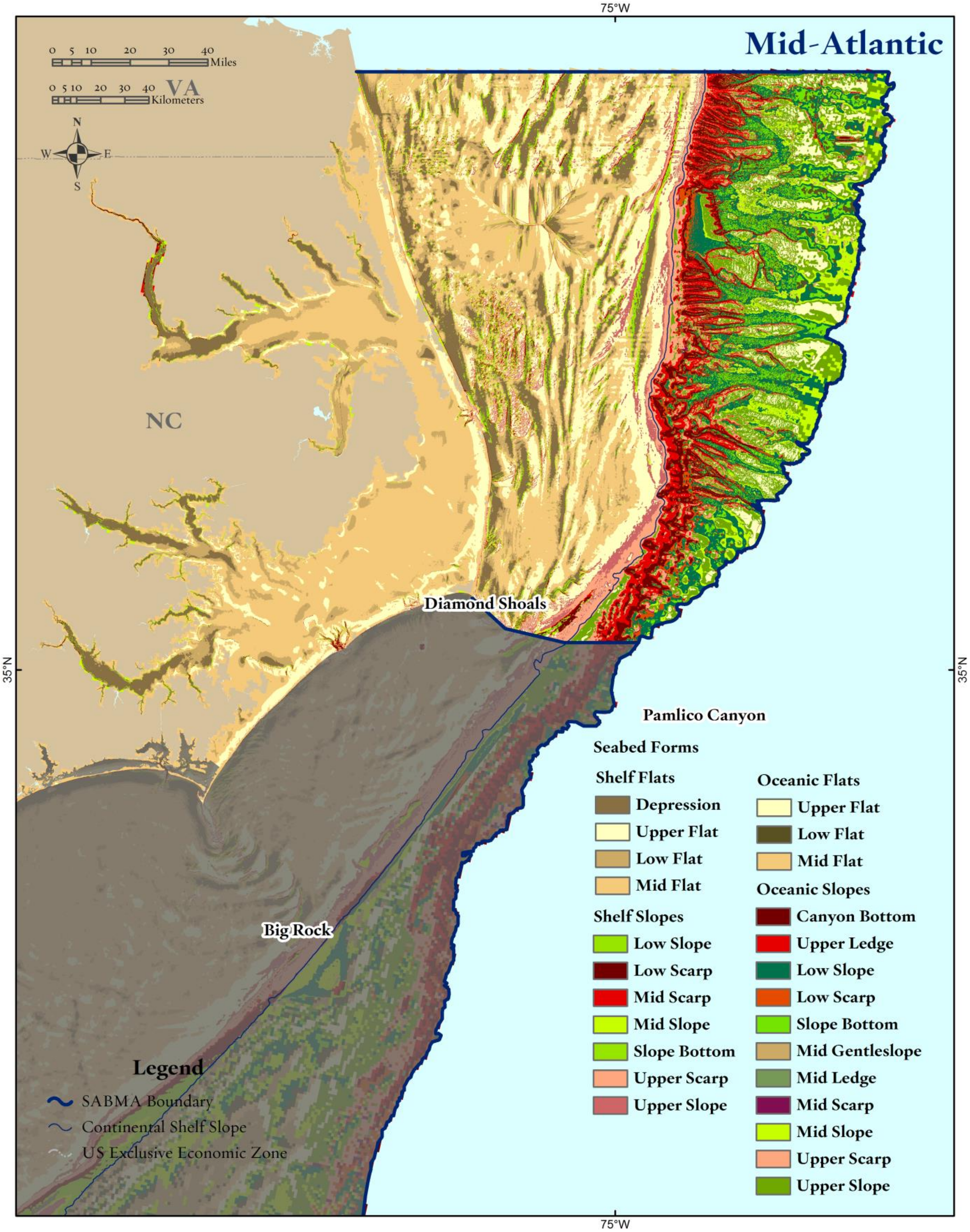


Figure 3.8. Seabed forms of the mid-Atlantic subregion

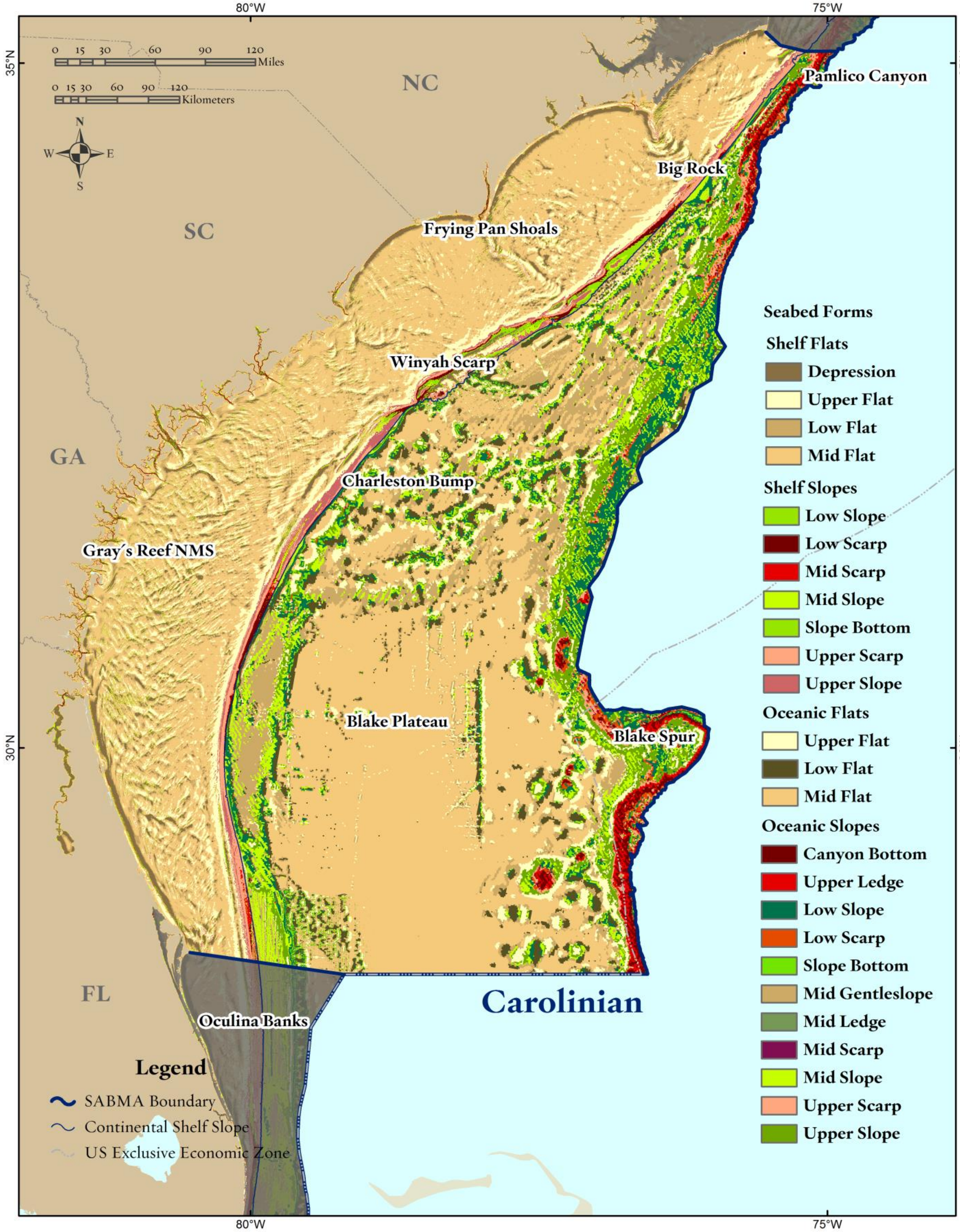


Figure 3.9. Seabed forms of the Carolinian subregion

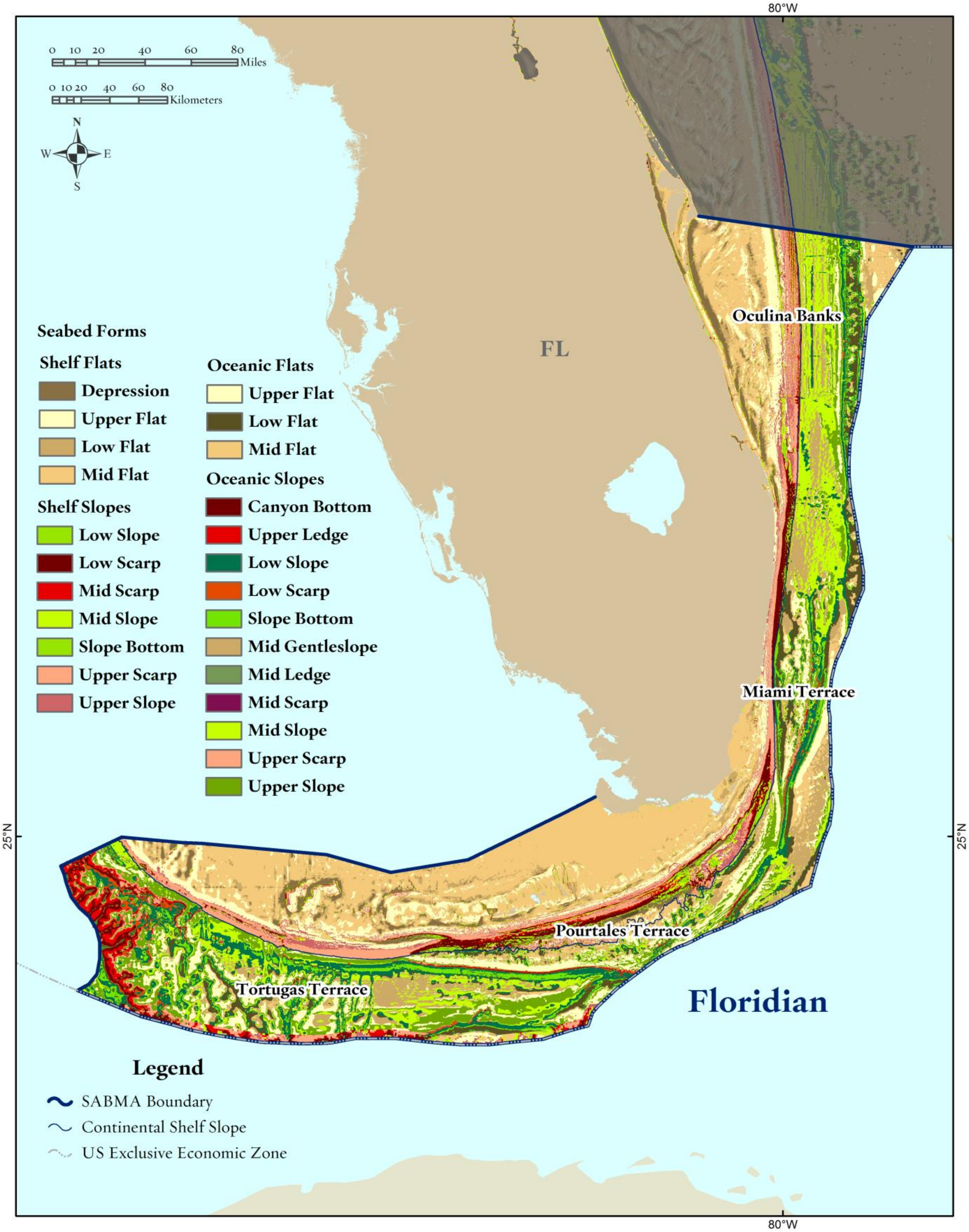


Figure 3.10. Seabed forms of the Floridian subregion

Comparison of the 90 m Seabed forms with Multibeam Data

To understand the strengths and limitations of the seabed form dataset we examined four test areas where we had fine scale 1-4 m Digital Elevation Models (DEM) created from multibeam bathymetric data (Figure 3.11-3.14).

The figures compare the seabed forms developed at a 90 m resolution with the seafloor topography mapped at a 1 to 4 m resolution. In general, the 90 m resolution accurately maps the larger and more dramatic features but misses the small-scale topographic diversity. For example, for Gray's Reef (Figure 3.11), the low depressions (multibeam - blue) are picked up by the seabed forms (dark brown), and the upper flats (multibeam - red) are also picked up (white) along with the larger slopes (green and red). However, much of the fine patterning shown in the flats (multibeam - green) is lost in the 90 m seabed forms.

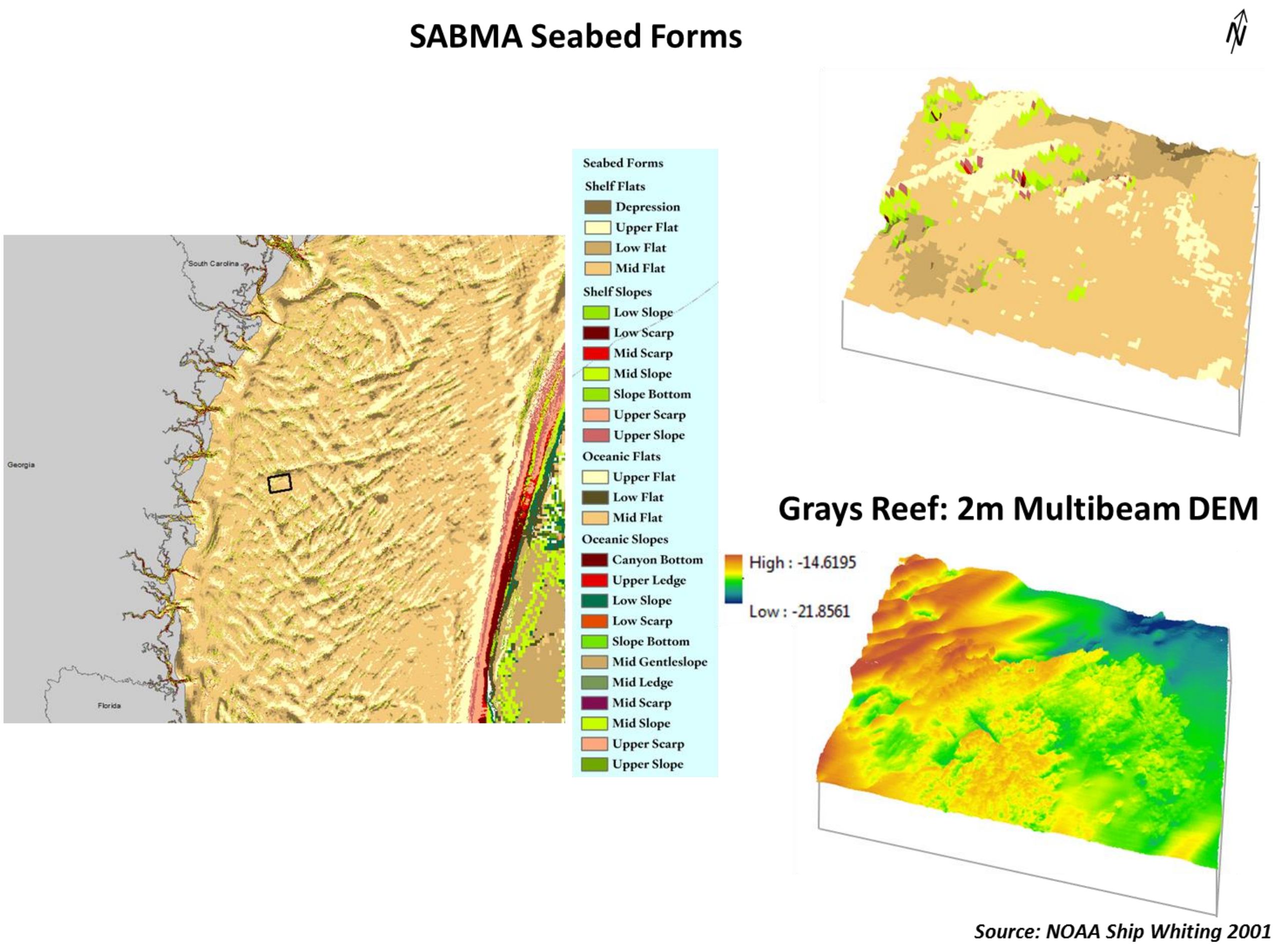


Figure 3.11. Multibeam data for Gray's Reef. The multibeam DEM shows a low depression (blue) with gentle slopes to the east (red) and steeper slopes to the north (green). These same features can be seen in the coarse 90 m seabed forms.

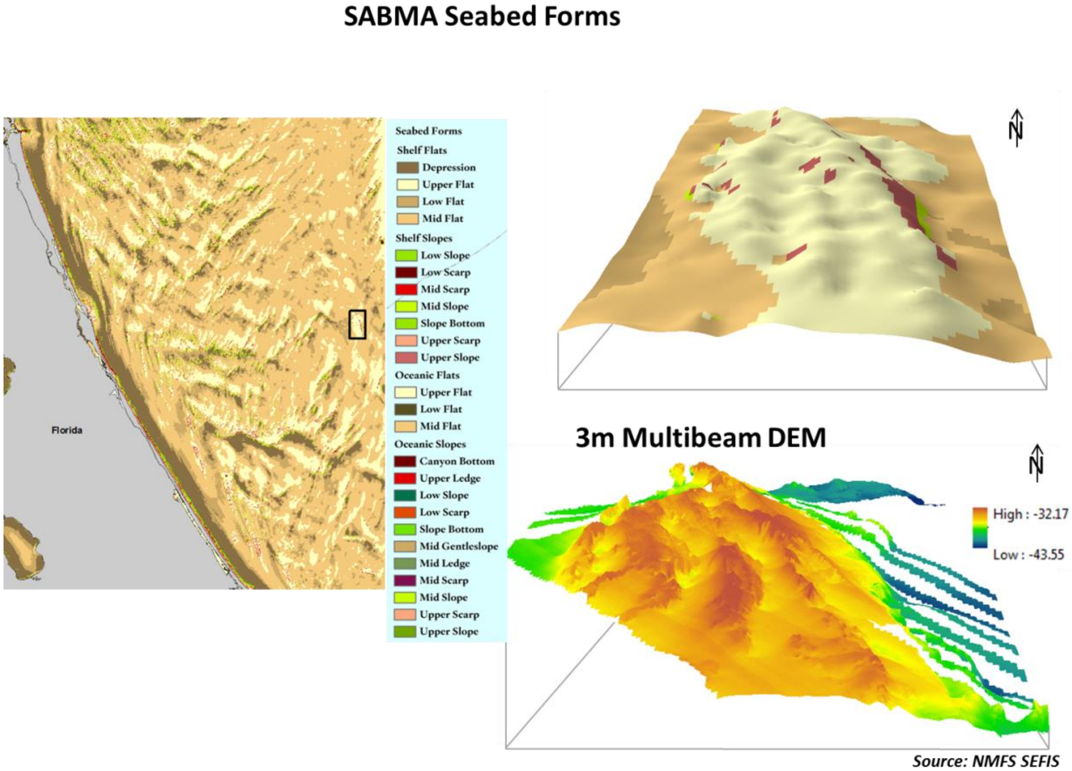


Figure 3.12. Multibeam data for the outer edge of the Continental Shelf. The multibeam data shows a raised seabed form with small slopes that can also be seen in the 90 m data.

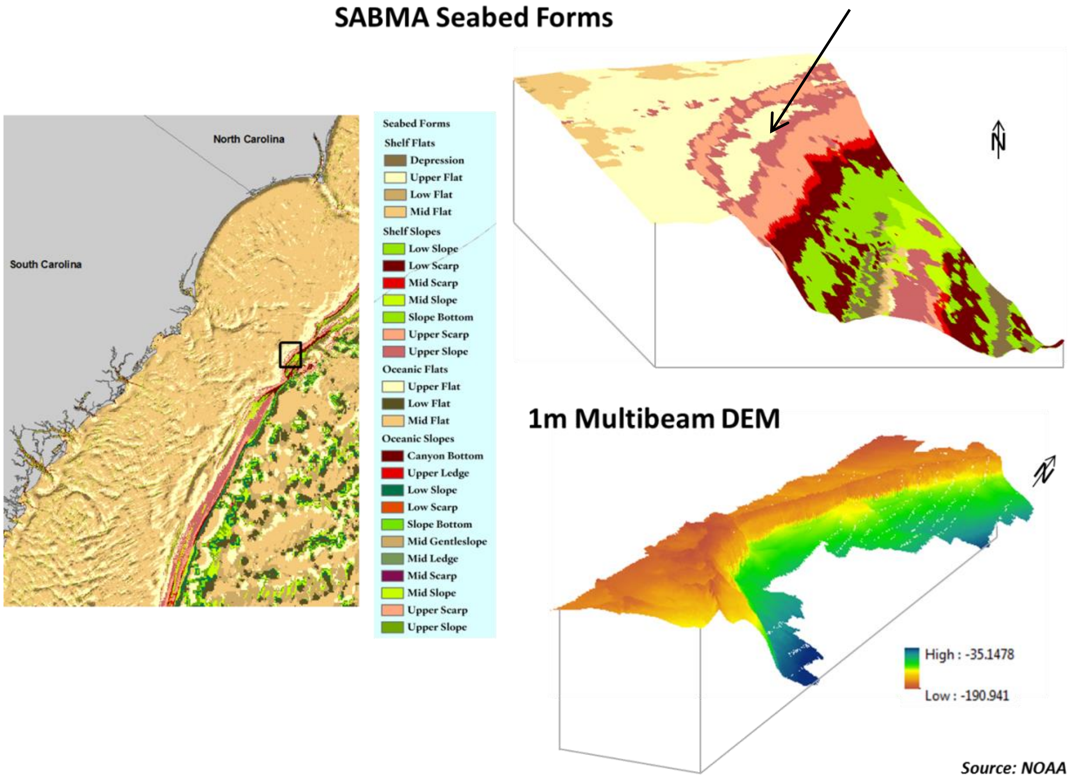
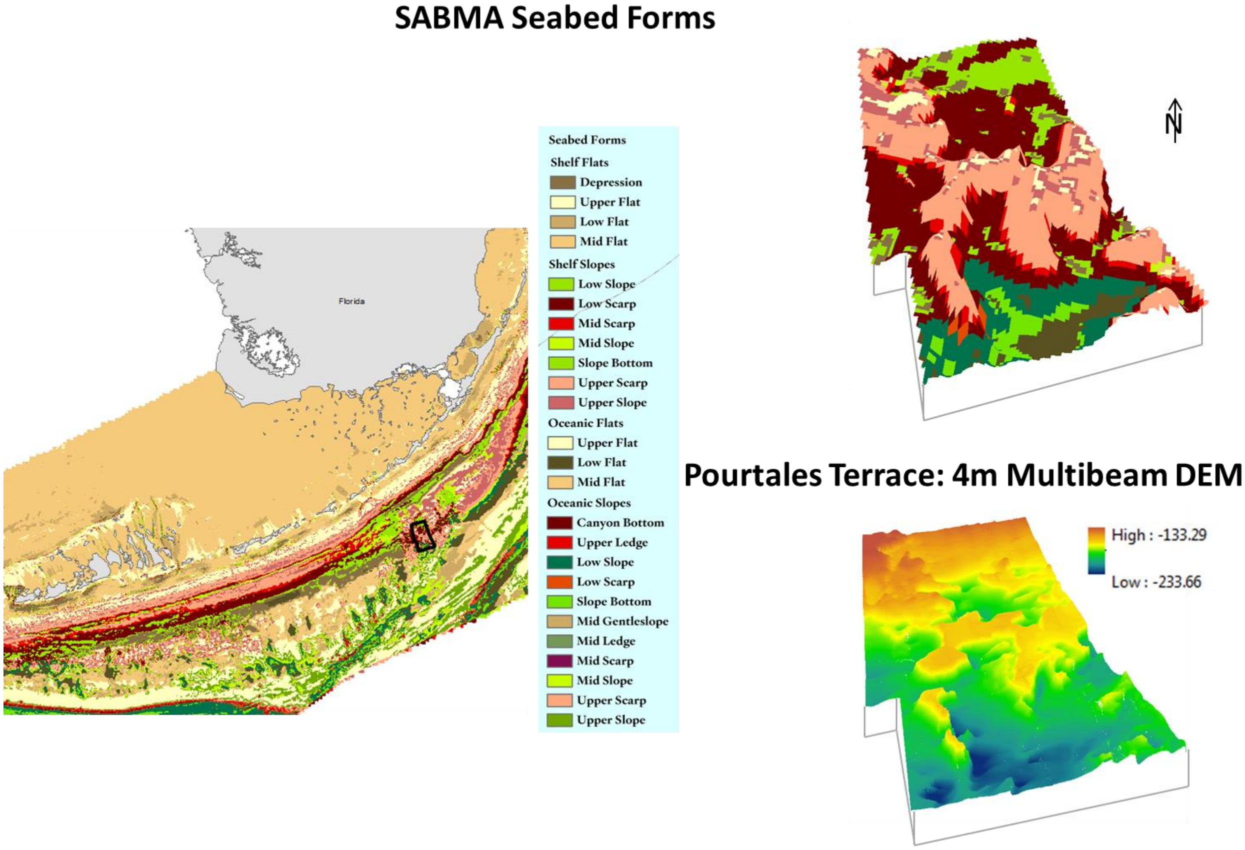


Figure 3.13. Multibeam data for the Shelf-Slope break. Where the multibeam shows a linear ridge, the seabed forms show a linear high position "flat" flanked by slopes on both sides. The linear ridge apparent in the multibeam data is mapped as a narrow linear flat flanked by slopes in the 90 m data (arrow). The steeper slopes off the shelf-slope break are visible at both scales.



Source: NOAA Ship Nancy Foster 2011 multibeam

Figure 3.14. Multibeam data for Pourtales Terrace. The multibeam data shows a large dissected plateau surrounded by slopes and this is also apparent in the seabed forms.

Seafloor Substrates

The South Atlantic seafloor is a mix of soft sediment and hardbottom that collectively offers a range of habitats for benthic invertebrates and demersal fish. Unconsolidated soft sediments of clay, silt, sand, and fine gravel form the majority of the seafloor while hardbottom formed by natural rock and reef substrates is distributed patchily throughout the region. The latter vary from flat limestone "pavements," to small outcrops, to vertical slopes with up to 10 m of relief, and they are often hot spots of diversity. The hard substrate provides a stable surface for colonizing species such as algae, sponges, corals, and bryozoans, and the hard structure creates refuge habitat for fish. We mapped soft sediments using interpolations of sample points to create a continuous soft sediment map. To delineate hardbottom we used observed rock substrate points and reef locations in conjunction with the seabed forms to create a map of estimated hardbottom areas. The final substrate map overlays the hardbottom on the soft sediment. Methods used to map the two substrates are discussed separately below.

Soft Sediment

To create the soft sediment dataset, sediment samples for the United States portion of the region were obtained from usSEABED, an innovative system that brings an assortment of spatially-explicit quantitative and descriptive sediment data together in a unified database (Reid et al. 2005). The information includes textural, geophysical, and compositional characteristics of points collected from the seafloor. The data coverage extends seaward across the Continental Shelf and slope, and combines more than 150 different data sources containing over 200,000 data points for the Atlantic/Gulf and Caribbean regions. A unique feature of the database is the use of data mining and processing software to extend the coverage of information in areas where data is more descriptive than quantitative (details in Reid et al. 2005). The usSEABED dataset provided 9,965 usable points for the South Atlantic and we supplemented it with other non-overlapping point locations from three sources: Florida Fish and Wildlife Conservation Commission Fish and Wildlife Research Institute (FWRI) Fisheries-Independent Monitoring (FIM) Program (15,994 points), Carteret Sand Search Cores (155 points), and South Carolina Department of Natural Resources (3,821 points), for a total or 29,935 points (Figure 3.15). These datasets were used with permission from the original sources.

<u>USSEABED</u> (Number of Records = 9,965)

We compiled the Atlantic/Gulf and Caribbean datasets and extracted all points within 10 km of the South Atlantic Bight boundary, keeping both extracted and parsed points. We removed records that did not contain usable information on sediment grain size or that were rock substrate (Shepherd Code = Solid and grain size = -99). A large number of locations had multiple records associated with a single point. For these records we gave priority to extracted data (measured) over parsed data (qualitatively estimated). If multiple extracted points were given, we used the mode grain size, and if there was no mode we used the lowest extracted grain size value. We used the same criteria when only parsed data were present. The final dataset of 9,965 unique points was converted to a shapefile with two fields for grain size: Phi and millimeters.

<u>FLORIDA FISH AND WILDLIFE CONSERVATION COMMISSION (FWRI 2013) FIM PROGRAM</u> (N = 15,994)

Data were exported to csv files from SAS datasets with qualitative attributes for the grain sizes. We converted the dataset to a shapefile and retained only records that had latitude and longitude values and that were coded as Sand or Mud. We assigned the sand records a value of 0.239 mm (the average sand value of usSEABED sand points within 1 km of these points). We assigned the mud records a value of 0.0025 mm which is the break point between clay and silt classes on the Wentworth scale (Wentworth 1922). All locations with multiple records that had conflicting bottom type values (sand and mud) were removed and those that agreed were reduced to one record/location and used along with the other unique records for a unique location.

These locations were also checked against the usSEABED data to verify there were no duplicate points between the two datasets.

2011 CARTERET SAND SEARCH CORES (N = 155)
Description of data was provided as an Excel spreadsheet. We converted the data to a shapefile and confirmed that there were no duplicate points with the usSEABED data. We used the geology description field (sand or silt) that was available for most records, and assigned these a sediment size based on the average usSEABED value for the equivalent sediment type (e.g., sand or silt). Records with no substrate description were removed.

SOUTH CAROLINA DEPARTMENT OF NATURAL RESOURCES/ARMY CORPS (N = 3,821)
This dataset was for South Carolina only and contained a location (latitude and longitude) and Phi size for each record. We added a calculated value for millimeters and confirmed that there were no duplicate points with the usSEABED data.

The final substrate dataset consisted of 29,935 points. The density of data points was highly skewed toward nearshore environments with no points occurring for large sections of the Blake Plateau region (Figure 3.15). To highlight this issue, a Voronoi analysis was used to create a polygon around each data point such that all the space within each polygon was closer to the central point than to any other data point (Figure 3.16-3.17).

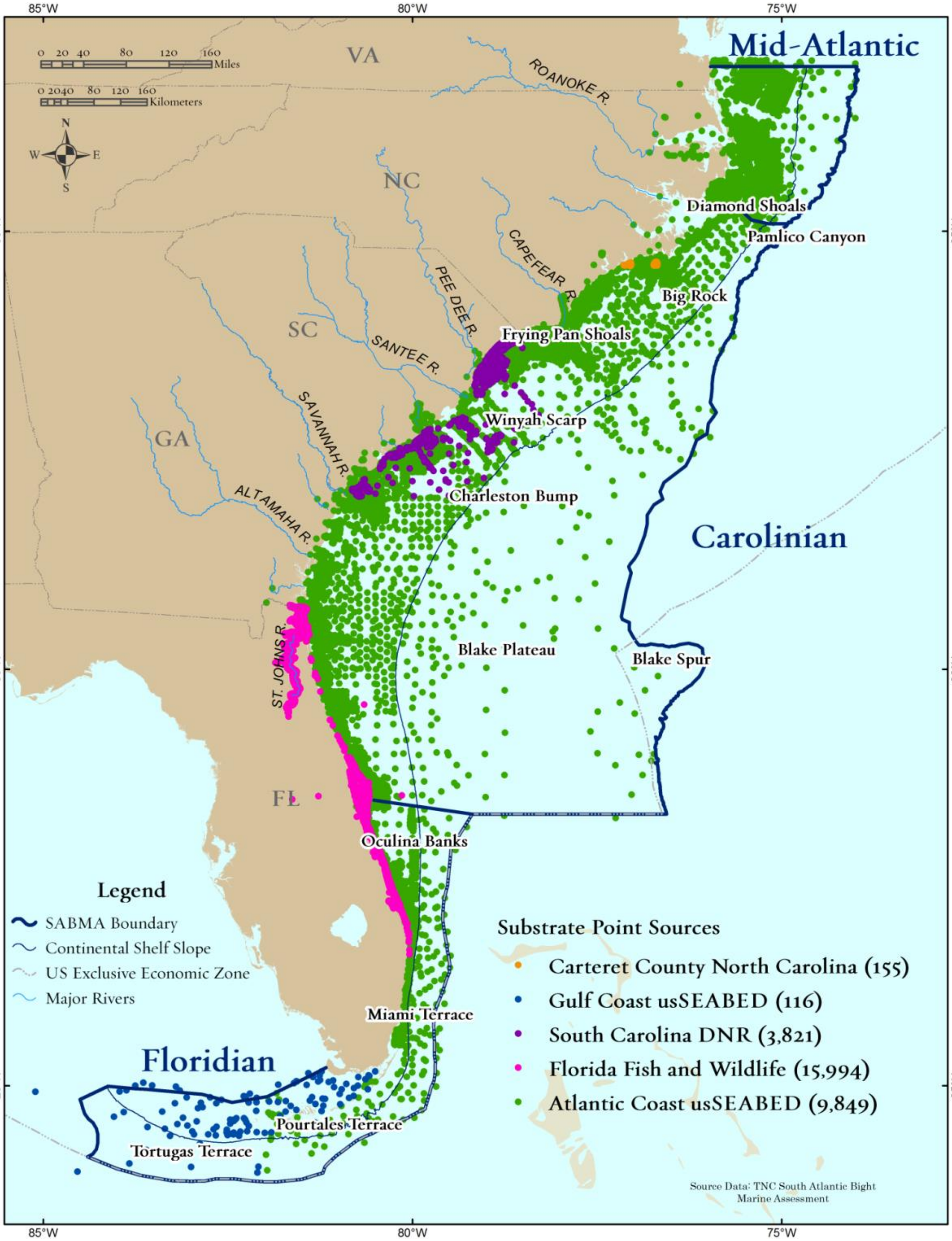


Figure 3.15. Distribution of the 29,935 soft sediment source data points in the South Atlantic Bight marine region

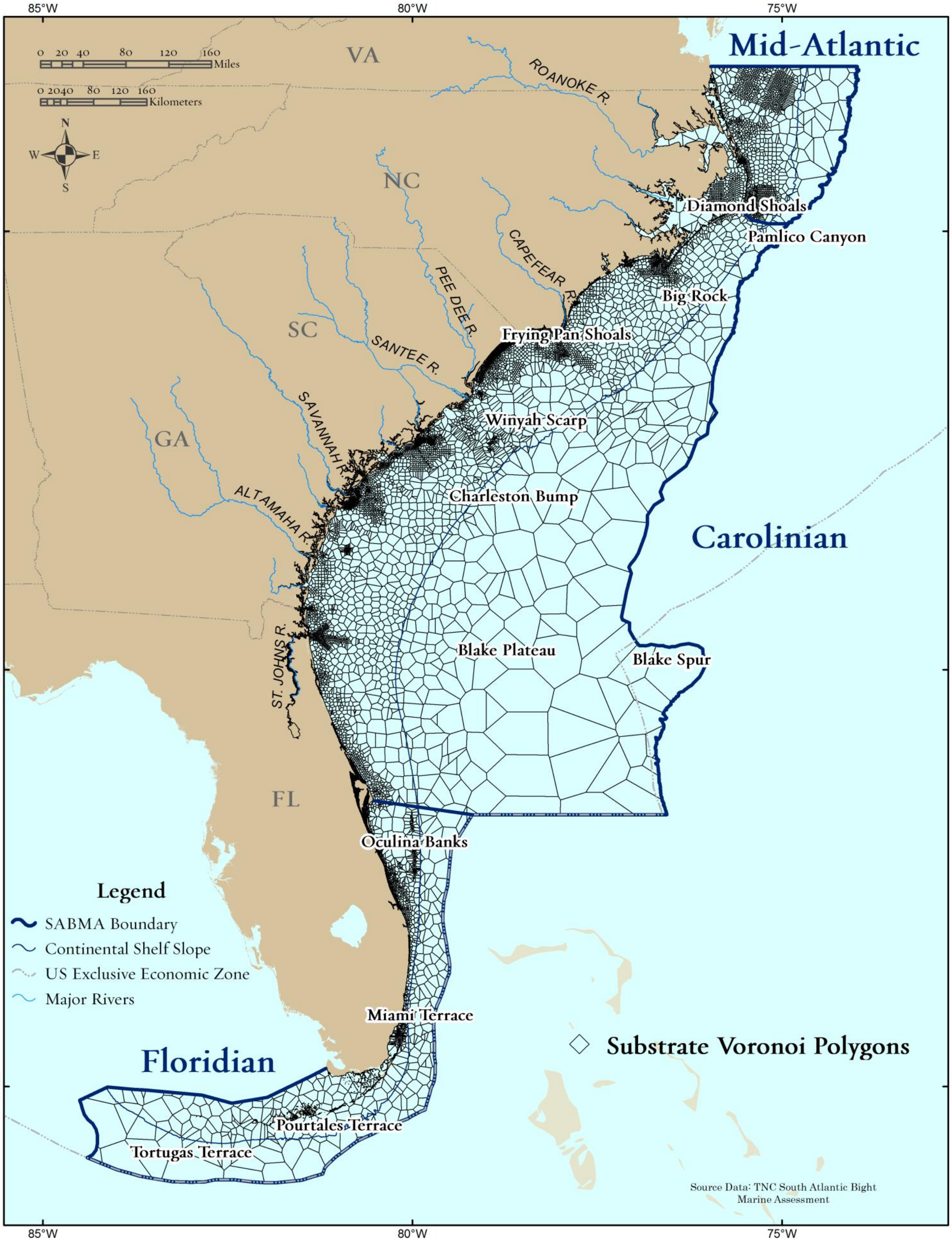


Figure 3.16. Distribution of soft sediment data in the South Atlantic Bight marine region displayed as Voronoi polygons

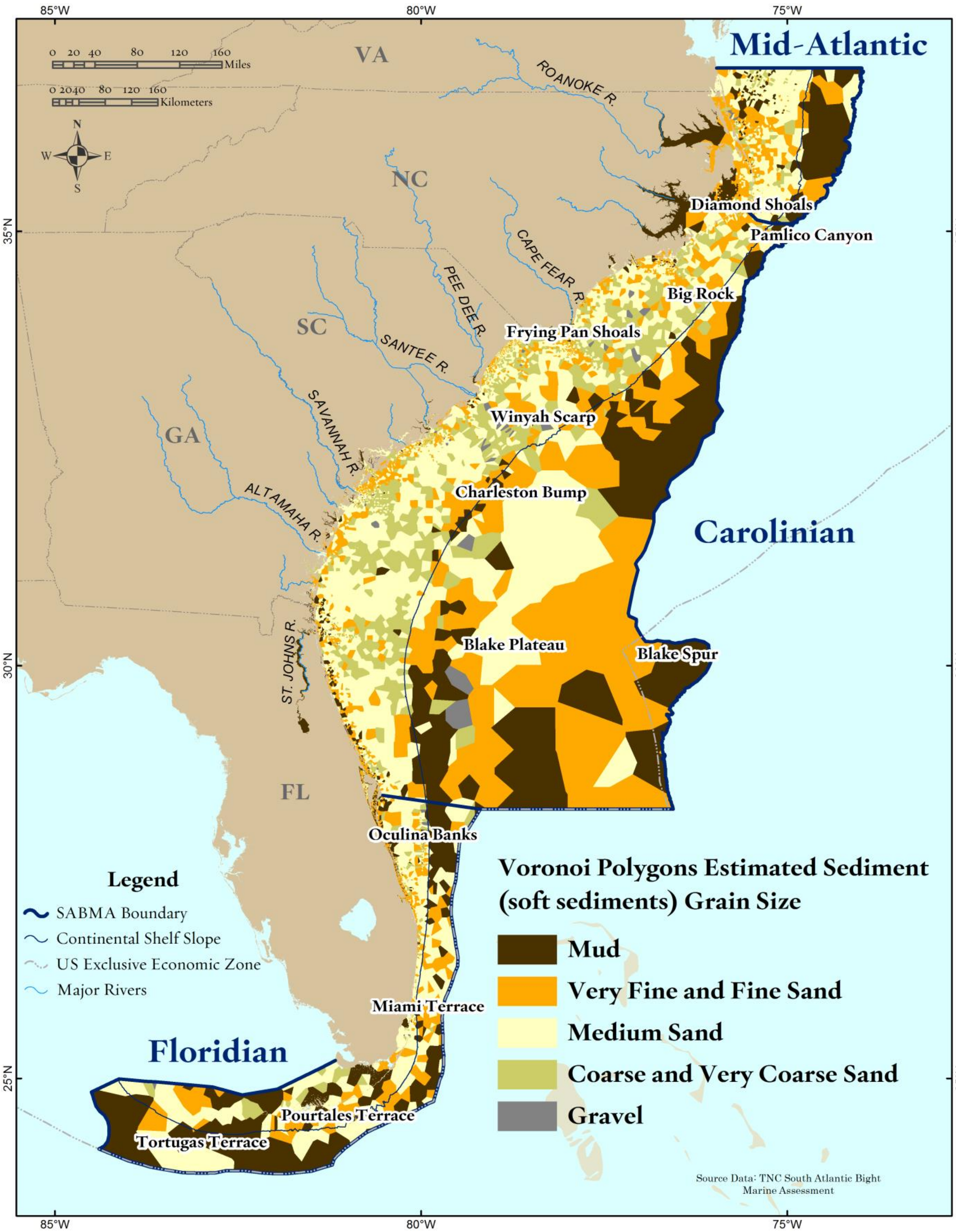


Figure 3.17. Distribution of soft sediment data in the South Atlantic Bight marine region displayed as Voronoi polygons colored by their sediment size class

We interpolated the sediment data using the following parameters: ordinary kriging, spherical semivariogram, variable search radius type using three points with no maximum distance, and an output cell size of 90 m. Kriging provides consistent results across areas that have been sparsely and densely sampled, and it provides an estimation of error (Figure 3.18). The resulting grids created by this method had a strong correlation with the Voronoi grids whereas using more than three points caused considerable smoothing and apparent warping of the raw data patterns. Thus the kriging interpolation resembled the Voronoi map with smoother surfaces and more realistic looking shapes.

GRAIN SIZE CLASSES

The ecology of unconsolidated sandy substrates that characterize the majority of the Continental Shelf is less studied than that of the uncommon (but more biologically diverse) rock substrates. However, the benthic fauna of sand and silt is a key component of seafloor ecosystems, playing a vital role in detrital decomposition, nutrient cycling, and energy flow to higher trophic levels (Hyland et al. 2006). None of the studies we reviewed (Frankenberg 1971; Frankenberg and Leiper 1977; Hopkinson 1985; Tenore 1985) related benthic composition directly to grain size but several focused on larger structure. For example, Kendall et al. (2005) separated flat sand plains from rippled sand on the Georgia Bight. On the shelf, water temperatures vary widely over the year, and the sediments are subject to strong tidal and wind-driven scour, thus most species are mobile and/or surface dwellers that can withstand unstable sediment conditions (Tenore 1985).

We used the Wentworth (1922) scale for the classification of sediments (Table 3.8). Our initial goal was to map all classes. However, because much of the sediment grain size data were derived from qualitative assessments with categorical information, we were unable to accurately distinguish the finer separations within any major category except sand. Even for sand, we could not determine some of the finer splits with confidence. Thus, we mapped the following five categories with confidence (Figures 3.19-3.22):

- Mud (Clay/Silt) 0 – 0.063 mm
- Very fine to fine sand 0.063 – 0.25 mm
- Medium sand 0.25 – 0.5 mm
- Coarse to very coarse sand 0.5 – 2 mm
- Gravel > 2 mm

Results of the interpolations reveal the Continental Shelf alternates between medium sand and coarse sand in a regular pattern. Oceanic regions and shallow estuaries are both dominated by fine sands and silt (Figures 3.19-3.22).

Table 3.7. Grain size and sediment class names (Wentworth 1922)

Grain Size (mm)		Class
0	0.001	Fine clay
0.001	0.002	Medium clay
0.002	0.004	Coarse clay
0.004	0.008	Very fine silt
0.008	0.016	Fine silt
0.016	0.031	Medium silt
0.031	0.063	Coarse silt
0.063	0.125	Very fine sand
0.125	0.25	Fine sand
0.25	0.5	Medium sand
0.5	1	Coarse sand
1	2	Very coarse sand
2	4	Very fine pebbles (granules)
4	8	Fine pebbles
8	16	Medium pebbles
16	32	Coarse pebbles
32	86	Very coarse pebbles to cobbles

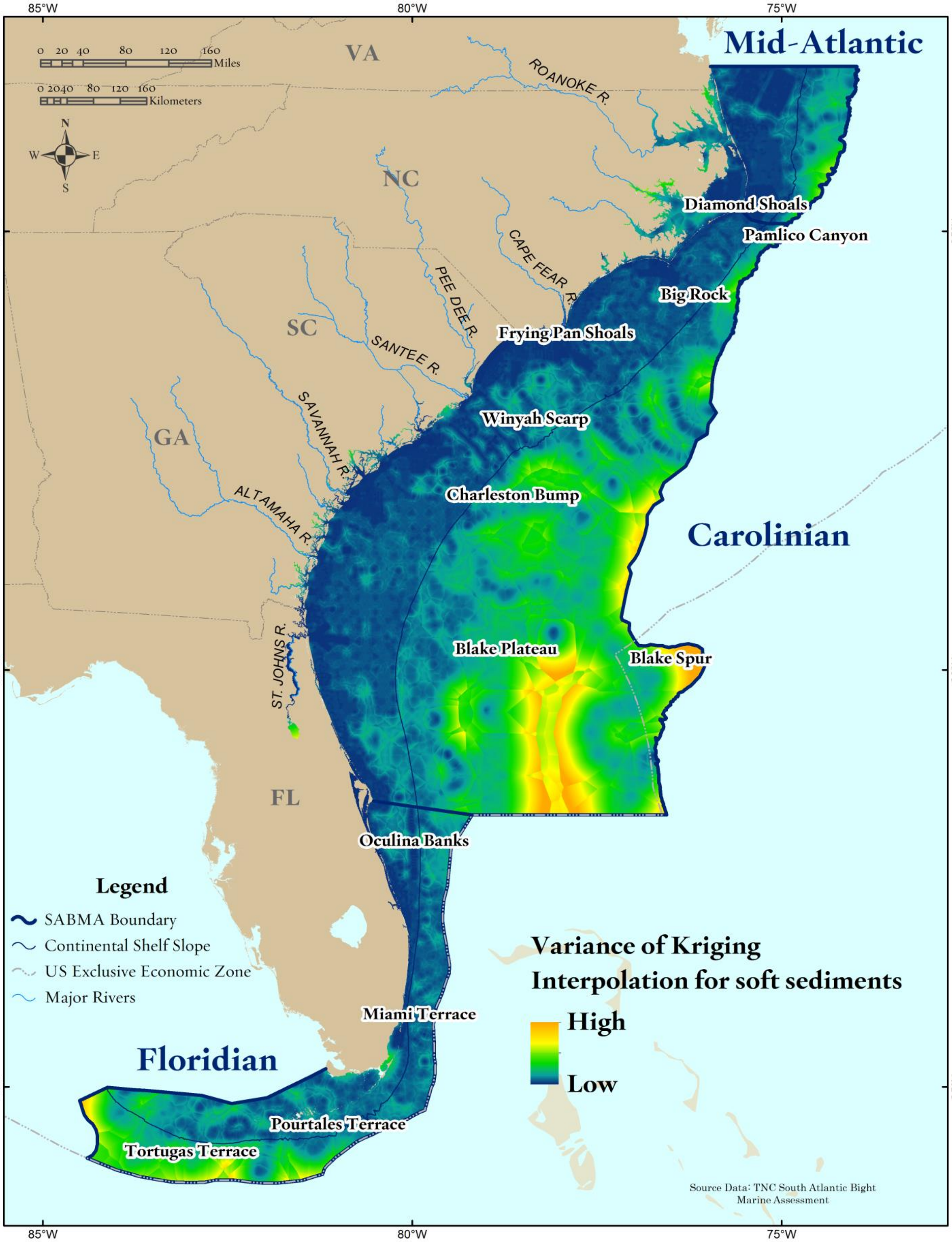


Figure 3.18. Kriging variance of soft sediments in the South Atlantic Bight marine region

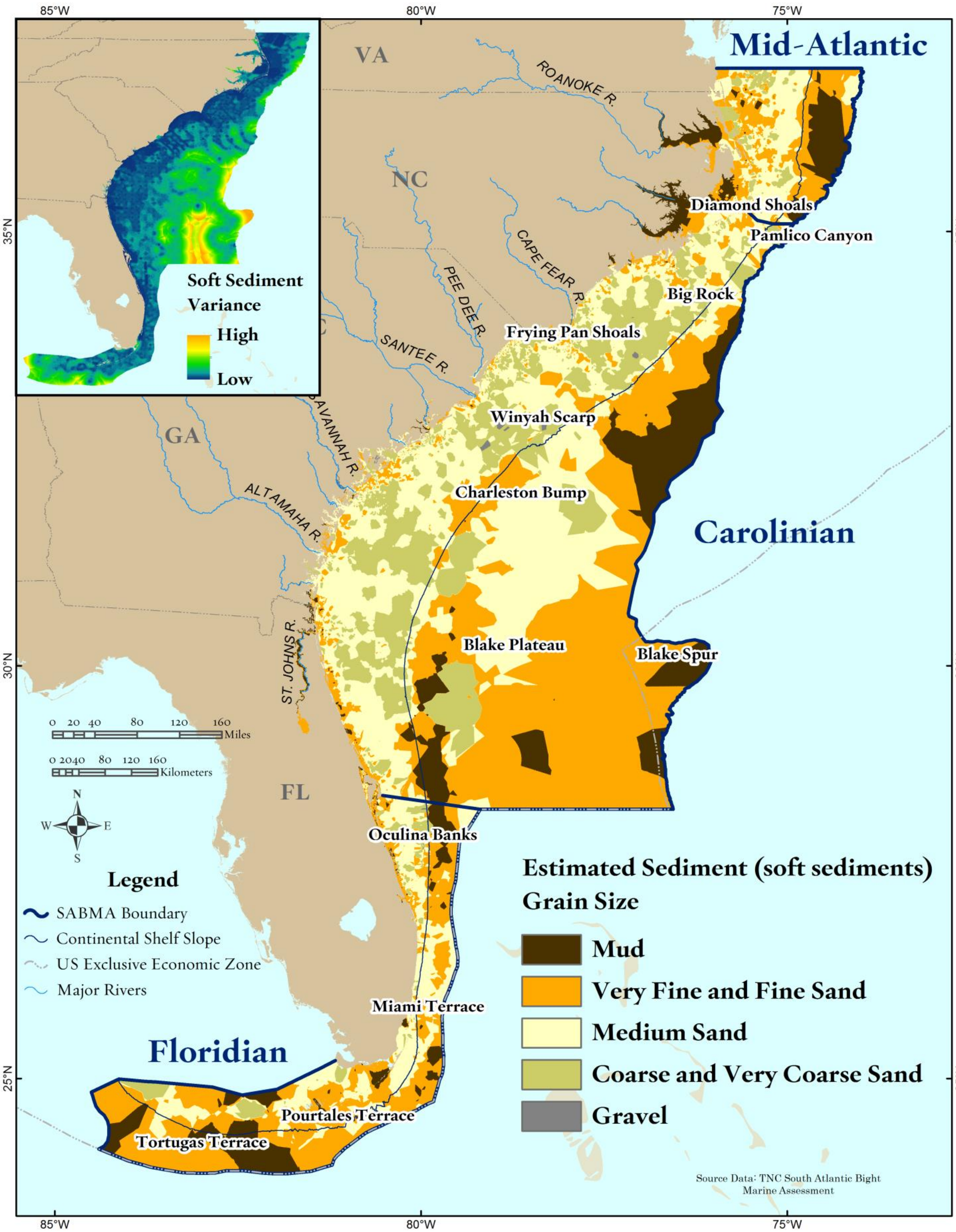


Figure 3.19. Distribution of soft sediments in the South Atlantic Bight marine region. See subregional maps on the following pages.

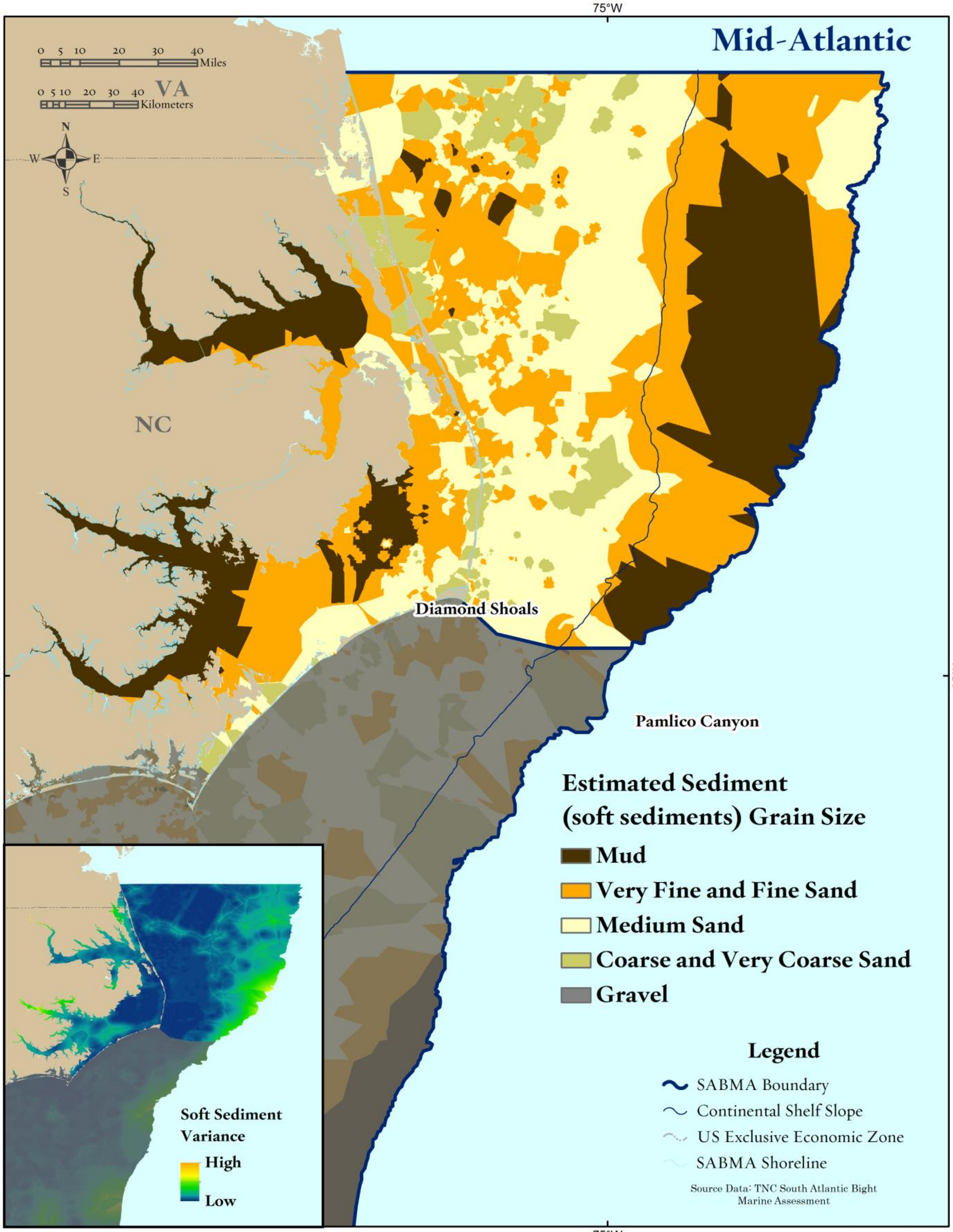


Figure 3.20. Distribution of soft sediments in the mid-Atlantic subregion

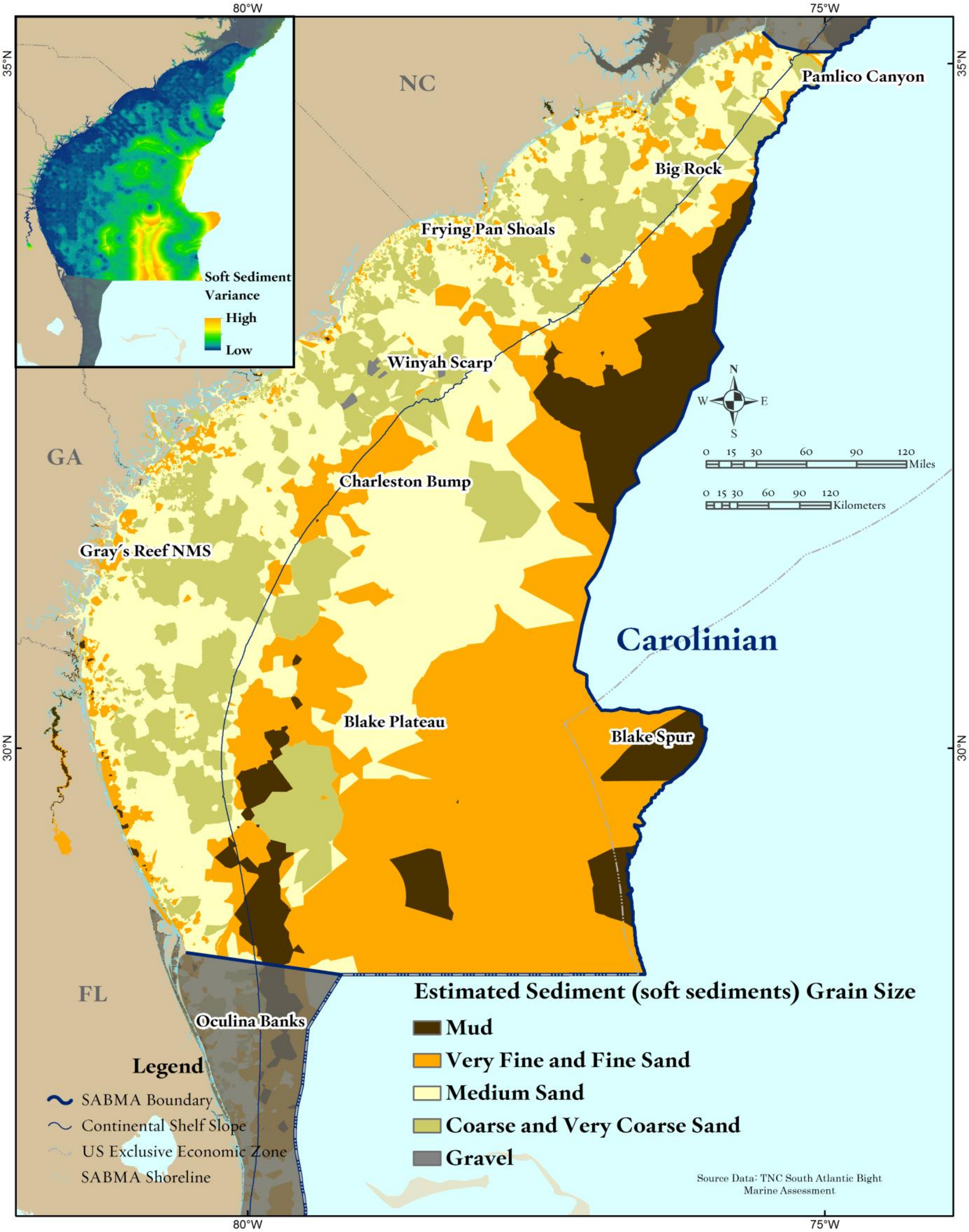


Figure 3.21. Distribution of soft sediments in the Carolinian subregion

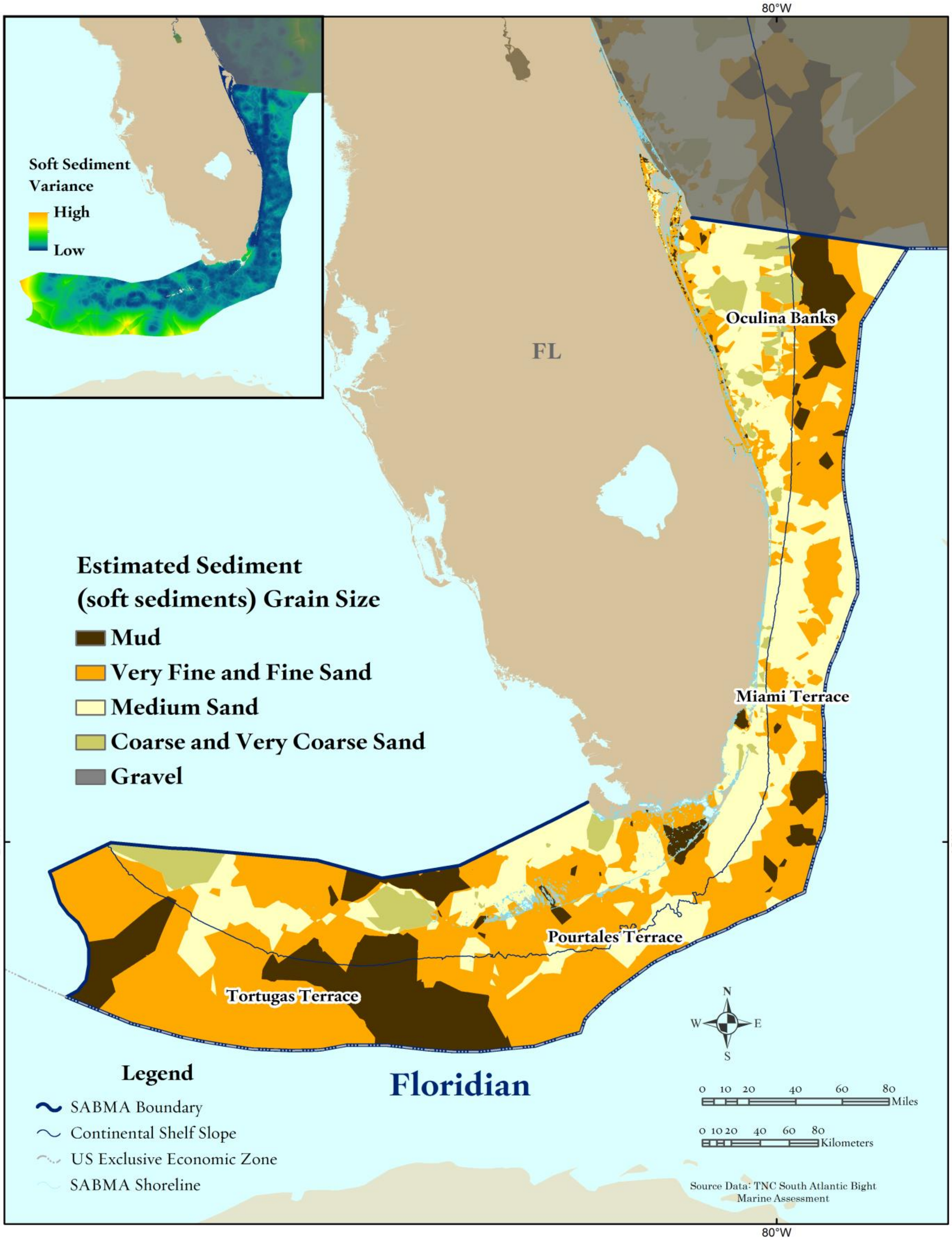


Figure 3.22. Distribution of soft sediments in the Floridian subregion

Hardbottom: Rock Substrate and Coral Reef

Natural rock substrates are areas of rock or consolidated sediment that provide stable substrate for colonization by corals, sponges, algae, bryozoans and other invertebrates. Colonized rock substrate, known as "rocky reef," "faunal beds" or "live-bottom" offers food and shelter to a large variety of organisms, from mollusks and annelids to sea turtles and demersal fish. The degree to which a reef is colonized varies with topography, currents, light availability, and location, but even uncolonized rocky reef is important as fish refuge habitat. Studies have shown that rock substrate areas support a more diverse and abundant demersal fish fauna than the surrounding unconsolidated sand and silt substrates. In the South Atlantic, rock substrate features vary from low-relief pavement dominated by corals, sponges, hydroids, bryozoans, and ascidians to high relief outcrops, ledges, ridges, boulder fields, and scarps dominated by sponges and gorgonian corals (Wenner et al. 1983).

Coral reefs are a specific type of hardbottom where the substrate itself is produced by living organisms (i.e., biogenic substrate). Stony corals may dominate a hardbottom habitat or be present as individual colonies within a community of sponges or macroalgae. In the Floridian region, shallow water coral reefs and coral communities occur in depths generally less than 40 m (130 ft). In some areas, reef-building corals form extensive structures and dominate the reef biota, while in other areas non-reef building corals colonize geologically derived hard substrates and may be a less dominant component of the benthic communities. Coral communities support a wide array of finfish, invertebrates, plants, and microorganisms. In deeper waters, large elongate mounds called deepwater banks, hundreds of meters in length, often support a rich fauna compared to adjacent areas, and coral mounds up to 150 m (490 ft) tall have been found on the Blake Plateau (Ross and Nizinski 2007; Fautin et al. 2010).

DATA SOURCES

Although there are large reefs in the Floridian region, much of the hardbottom habitat is small and patchy. In order to create a consistent map of hardbottom habitat across the whole South Atlantic, we compiled data from many different sources and applied analysis methods specifically developed to map areas where we were most confident that habitat was present. Below we describe the sources and types of spatially explicit hardbottom data and the methods we used to generate the final hardbottom maps. A complete list of all the datasets used in this analysis is included in Appendix 2.

POLYGON DATA SOURCES

Hardbottom polygons from the SABMA benthic hardbottom database (TNC 2013) were selected (n = 33,861) as were 201 hardbottom polygons from a recent benthic mapping effort in Florida (Walker and Gilliam 2013). Four polygons of the current Oculina Banks Habitat Area of Particular Concern (HAPC), one final polygon for the proposed Oculina Bank HAPC northern extension, and one polygon for an alternative western extension of the Oculina Bank HAPC were obtained and used to estimate the distribution of Oculina Bank hardbottom.

POINT DATA SOURCES

Chevron trap data from 1990 to 2013 from the SCDNR/NOAA Marine Resources Monitoring, Assessment and Prediction (MARMAP) Program database (Reichert 2009) were converted to point locations (n=7,885). After discussion with experts in the South Atlantic system, we reviewed the hardbottom point data from the original SEAMAP (2001) hardbottom database (n=4,466) and removed all points unless the point had been obtained from video, closed circuit TV, or the MARMAP program. In addition, MARMAP trap points for the years 1990-1996 were removed as they were duplicated in the larger 1990-2013 MARMAP dataset described above. After these refinements, the original SEAMAP hardbottom dataset was reduced from 4,466 points to 2,120 points.

Information on coldwater coral observations from seven spatially-explicit coral datasets (Fautin 2011; Woods Hole 2012; Scanlon et al. 2010; Partyka et al. 2007; Freiwald et al. 2005; Watling and Auster 2005; Skidaway Institute of Oceanography 2004) was compiled, and key fields were standardized across all the databases. All observations that contained soft substrate species, dead specimens, and incomplete species information were removed from the combined coral dataset, as were identical overlapping points. With multiple databases, there were often duplicate observations that did not spatially coincide due to slight locational coordinate differences. The distance from each point to all other points in the combined coral database was calculated and then used in a series of queries to identify likely duplicates based on species information, date, and distance. After the above processing steps, there were 1,167 hard substrate coral observations remaining from the original 3,577 points.

Each unique source for point data in the SABMA benthic hardbottom database that had not previously been in the original SEAMAP hardbottom database and was not in the coldwater coral databases described above (n=6,155) was also reviewed. Points that were based on the presence of obligate reef species rather than direct observance of hardbottom were removed from the dataset (n=219).

In addition, hardbottom points from the various usSEABED sediment datasets (n=49) were reviewed and only those that occurred on sloped seabed forms were retained (n=11). The resultant point dataset contained 5,898 points.

LINE DATA SOURCES

Trawl polylines from the SEAMAP Bottom Mapping Project database that recorded the presence of hardbottom habitat somewhere along the trawl and were less than or equal to 1.58 km in length were converted to their original start and end points using the start and stop longitude and latitude values. As the actual location of hardbottom was not captured in the dataset, we used a length threshold to avoid using very long trawls where the actual hardbottom occurrence could be a large distance from the start and/or end point. We used 1.58 km in length as this was the mean plus one standard deviation of the trawl lengths and was similar to the 1 and 2 km confidence zones used in the pavement and slope analyses described below. Any end points that overlapped with start points (i.e., a new trawl began at the end point of the previous trawl) were removed to avoid inflating the subsequent point density analysis conducted with the hardbottom points. These processing steps resulted in 3,802 trawl points for use in the hardbottom analysis.

All hardbottom points derived from the above sources were merged into one dataset containing a total of 20,872 points. A year flag was created to assign all points to one of the following three classes: 1) no date information (n=1,509), 2) historic data from the 1800s to the 1950s (n=40), and 3) current data from 1960 to present (n=19,323). Finally, as experts noted that commercially-identified hardbottom points beyond the shelf slope break often capture deepwater canyon features, we flagged all points from commercial data sources (n=2,584) with a value of 1 in the “COMM_PT” field.

MAPPING METHODS

We mapped four categories of hardbottom based on location and degree of relief. In reality, these types intergrade and their associated biota overlaps considerably.

- **Hardbottom Slope:** High relief rock or hard substrate associated with ledges and slopes, excluding the upper continental shelf edge
- **Hardbottom Upper Shelf Edge:** High relief rock or hard substrate associated with the upper portion of the steep continental shelf edge to a depth of -100 m

- **Hardbottom Pavement:** Low relief hard substrate composed of consolidated carbonate sands and coral rubble often encrusted with coralline algae and small coral colonies

- **Patchy Hardbottom (corals, sponges and/or rock):** Patches of low relief pavement-like hardbottom composed of sandstone or consolidated carbonate sands with sponges and soft corals. The mapped areas are regions with high concentrations of patchy hardbottom. Small isolated hardbottom patches are not shown.

HARDBOTTOM SLOPE

This analysis identified likely rock substrate habitat underlying high relief features such as ledges and scarps. First, all sloping seabed forms (e.g., slope, scarp, and ledge) were selected from the 90 m grid of seabed topographic forms previously described. The cells from all the selected seabed forms that were immediately adjacent or diagonal to each other were grouped together to create contiguous sloping seabed forms. The blocks of seabed forms were then converted to polygons and individual seabed forms that were within 500 m of a hardbottom point location were selected (n = 1,119). The selected seabed forms were often long linear ridges that extended far beyond the known hardbottom occurrences. To distinguish the areas where we had high confidence that hardbottom was present we created confidence zones based on the hardbottom point data. A "high confidence" zone was created by selecting the portion of a sloping seabed form within 1 km of a known hardbottom point. Next, a "probable" hardbottom zone was created by selecting the portion of each seabed form greater than 1 km and less than or equal to 2 km from a hardbottom point occurrence. The minimum and maximum year of the point data used to derive the confidence zones was spatially assigned to each hardbottom slope polygon when date information was available. We designated all sloping seabed form areas greater than 2 km from a confirmed hardbottom occurrence as "potential" hardbottom habitat, and we designated all slope forms that were not within 500 m of a hardbottom point as "possible" hardbottom slopes. For all slope forms, the underlying classification (e.g., oceanic mid scarp, shelf mid scarp, etc.) was retained and is available in the final dataset. *Only the **high confidence** and **probable confidence** areas are shown in the maps and used in the substrate and ecological marine unit synthesis.*

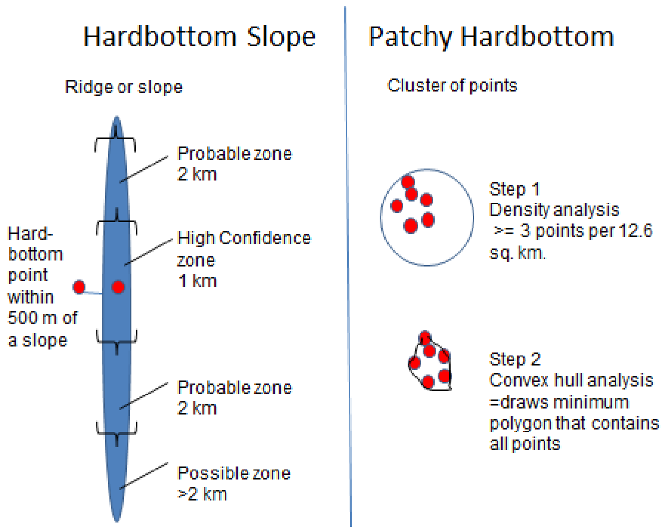


Figure 3.23. Diagram of hardbottom mapping methods. The diagram illustrates the method for determining high confidence and probable zones for hardbottom slopes and high density areas for patchy hardbottom.

HARDBOTTOM UPPER SHELF EDGE

Fish community data from deep shelf-edge hardbottom are limited but include at least 117 species (Quattrini and Ross 2006). The Continental Shelf forms an almost continuous feature and consequently the shelf polygon was represented as a long continuous polygon that ran the full extent of the project area. We processed this large formation separately from the other slopes using the following steps. Bathymetry data was used to divide the shelf into two depth zones. The first zone, referred to as the upper slope, constitutes the portion of the shelf with depth values shallower than -100 m and is the zone of the shelf most likely to have hardbottom habitat. The second zone is the lower slope and occurs at depths of -100 m and deeper. For those portions of the upper shelf for which confirmed hardbottom point data existed, confidence zones were created using the same approach as previously described for the seabed slope analysis. The confidence zones were defined for both the lower and upper slope segments of the outer shelf; however only the upper slope areas are included here (lower slope areas were classified as "hardbottom slopes"). When temporal data were available, the minimum and maximum year of the point data used to derive the confidence zones was attributed to the combined depth and confidence zone polygons. The seabed form types that comprise the upper shelf were retained and are available in the final dataset. *Only the **high confidence** and **probable confidence** areas are shown in the maps and used in the substrate and ecological marine unit synthesis.*

PATCHY HARDBOTTOM (CORALS, SPONGES AND/OR ROCK

Patches of low relief pavement-like hardbottom composed of sandstone or consolidated carbonate sands occur throughout the region; our goal was to map areas with high concentrations of these features. In the Floridian ecoregion, patchy hardbottom was mapped directly and we obtained polygons from Florida Marine Research Institute (FMRI 2000) showing its distribution. Outside of the Floridian region we estimated the extent and shape of patchy hardbottom concentrations using a density analysis applied to the individual hardbottom points (Figure 3.23). To delineate concentrations of patchy hardbottom, we conducted point density analyses using all the hardbottom points collected since 1960 that were not within 500 m of the selected high relief seabed forms used for mapping hardbottom slopes (n = 13,454). In the analysis, density was calculated for all points in a circle with a 1 km radius around each 90 m grid cell. The gridded output was then classified into high density areas by selecting all cells with at least three points in the 3.14 km^2 circular neighborhood. That is, all cells with a density value greater than or equal to 0.96 were selected and coded as high density hardbottom areas. Our assumption was that we could have high confidence that actual hardbottom exists in areas where three confirmed points occurred in close proximity. The high density/high confidence point density areas were converted to polygons with unique identification numbers. A spatial analysis was conducted to assign the hardbottom points to the density polygons with which they intersected. The hardbottom points thus each had a value to identify to which density polygon they belonged. Next, a convex hull was used to generate the minimum bounding polygon for hardbottom points with the same polygon density ID value. For convex hulls with only two or fewer points or with multiple points that closely overlapped, the resultant minimum bounding area was a narrow line that we subsequently buffered by 150 m in an attempt to create a more ecologically meaningful boundary. For all the patchy hardbottom areas, the minimum and maximum year of the point data used to derive the boundaries (when information was available) was attributed to the polygons. The final dataset had a total of 353 high density/high confidence patchy hardbottom areas with an average area of 223 ha. We performed a second analysis to identify larger "probable" areas; a 2 km radius was used to define the circular neighborhood but *only the **high density/high confidence** areas are shown in the maps and used in the substrate and ecological marine unit synthesis.*

Hardbottom Pavement

Low relief hard "pavement" composed of consolidated carbonate sands and coral rubble is found in the Florida Keys behind fringing or barrier reefs. The extensive consolidated substrate is often encrusted with coralline algae and small coral colonies, and is quite different than patchy flat pavement-like hardbottom off the Carolinas and Georgia. In the Floridian subregion we used polygon data provided by the Fish and Wildlife Research Institute (FMRI 2000) to map the hardbottom pavement. The data also contained information as to whether the pavement was colonized or uncolonized.

ISOLATED HARDBOTTOM (NOT SHOWN)

All rock substrate points that were not used in the slope, upper shelf, or patchy hardbottom analyses (n = 896) were buffered by 150 m and defined as isolated hardbottom occurrences. These isolated points are not included in the dataset or shown on the maps because we did not have high confidence that they represent actual hardbottom locations.

CORAL REEFS

Shallow water coral reefs exist in the Floridian subregion where stony corals form reef structures. Offshore reefs reflect an assemblage of hard corals, soft corals, and sponges that is relatively consistent along Southeast Florida (Blair and Flynn 1989). Coral reefs tend to have clear ecological zonation. They are concentrated in southeast Florida where the distribution pattern between Cape Canaveral and Key Biscayne consists of an inner reef in approximately 4 to 8 m of water, a middle patch reef zone in about 9 to 15 m of water, and an outer reef in approximately 18 to 30 m of water (Duane and Meisburger 1969; Goldberg 1973; Courtenay et al. 1974; Lighty et al. 1978; Jaap 1984). These reef zones are separated by areas of sand or sand and rubble. A unique deep/cold-water coral reef system, the Oculina Bank, occurs off the Central Florida coast. This diverse deepwater ecosystem is dominated by the ivory tree coral, *Oculina varicosa*, which thrives in cooler waters. Found as deep as 100 m on the shelf edge, the corals form thickets of white branches that are home to hundreds of different kinds of invertebrates and provide essential habitat for many commercial fish species. *Oculina* occurs elsewhere in the region but not to the extent and abundance that it does in this unique area. *Lophelia* reefs occur in deep water zones (> 1000 m) east of the shelf-slope break in the Carolinian subregion, but the locations of these reefs are not mapped.

Coral reefs intergrade with rock substrate which, when colonized, can have coral reef biota as a less dominant component of diverse benthic assemblages. When non-reef building corals are dominant on rock substrate they form the hardbottom slopes of rocky ledges or the patchy hardbottom described above for low relief areas. In each case, species composition may vary depending on water depth and associated parameters (light, temperature, etc.) and geography.

To map coral reefs, we obtained a comprehensive set of polygons of coral reefs, rock substrate, and related features from several recent benthic mapping efforts in Florida (FMRI 2000; Walker 2012; Walker and Gilliam 2013). The various sources used slightly different classification systems and we aggregated all polygons into several broad types following the recommendations of the Florida

System for Classifying Estuarine and Marine Environments (SCHEME; Madley et al. 2002) while retaining the original attributes. The following scheme was used to simplify the many attributes associated with the coral reef polygons across all the sources:

- **Platform Reef**: reef consisting of hardened substrate of unspecified relief formed by the deposition of calcium carbonate by reef-building corals. This group includes coral reef and colonized rock substrate, linear reef, reef terrace, spur and groove reef, nearshore reef, offshore reef, and associated remnants and reef rubble.
- **Patch Reef**: irregularly distributed clusters of corals and associated biota along the coast of the Florida Keys. This class includes aggregated patch reef, aggregate reef, and individual patch reef.
- **Oculina Bank**: deeper water reefs off the Florida coast dominated by *Oculina varicosa*.
- **Hardbottom Pavement**: low relief solid carbonate rock, colonized or uncolonized by organisms. Colonized occurrences have macroalgae, hard coral, gorgonians and other sessile invertebrates, often dense enough to obscure the substrate.

In the final processing step, all the data types and results from the various data sources were merged to create a shapefile of hardbottom and reef substrate areas in the study area. Although hardbottom types may overlap and are typically covered with a thin veneer of soft substrate such as sand or mud, we mapped the final classes giving precedence to reefs over hardbottom, and hardbottom over soft sediment. The final maps show seven classes with the last four found only in the Floridian subregion:

- **Hardbottom Slope:** High relief hardbottom associated with ledges and slopes
- **Hardbottom Upper Shelf Edge:** High relief hardbottom associated with the upper shelf edge to -100 m
- **Patchy Hardbottom (corals, sponges and/or rock):** Concentrations of patchy low relief pavement-like hardbottom composed of sandstone or consolidated carbonate sands with sponges and soft corals.
- **Hardbottom Pavement:** Low relief hard substrate composed of consolidated carbonate sands
- **Platform Reef:** reef structures composed of coral forming organisms
- **Patch Reef:** irregularly distributed clusters of corals
- **Oculina Bank:** reefs dominated by *Oculina varicosa*

Related attributes in the dataset not included in the maps include: isolated hardbottom, possible and potential hardbottom slope, and potential patchy hardbottom. Results for the region and subregions are shown in Figures 3.24-3.27 and were then integrated with the soft sediment maps giving precedence to hardbottom over soft sediments (Figures 3.28-3.31).

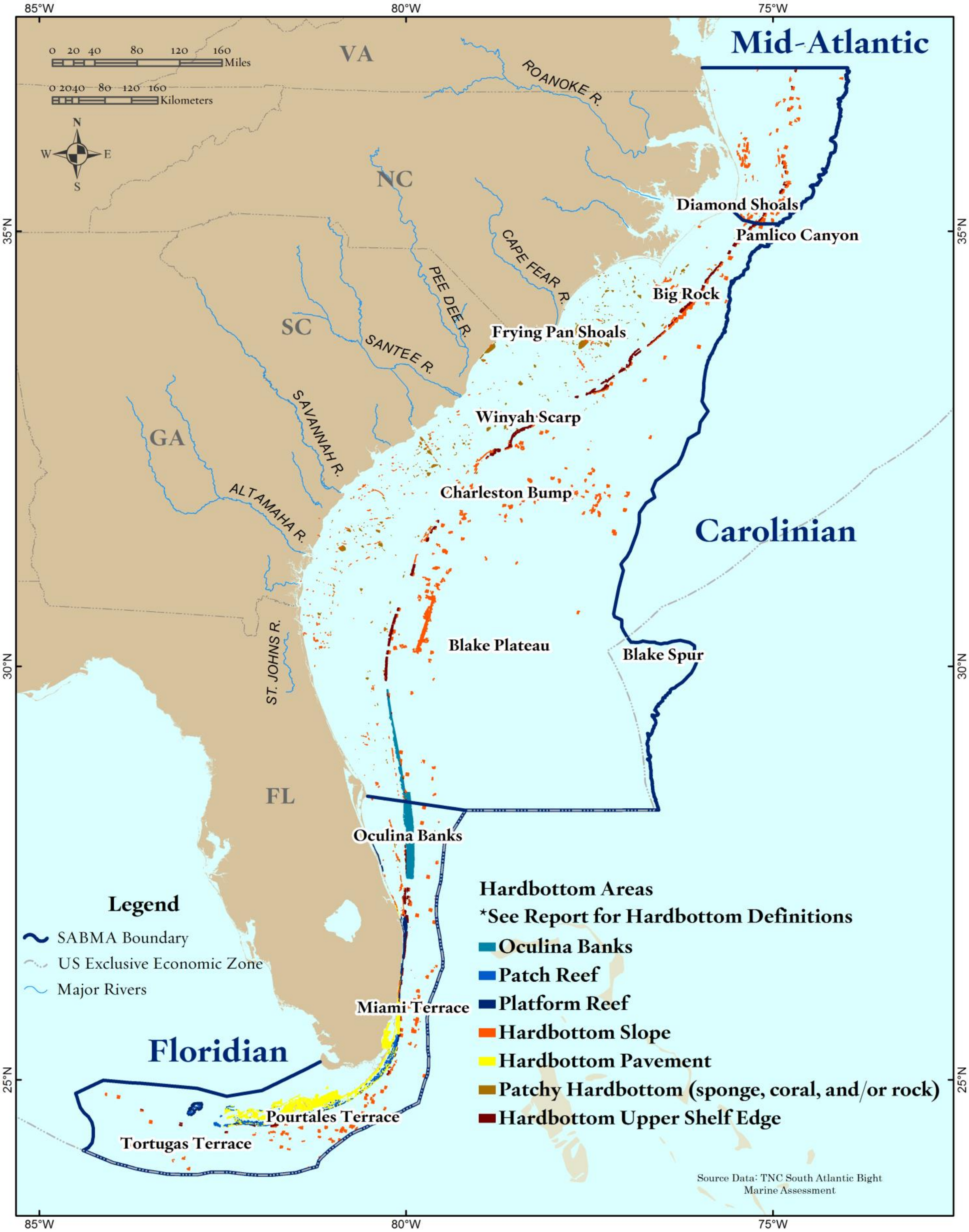


Figure 3.24. Hardbottom in the South Atlantic Bight. The map shows the hardbottom and reef locations. See subregional maps on the following pages.

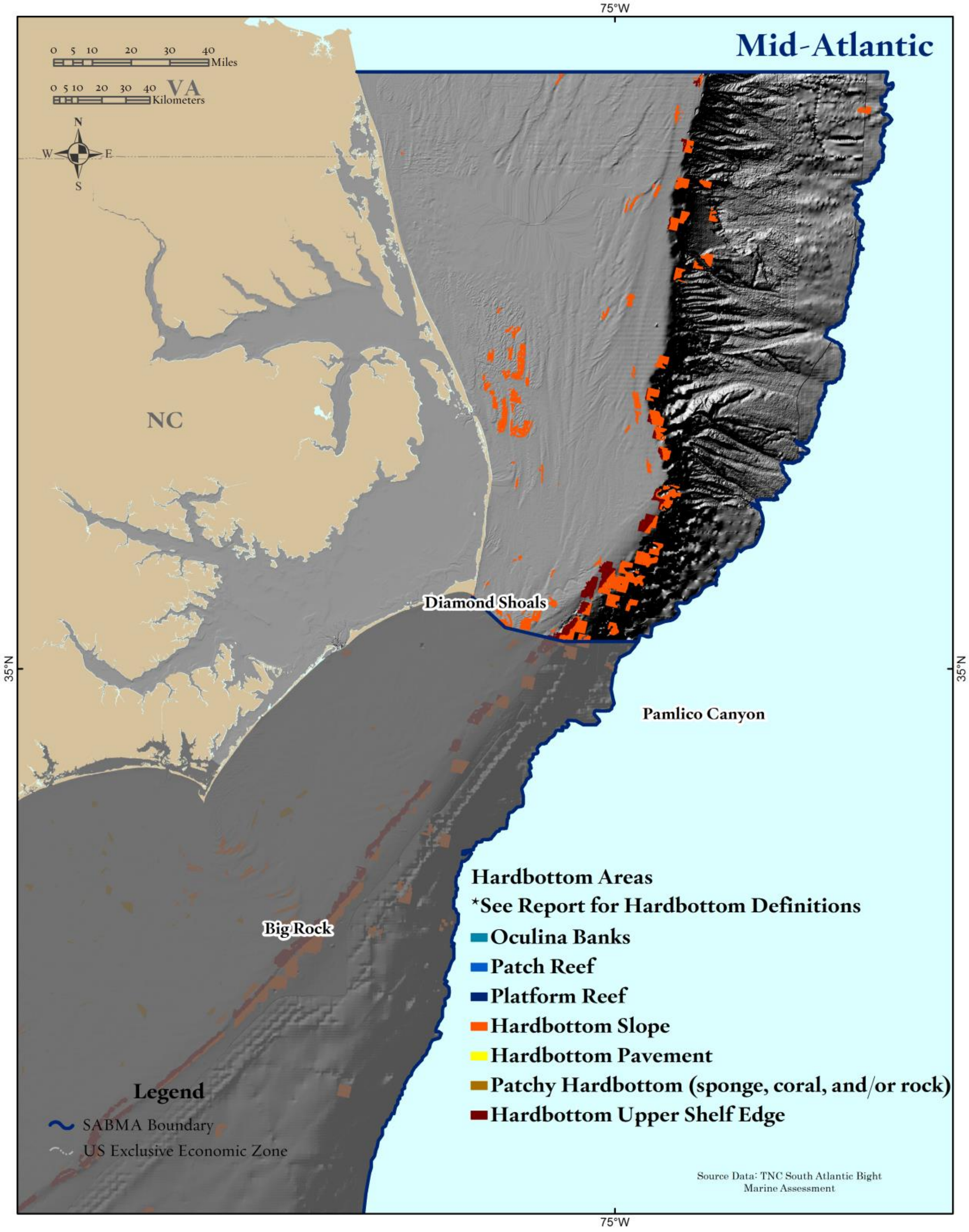


Figure 3.25. Hardbottom areas in the mid-Atlantic subregion. The map shows the location of hardbottom and corals over a hillshade map.

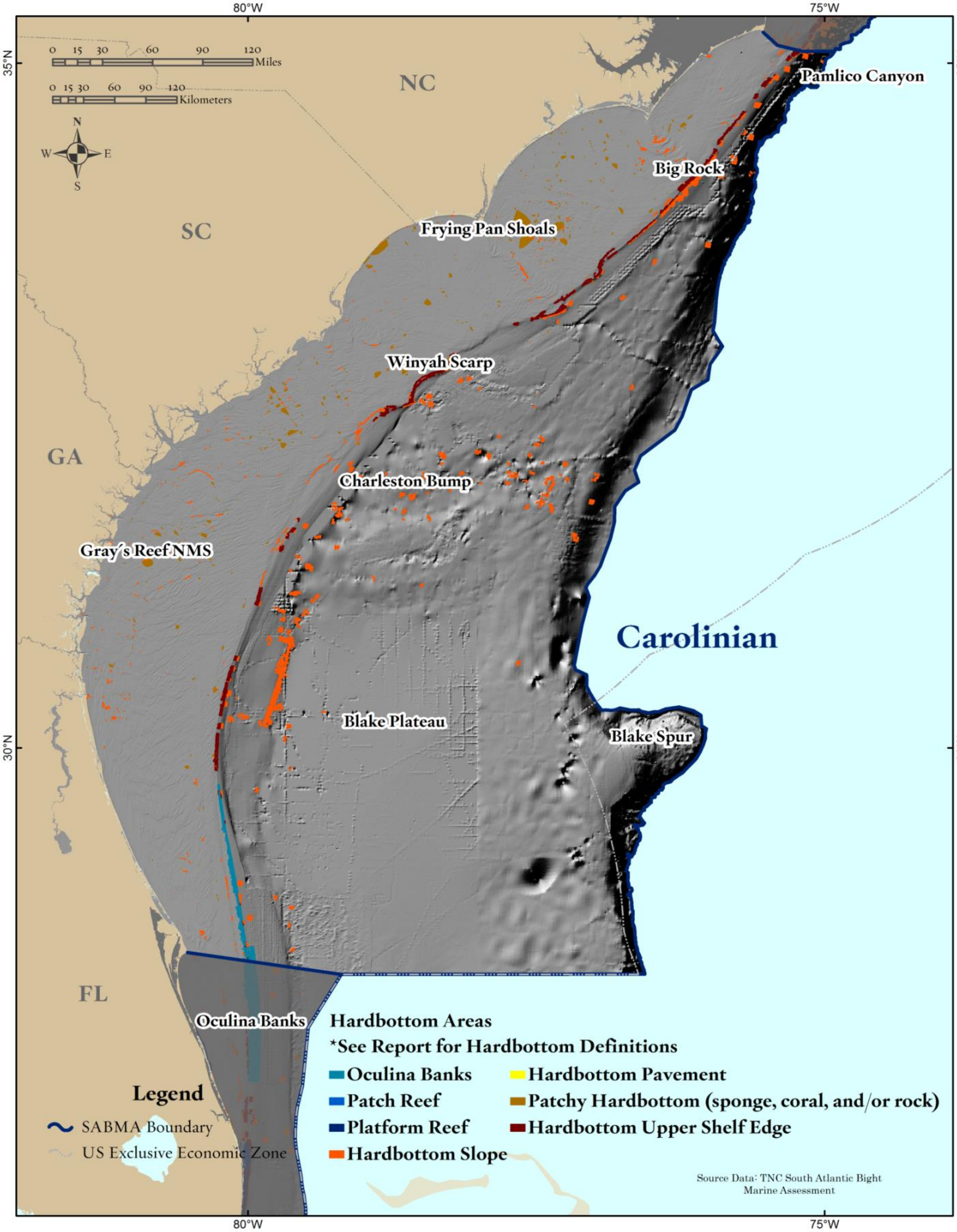


Figure 3.26. Hardbottom areas in the Carolinian subregion overlaid on a hillshade map. The map shows the location of hardbottom and corals over a hillshade map.

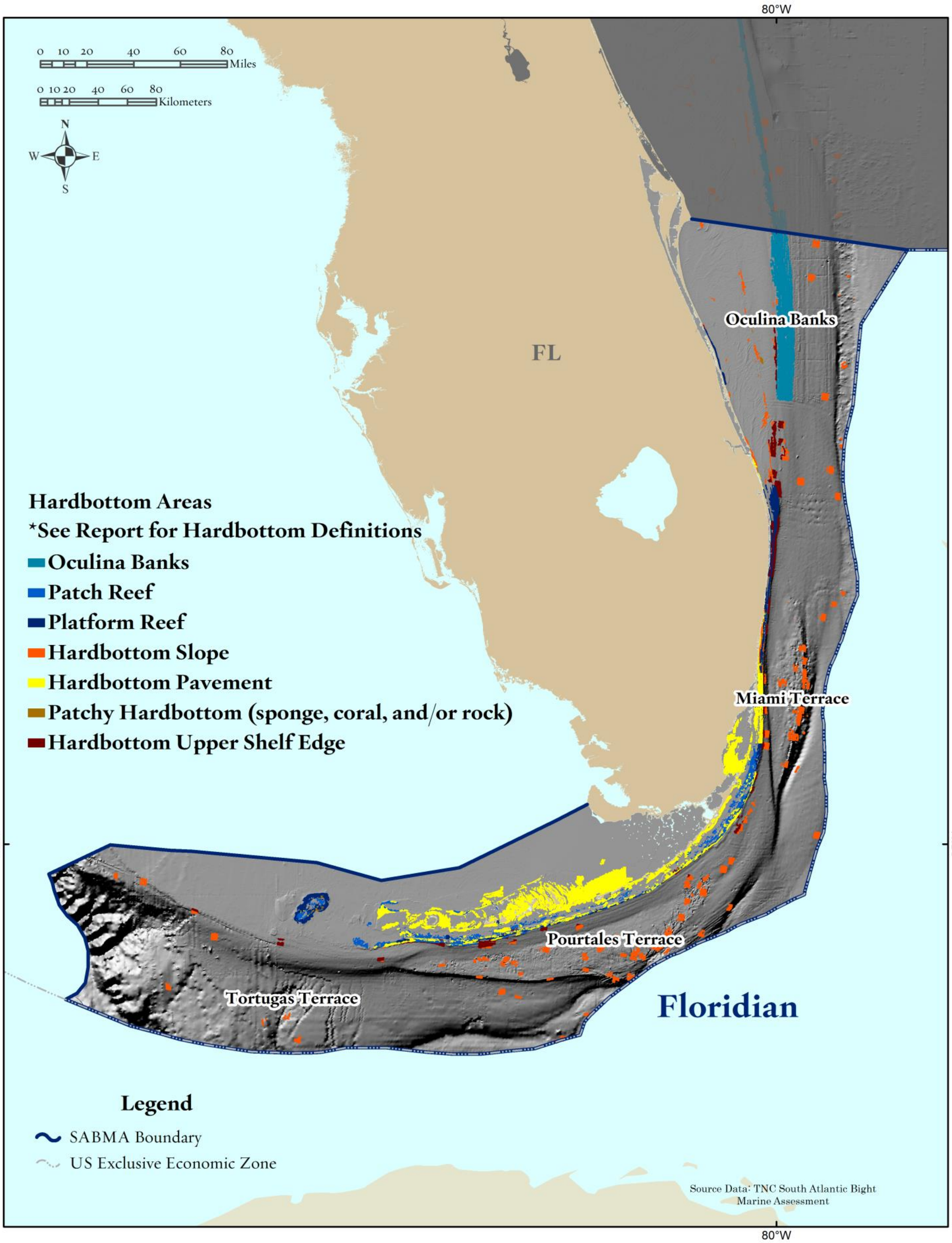


Figure 3.27. Hardbottom areas in the Floridian subregion. The map shows hardbottom and reef types on top of a hillshade map.

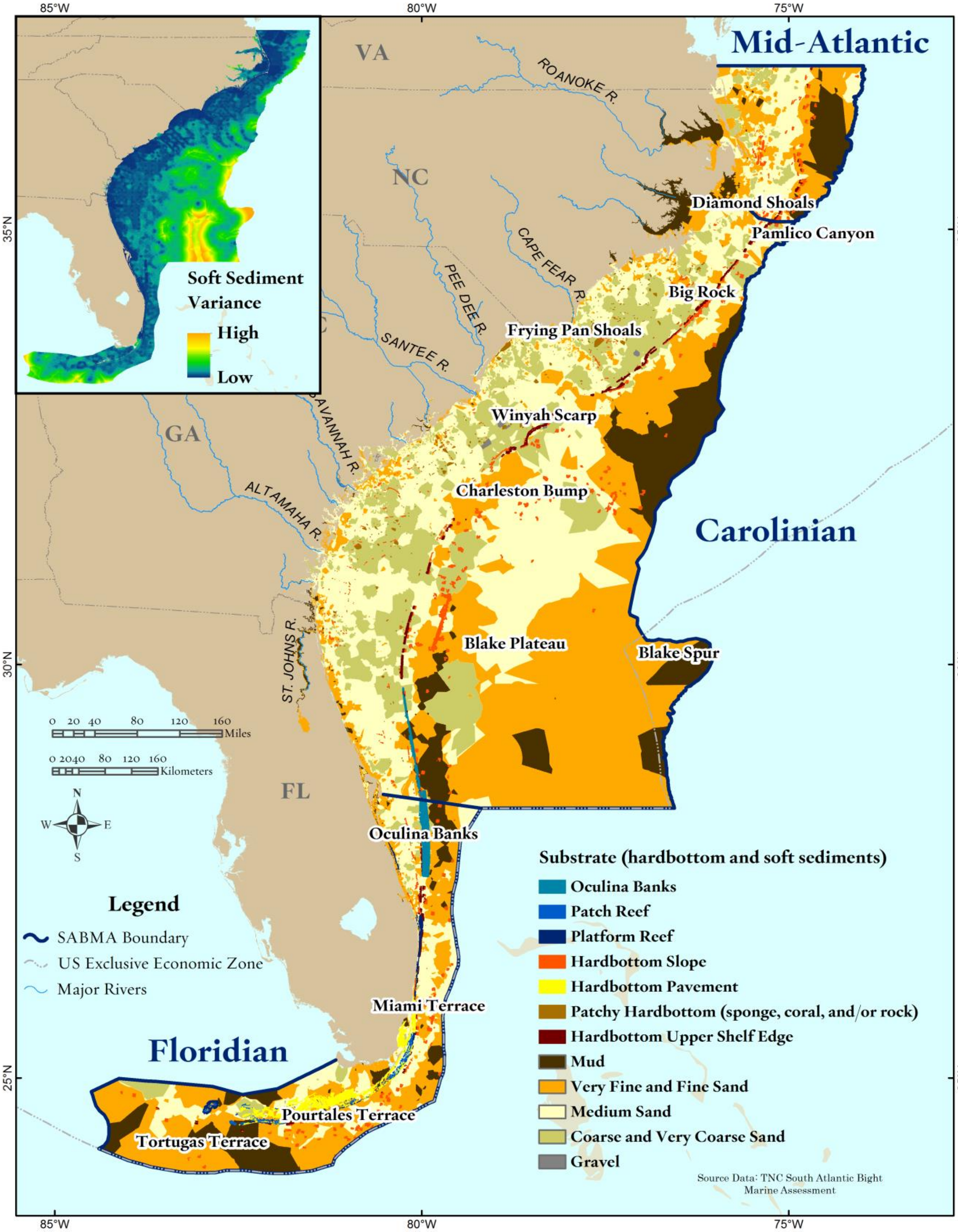


Figure 3.28. Integrated hardbottom and soft sediment substrate in the South Atlantic Bight. See subregional maps on the following pages.

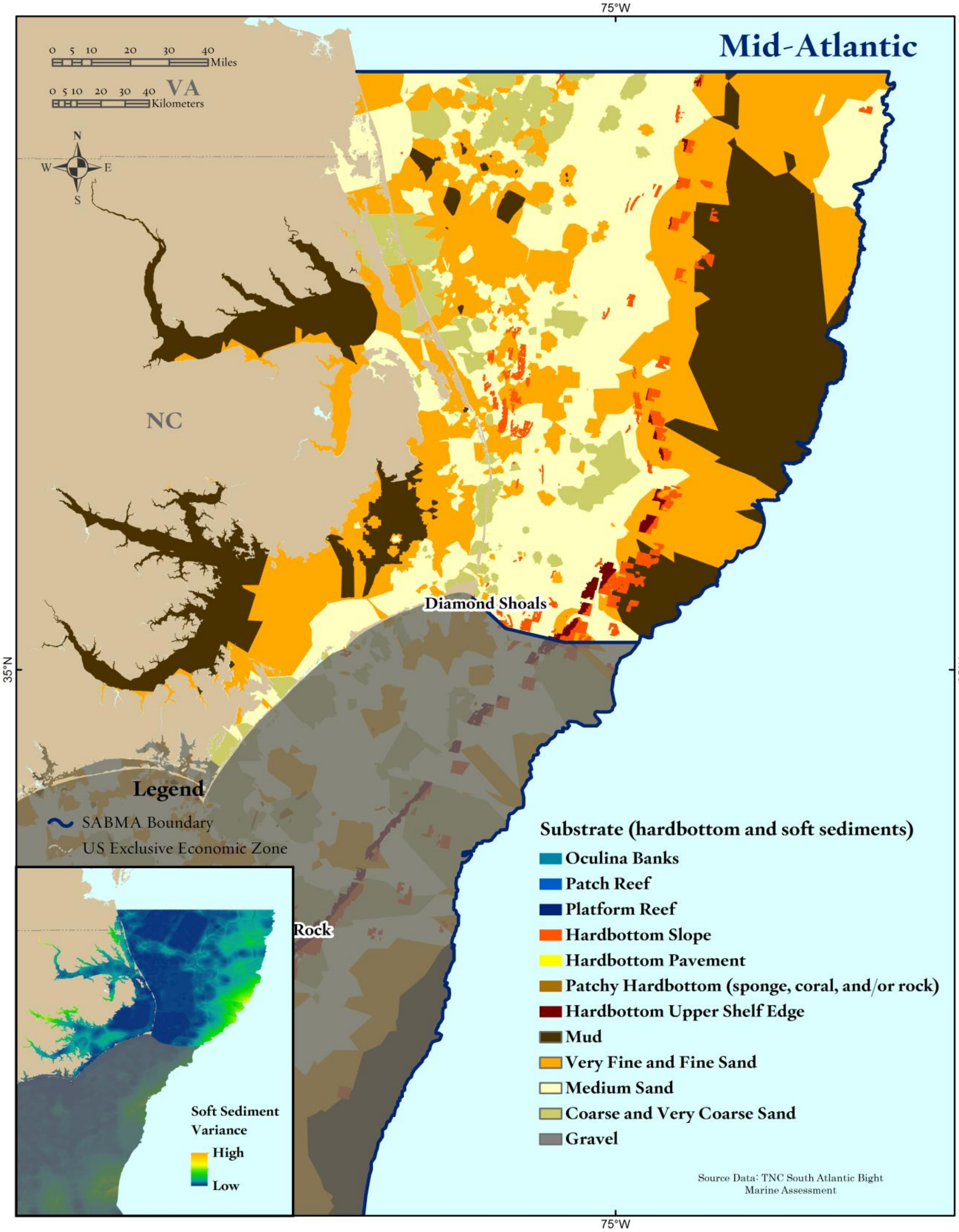


Figure 3.29. Integrated hardbottom and soft sediment substrate in the mid-Atlantic subregion

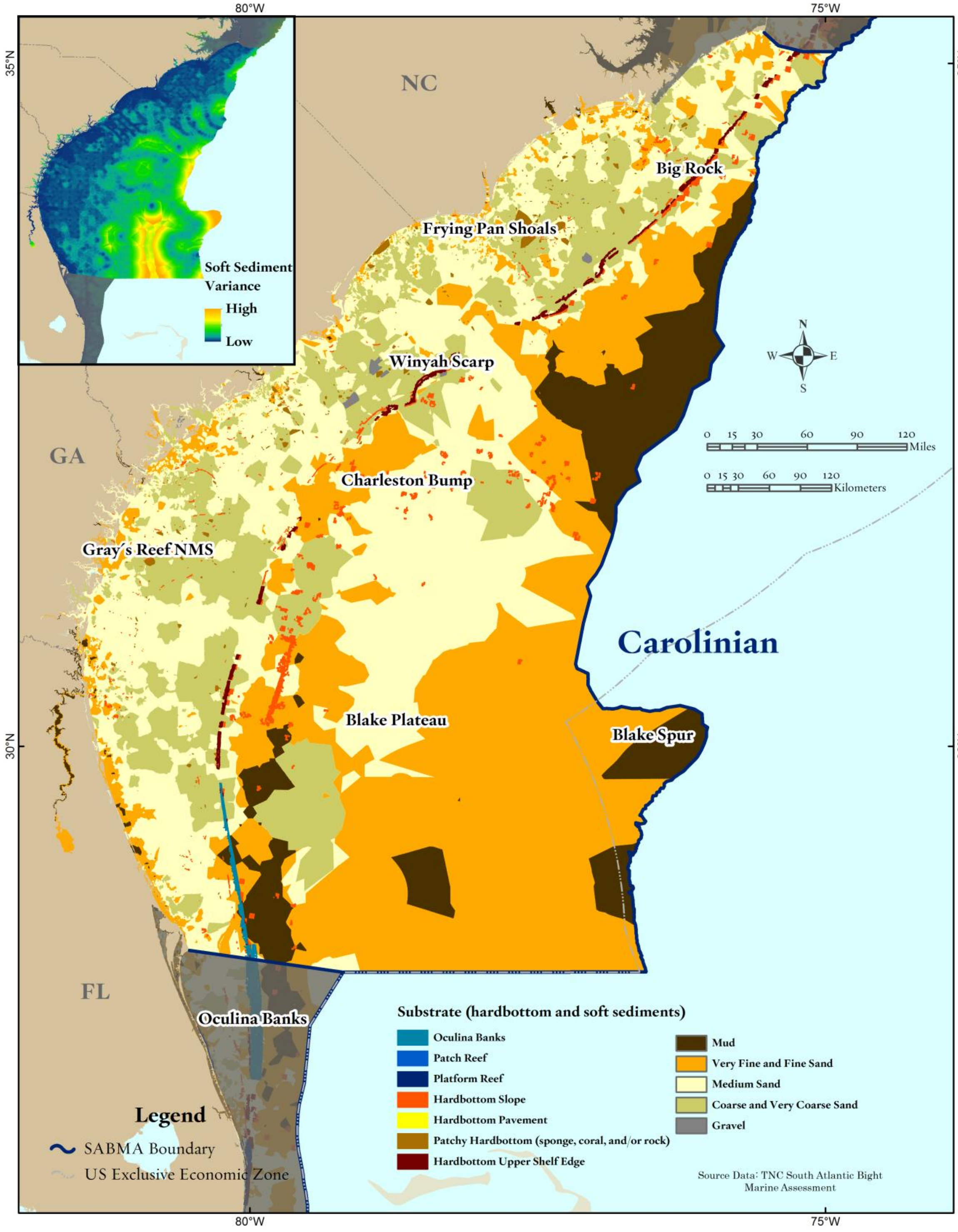


Figure 3.30. Integrated hardbottom and soft sediment substrate map in the Carolinian subregion

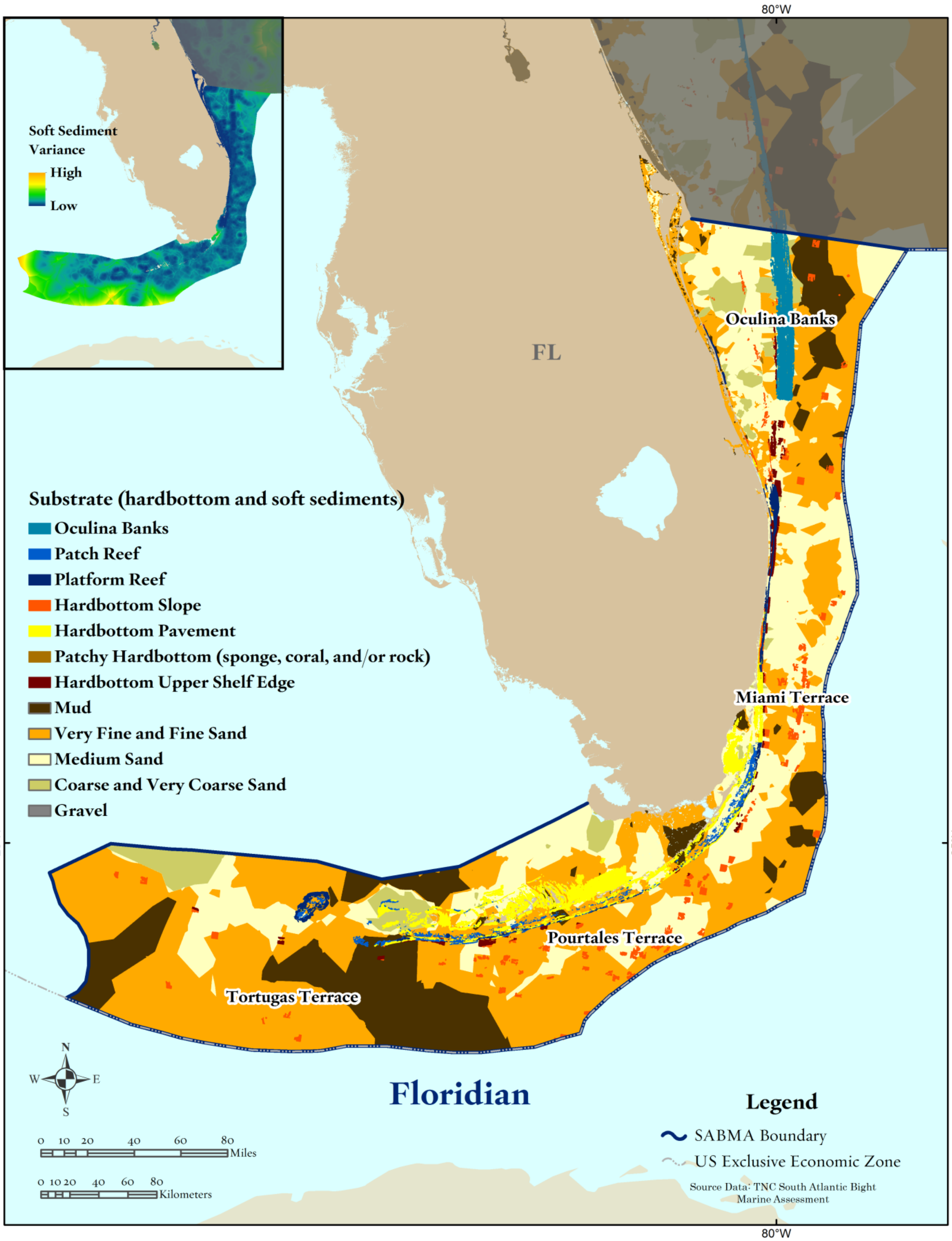


Figure 3.31. Integrated hardbottom and soft sediment substrate map in the Floridian subregion

Ecological Marine Units

We combined and integrated the bathymetry, seabed forms, and substrate information into a single map and data layer that we termed Ecological Marine Units (EMUs). The EMUs represent the physical structure of the South Atlantic Bight which can be used to approximate the distribution of benthic habitats. To create the EMUs, each cell was given a code based on all of its properties determined from the previous analyses. The coding scheme used 1000s for depth, 100s for substrate, and 10s for seabed form (Table 3.9). For example: 1113 = Infralittoral mud depression and 4621 = Mesobenthic hardbottom upper slope.

Table 3.9. Ecological Marine Units: components and codes. DCode = depth code, SCode = substrate code, and SBCode = seabed form code

D Code	Depth Zone	S Code	Substrate Class	SB Code	Seabed Form
1000	Infralittoral (0-30 m)	100	Mud	10	upper flat
2000	Shallow Circalittoral (30-70 m)	200	Fine Sand	11	mid flat
3000	Deep Circalittoral (70-200 m)	300	Medium Sand	12	low flat
4000	Shallow Mesobenthic (200-600 m)	400	Coarse Sand	13	depression
5000	Deep Mesobenthic (600-1000 m)	500	Gravel	21	upper slope
6000	Bathybenthic/Abyssal (1000+ m)	600	Hardbottom Slope	22	mid slope
		700	Hardbottom Upper Shelf	23	low slope
		800	Hardbottom Pavement	24	slope bottom
		900	Reef	25	mid gentle-slope
		000	Patchy Hardbottom	31	upper scarp
				32	mid scarp
				33	low scarp
				41	upper ledge
				42	mid ledge
				43	canyon bottom
				50	platform reef
				60	patch reef
				80	Oculina bank

The combined EMUs are displayed on the maps using color changes to represent changes in bathymetry zones, with blues for the Continental Shelf (infralittoral, circalittoral) and browns for the oceanic zone (mesobenthic, bathybenthic). Within each zone, low position seabed forms are darker in color and high position forms are lighter. Slopes are uniformly shown as green and scarps as red. Hardbottom is shown in orange or orange-brown, and reefs are in purples. The first set of maps (Depth and Seabed form from EMUs) shows only the depth zone, seabed forms and hardbottom for the region and the three subregions (Figures 3.32–3.36). The second set of maps (the complete EMUs) is similar but has an overlay showing mud, coarse sand and gravel areas. Areas with no overlay are composed of fine to medium sand (Figures 3.37-3.40).

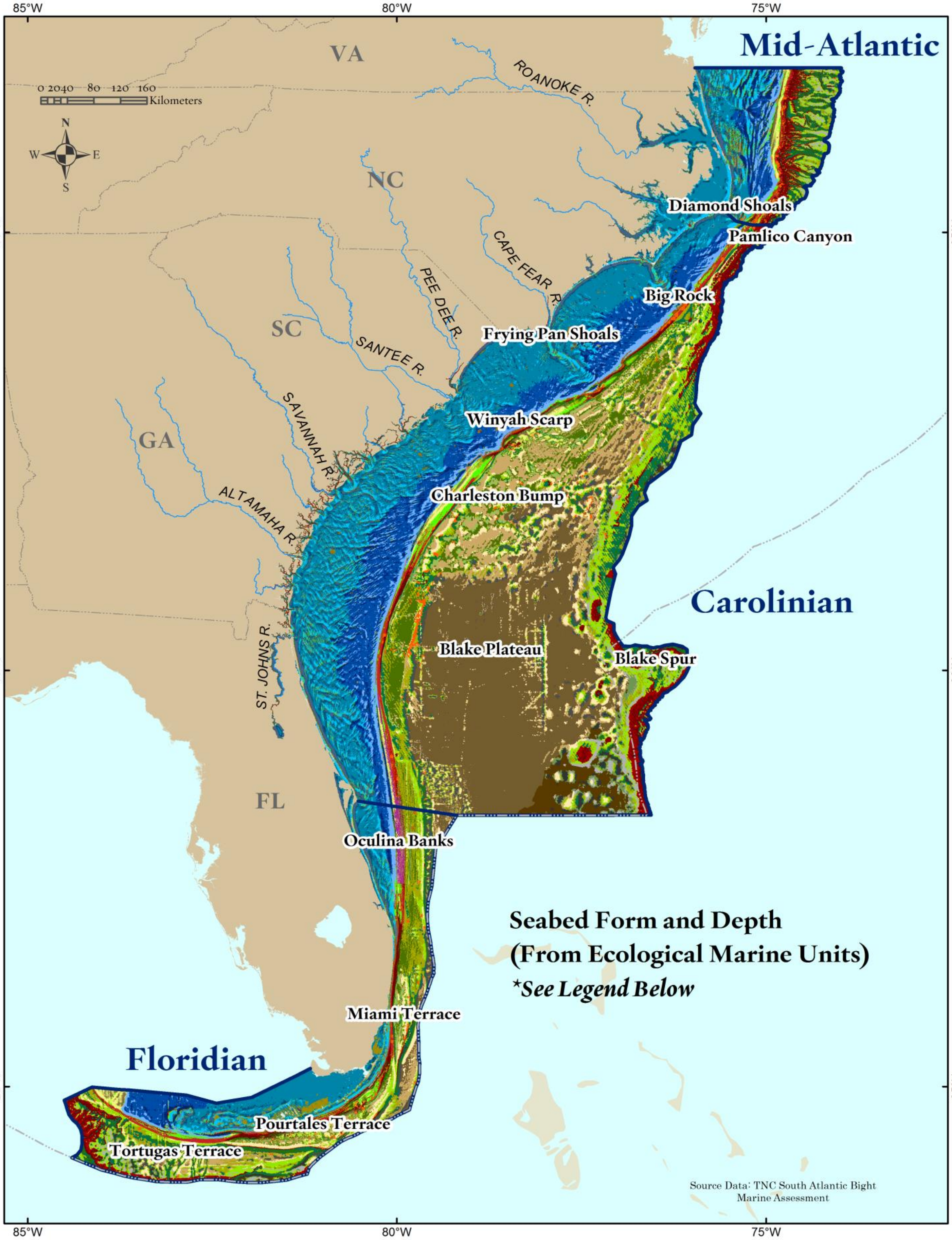


Figure 3.32. Seabed form and depth (from Ecological Marine Units) of the South Atlantic Bight: depth zones, seabed forms and hardbottom

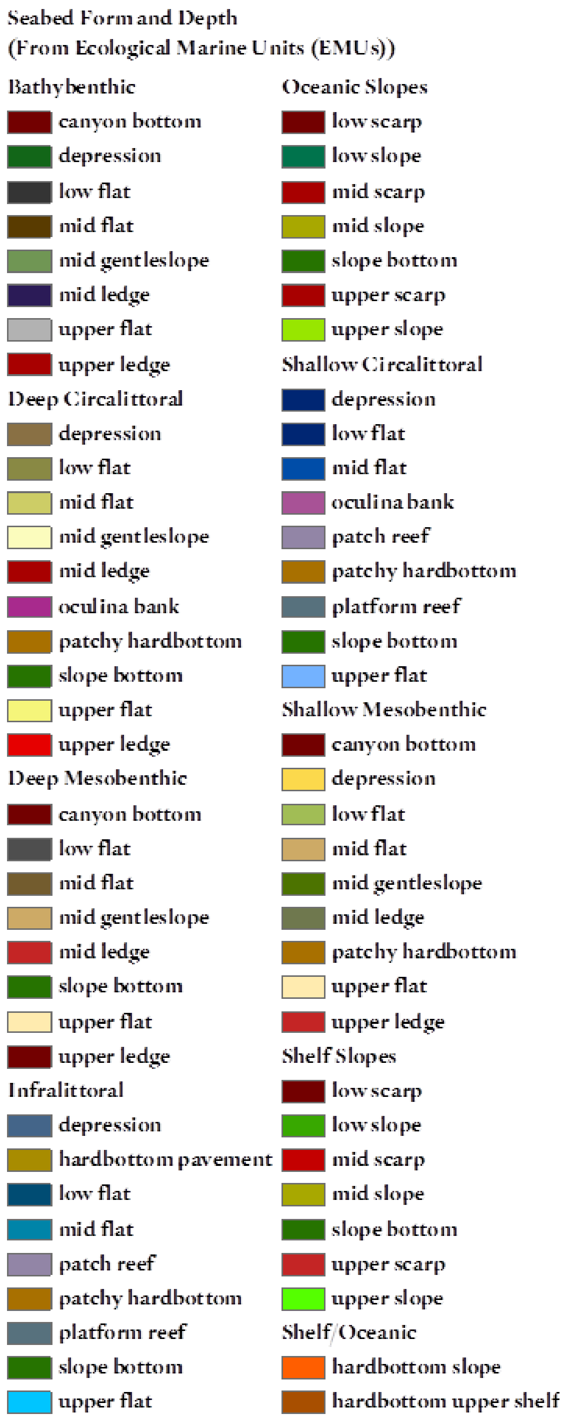


Figure 3.33. Legend for seabed form and depth (from Ecological Marine Units): seabed forms and hardbottom organized within depth zones

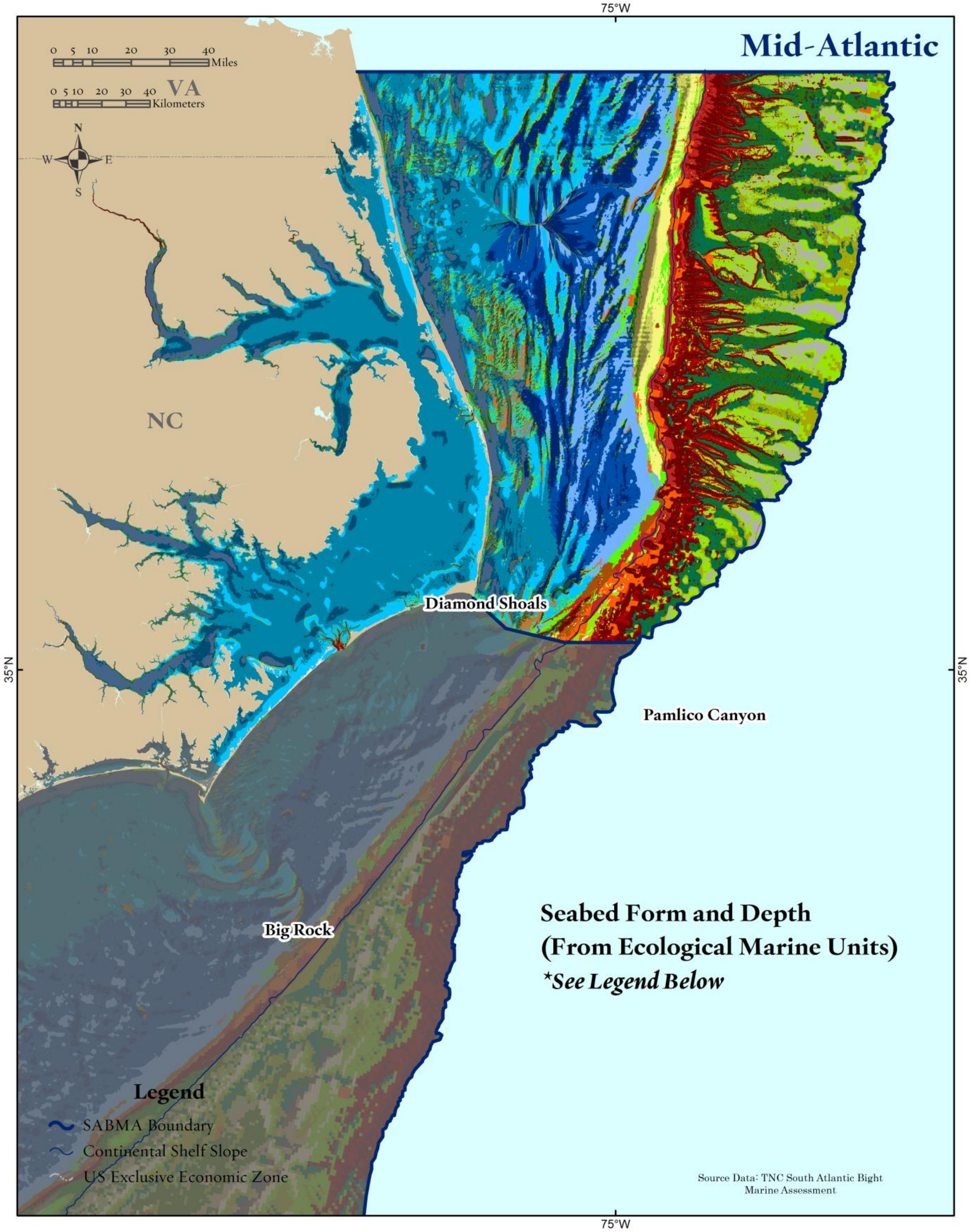


Figure 3.34. Seabed form and depth (from Ecological Marine Units) of the mid-Atlantic subregion: depth zones, seabed forms and hardbottom

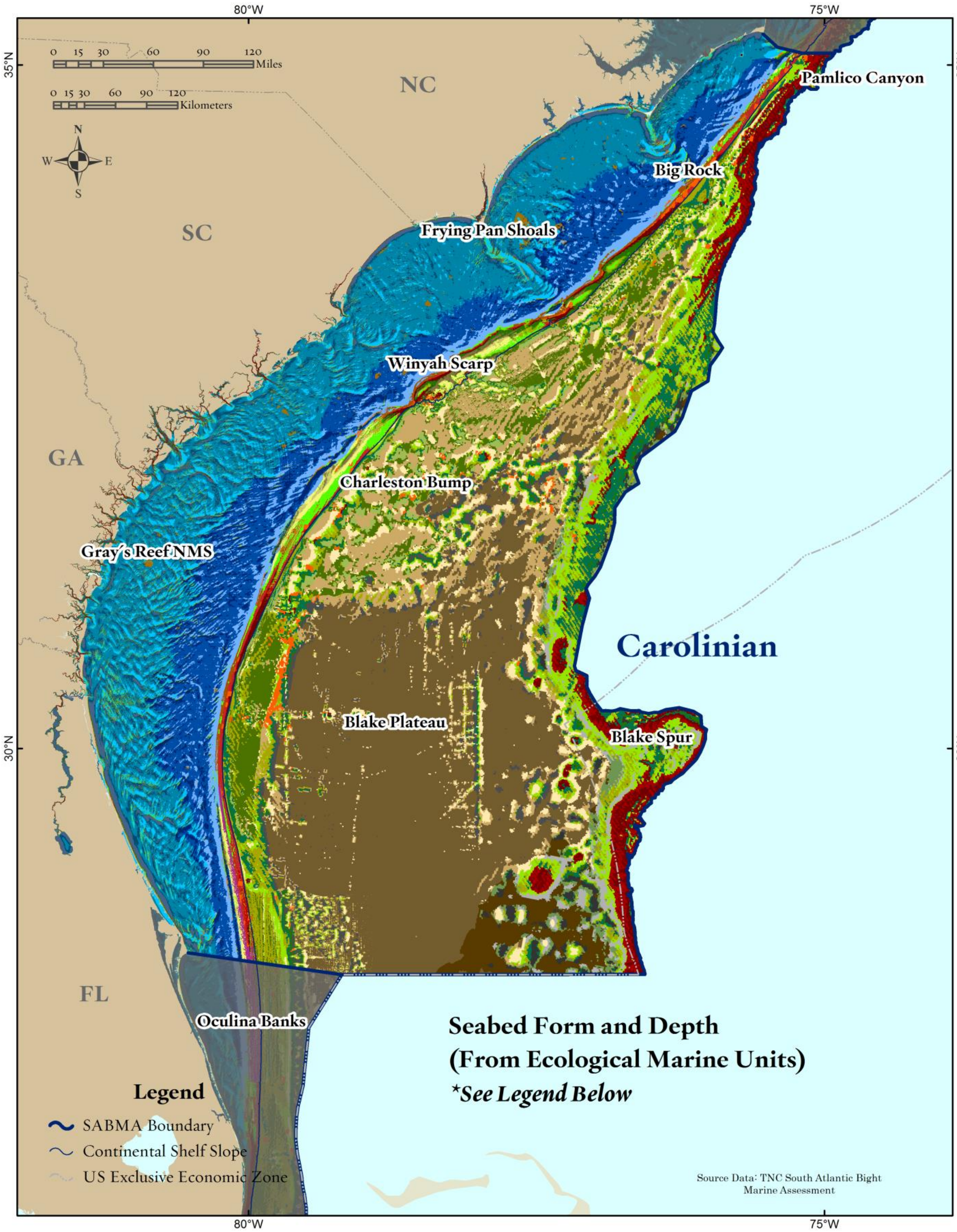


Figure 3.35. Seabed form and depth (from Ecological Marine Units of the Carolinian subregion: depth zones, seabed forms and hardbottom

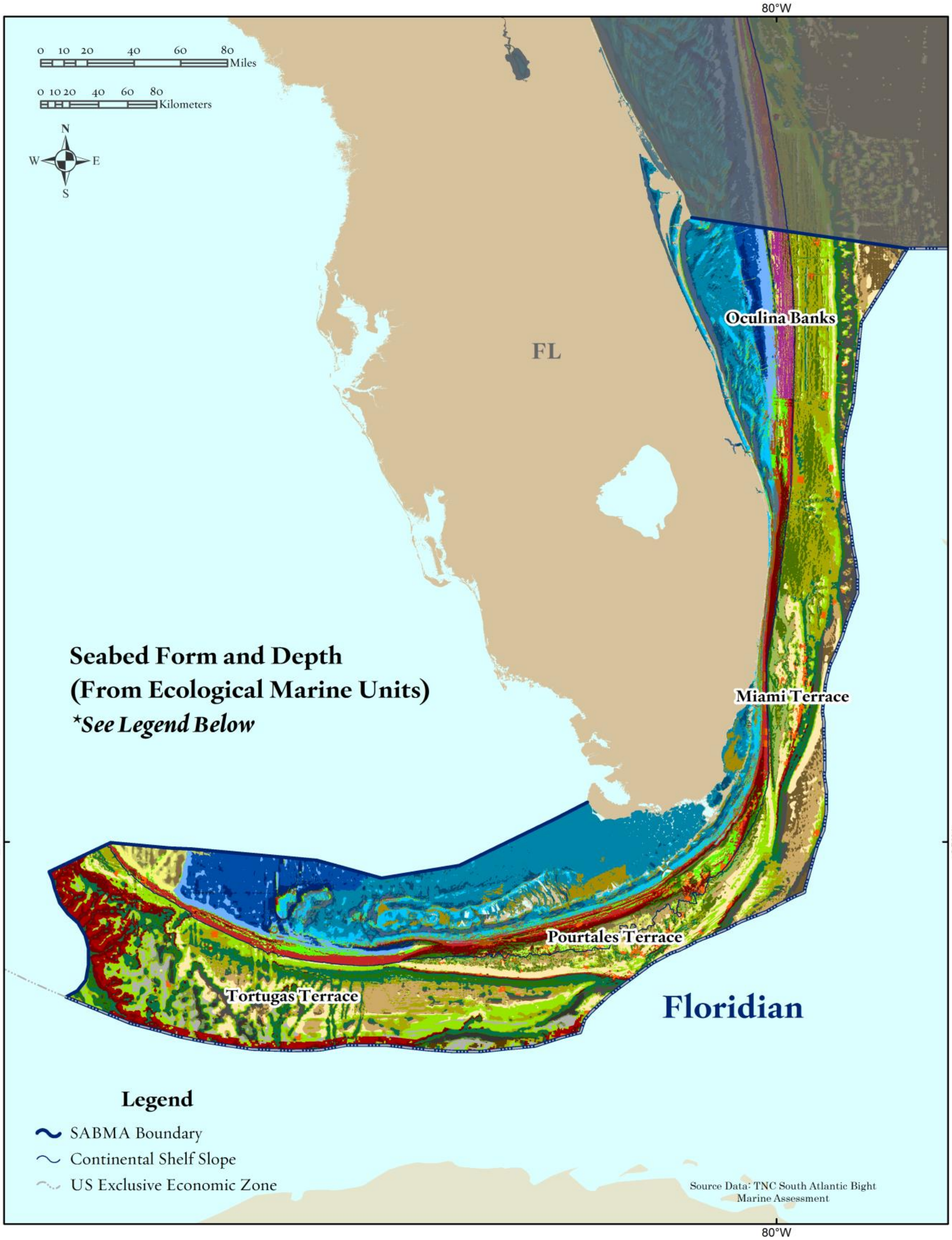


Figure 3.36. Seabed form and depth (from Ecological Marine Units of the Floridian subregion: depth zones, seabed forms and hardbottom

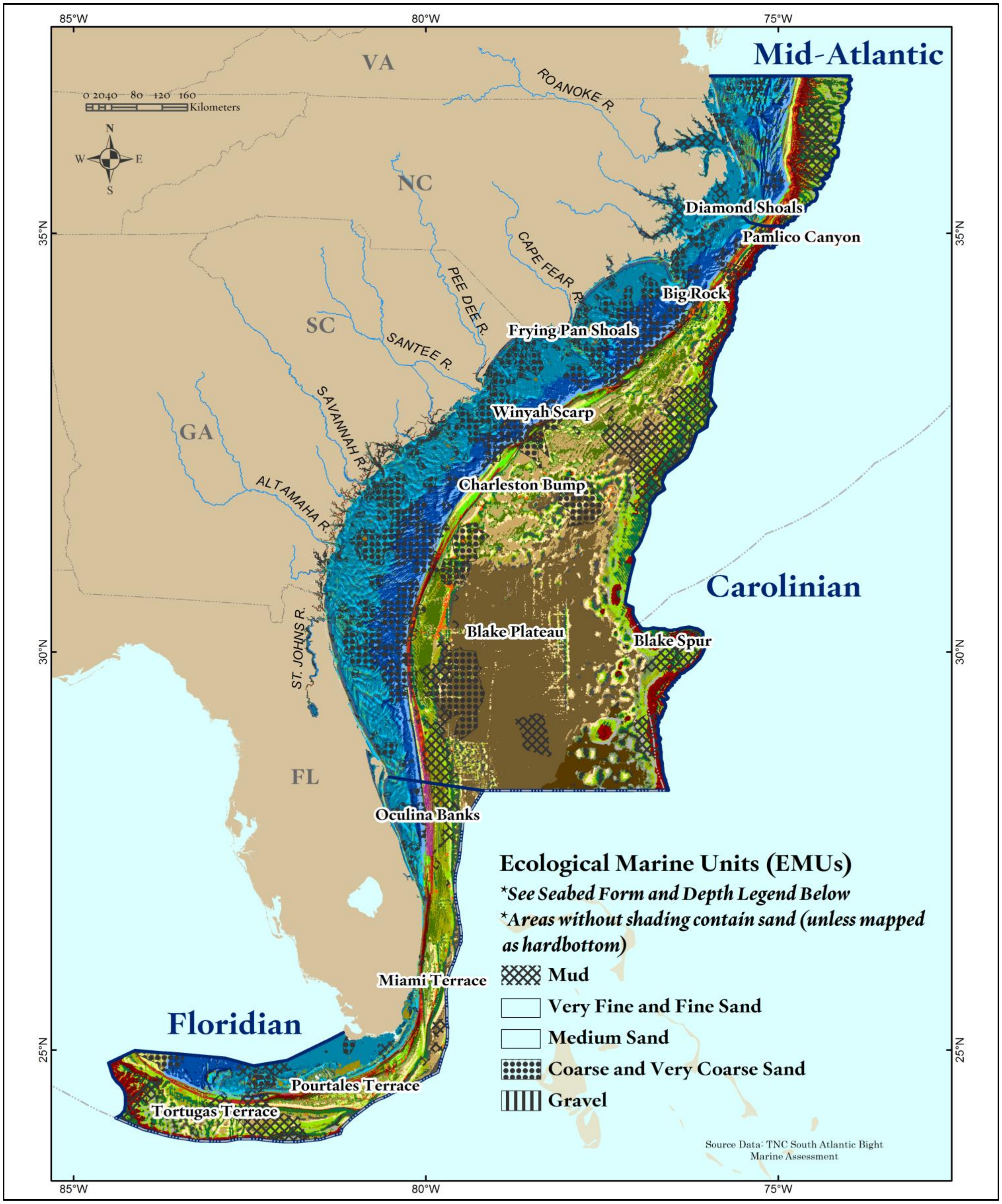


Figure 3.37. Ecological Marine Units of the South Atlantic Bight: depth zones, seabed forms and hardbottom, with soft substrate overlaid. Areas that are fully transparent are medium to fine sand.

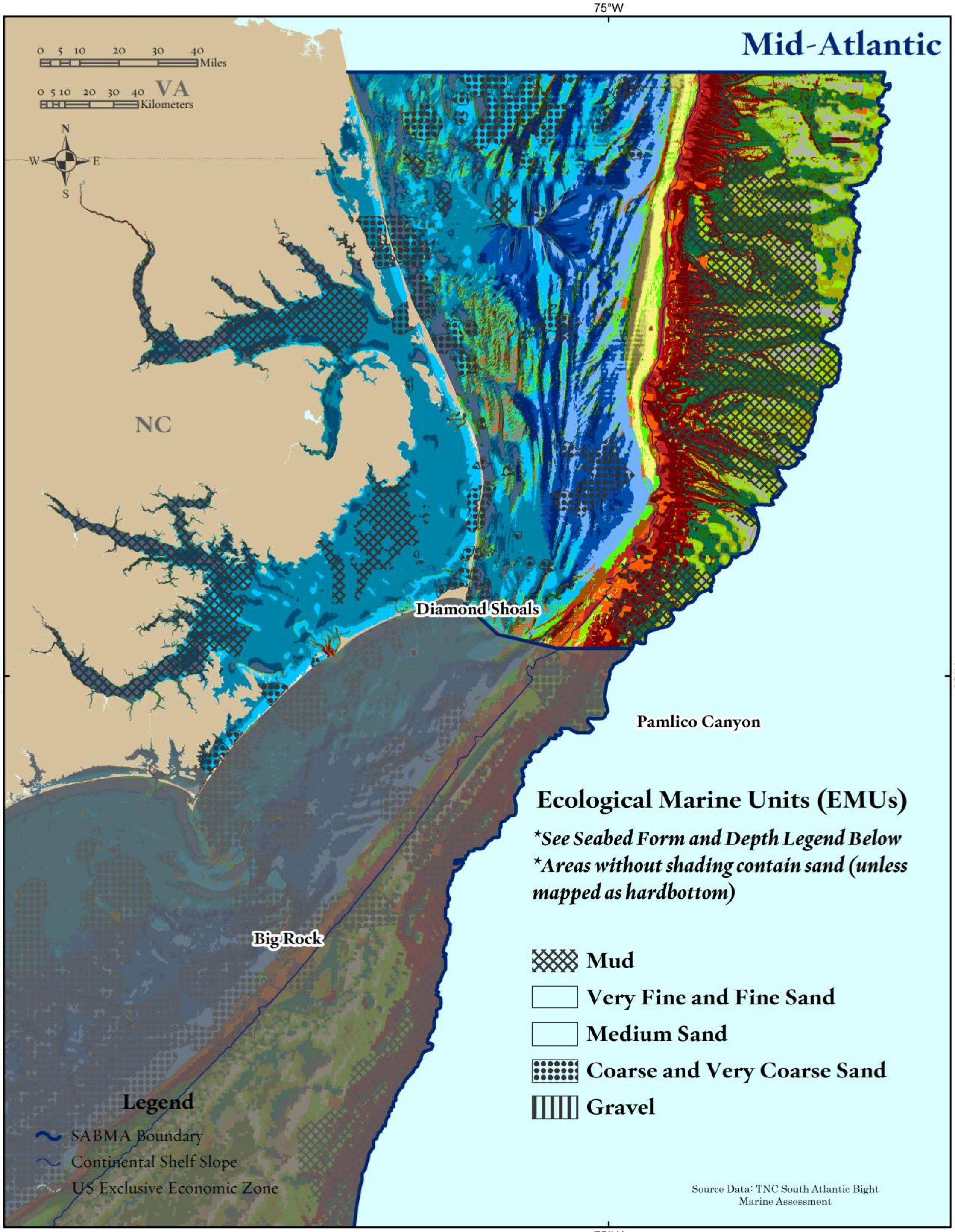


Figure 3.38. Ecological Marine Units of the mid-Atlantic subregion: depth zones, seabed forms, hardbottom and soft sediment

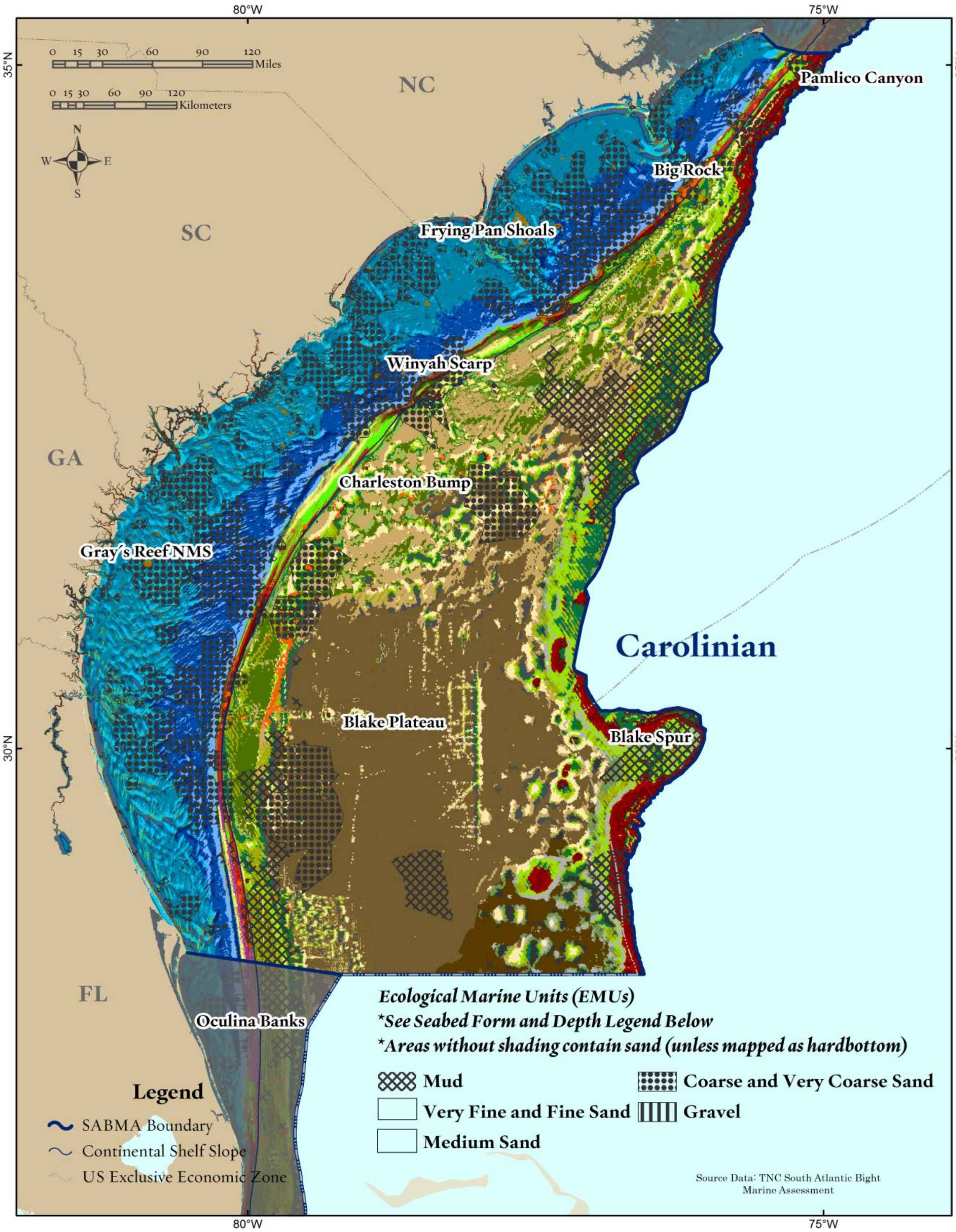


Figure 3.39. Ecological Marine Units of the Carolinian subregion: depth zones, seabed forms, hardbottom, and soft sediment

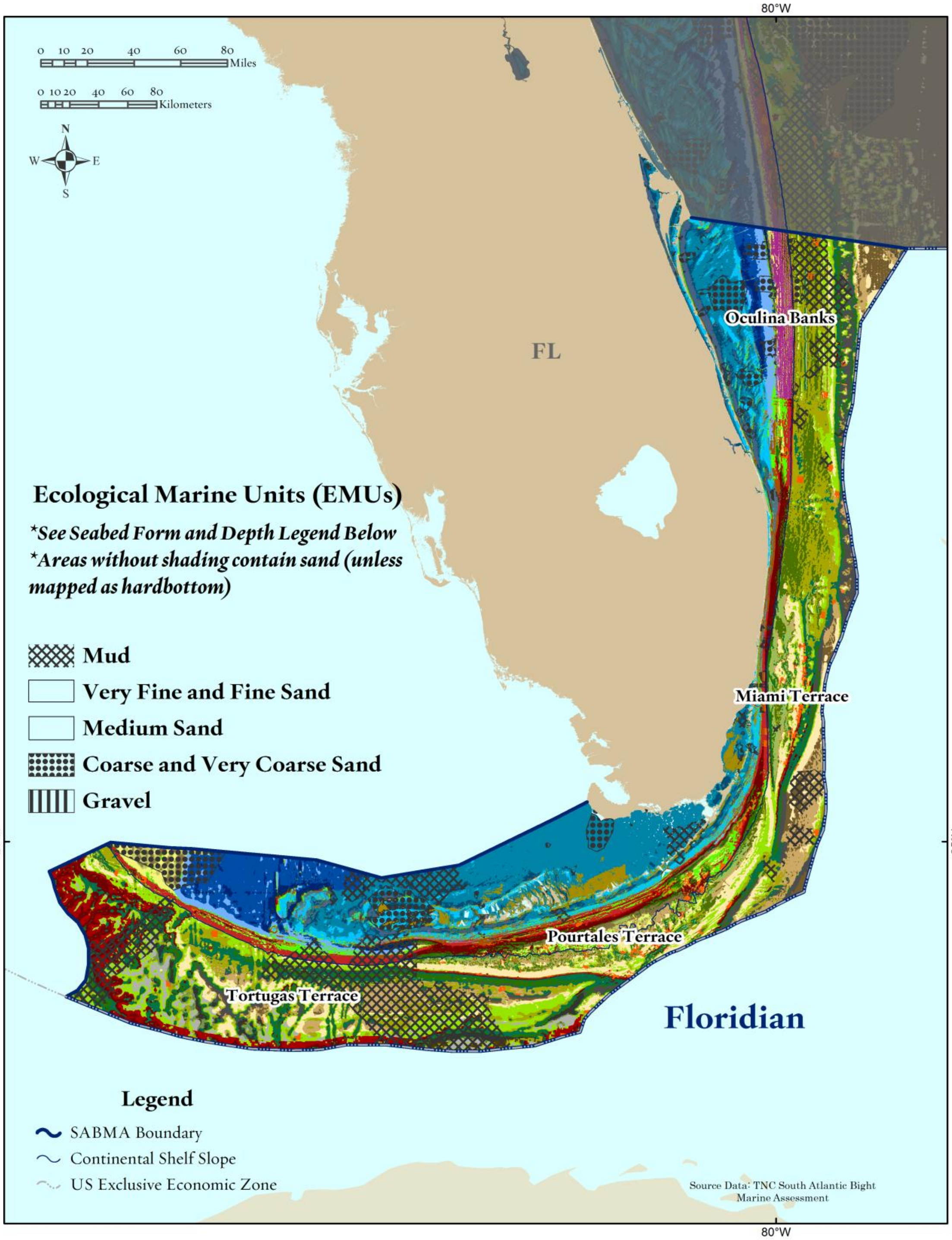


Figure 3.40. Ecological Marine Units of the Floridian subregion: depth zones, seabed forms, hardbottom, and soft sediment

Human Interaction and Threats

(This section is condensed from Fautin et al. 2010 except where noted)

South Atlantic seafloor habitats are sensitive to a range of alterations from increased sea temperature and ocean acidification to overfishing and dredging. Extensive coastal development has impacted the habitats of estuarine species and estuarine-dependent stages of offshore species. Nonselective fishing gear, invasive species, and changing environmental factors make management for sustainable fisheries and conservation of biodiversity a challenge. Coral reefs are in decline worldwide as global change and concomitant ocean acidification and sea level rise degrade these nearshore habitats.

Fisheries in the region target the highly diverse assemblage of reef fishes associated with hardbottom substrates or coral reefs. Overfishing has depleted populations of top-level demersal predatory fishes such as snappers and groupers, and fishing pressure and demand remain high. These depletions, combined with fishing gear effects, likely impact the health of associated reef species such as algae, invertebrates, and other vertebrates. Management efforts are largely aimed at restoring sustainable stocks of individual species rather than the ecosystem as a whole, and the interactions among reef species are poorly understood. Decades of fishing on reef fish spawning aggregations have resulted in declining abundance, although recent protection of spawning sites has reversed this trend for mutton snapper (Burton et al. 2005) and may be effective for other species. Finally, there is concern about the large populations of the invasive lionfish (Pterois spp.) now present in some reef areas. Because lionfish have no predators in this system and they prey on small fishes, including new recruits, their impact on endemic fish population recovery and restoration could be substantial.

Reef-forming corals of the Florida Keys are declining (National Marine Sanctuary Program 2007), their poor condition resulting from combined effects of coastal development, overfishing, ship groundings, temperature increases, and water quality degradation from terrestrial, marine, and atmospheric pollution. The National Marine Fisheries Service is now evaluating the status of 82 species of stony coral that the Center for Biological Diversity has asked to be listed as threatened or endangered under the Endangered Species Act. These include *Montastrea* spp., which form large colonies and are important in building reefs of the Florida Keys, and *Oculina varicosa*, which occurs on deep reefs in the region. New coral species and assemblages are likely to be discovered in deep water sponge and coral fauna of the Blake Plateau.

Sediment dredging occurs in nearshore sand flats, shoals, and shoal-ridge complexes. Michel et al. (2013) studied the effects and provided recommendations to limit the physical and biological impacts of dredging on seafloor habitats. These include: dredging only on shoals with a large height to depth ratio, dredging only in actively accreting areas, and using rotational dredging (or removing materials in bands) to leave untouched sediment in- between to provide a local source of benthic infauna for recolonization. They encourage dredgers to maintain shoal geometry by following natural contours, limiting the depth and amount of removal to less than 10% per shoal, and avoiding removal from the crest in order to maintain nursery habitat. If hardbottom habitat or coral reefs occur in the vicinity of the shoal they suggest that vessels restrict anchoring or drilling to avoid these features.

Management and Conservation

The South Atlantic region has been the subject of substantial conservation efforts including three National Marine Sanctuaries (NMS), 53 Habitat Areas of Particular Concern (HAPC), and eight deepwater Marine Protected Areas (MPA). The designation of reef areas as no-fishing zones has been successful in restoring populations of top-level predatory fishes in the Florida Keys (Kramer and Heck 2007), and recent implementation of small areas where bottom fishing is not allowed show promise for restoring predators in those areas as well.

The region contains three National Marine Sanctuaries. Monitor, the nation's first marine sanctuary was established in 1975 to protect the shipwreck of the USS Monitor. Gray's Reef, designated in 1981, protects a 5,700-hectare (22 mi^2) stretch of natural rocky reef and hardbottom on the Continental Shelf off the Georgia coast. The Florida Keys, established in 1990, protects 751,000 hectares (2,900 square miles) of waters surrounding the Florida Keys and includes the world's third largest barrier reef, extensive seagrass beds, mangrove-fringed islands, and more than 6,000 species.

The 53 Habitat Areas of Particular Concern (HAPC) have been designated for deepwater corals, sargassum, and essential fish habitat. To safeguard the importance and uniqueness of deep water coral habitats in the South Atlantic, the South Atlantic Fisheries Management Council designated five areas, encompassing more than 59,000 km^2 (23,000 mi^2), as Coral Habitat Areas of Particular Concern (C-HAPC) in 2010. Management measures to help protect these sensitive habitats include a prohibition on the use of fishing gear (bottom longline, bottom and mid-water trawl, dredge, pot, and trap), anchoring by fishing vessels, and possession of deep water coral. Oculina Bank, designated in 1984 by the council, closed 9,320 hectares (36 square miles) on the upper slope off Florida to trawling, dredging, longlining, and trapping to protect banks of ivory tree coral (*Oculina varicosa*; Ross and Nizinski 2007). Ten years later, the council created the Experimental Oculina Research Reserve, closing the area to all bottom fishing indefinitely in order to protect spawning reef fishes, restore reef fish stocks, and protect sensitive habitat that includes at least 350 invertebrate species (Ross and Nizinski 2007; Reed 2002). The large Deep Sea Coral C-HAPC includes a substantial portion of deep water area (more than 400 m^2 (4,300 ft^2), and has been approved to protect banks of the coral *Lophelia* and other coral banks on the Blake Plateau and the Straits of Florida.

The smaller HAPCs are mostly focused on protecting essential habitat for particular fish species. The designated habitats include: sandy shoals (e.g., Cape Lookout, Cape Fear), estuaries (e.g., Ace Basin, Indian River lagoon), and hardbottom or shelf habitat (e.g., Fathom Ledge, Big Rock, The Point, Charleston Bump). These designations are expected to have positive impacts on the conservation of biodiversity, although they vary widely in their degree of protection. Some HAPCs, such as the Charleston Bump complex, have seasonal fisheries closures.

Eight Marine Protected Areas (MPAs) were established by the SAFMC in 2009 to protect a portion of the long-lived, deep water, snapper and grouper species such as snowy grouper, speckled hind, and blueline tilefish. These MPAs consist of eight no-bottom-fishing zones on the outer Continental Shelf between southern North Carolina and the Florida Keys that range in size from 2,070 to 38,850 hectares (8 to 150 square miles). They all encompass natural habitat except for one area off Charleston, South Carolina, that was established to create a deep water artificial reef. These small areas are aimed at protecting deepwater reef species and providing areas where a natural reef ecosystem can function. The small MPAs in the region will be useful in providing data on how no-take zones established for the conservation of habitat and restoration of fishery species affect sustainable fisheries and biodiversity.

The region's estuarine resources are partially protected by five National Estuary Research Reserves. These include the four linked sites in North Carolina (from Currituck Banks south to Masonboro Island), North Inlet-Winyah Bay and ACE Basin in South Carolina, Sapelo Island in Georgia, and Guana Tolomato Matanzas in northeast Florida. These areas comprise large shallow sounds and other estuarine lagoons and tidal creeks, relatively pristine saltmarsh, mangrove and other wetlands, subtidal seagrass and oyster beds, and upland maritime forest.

The many small HAPCs and the dispersed nature of the seafloor habitats characterized in this study (hardbottom, coral mounds, shoal, ridges, sand waves) suggest a crucial role for multi-objective ocean planning. The maps and data provided in this report, in conjunction with the SAFMC's mapped HAPCs and essential fish habitats, offer a strong spatial foundation for characterizing the region's key habitats and processes. We encourage agencies such as the Bureau of Ocean Energy Management and the Army Corps of Engineers to incorporate this information into their planning and permitting for dredging, offshore mineral mining, oil and gas development and leasing, alternative energy development, and state-based wind energy siting to ensure the conservation of marine diversity.

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CHAPTER
4

MARINE MAMMALS AND SEA TURTLES

Laura Geselbracht, Robert Newton, Jennifer Greene

Introduction

Marine mammals and sea turtles serve a number of important functions in the South Atlantic Bight ecosystem. They are pelagic and, in many cases, are highly migratory or wide-ranging. They serve as vital components of marine food webs as predators, planktivores, or herbivores, and are important conduits for the movement of carbon and nutrients between coastal habitats and the open ocean. These "charismatic megafauna" draw public attention, helping to educate people about the importance of our oceans to life on earth. In many cases, the marine mammal and sea turtle species occurring in the SAB region are endangered, threatened or vulnerable and require a concerted effort by humans to ensure their persistence into the future. A consequence of the large geographic ranges of many of these species is frequent opportunity to interact with humans. These interactions can include exposure to ship and boat traffic, fishing gear (active and derelict) and pollution (including marine debris), underwater noise, and the effects of climate change, which all may pose serious threats to these sensitive populations.

Three sub-groups of marine mammals are found in the South Atlantic Bight study area: cetaceans, sirenians and pinnipeds. Cetaceans are the sub-group of marine mammals that includes whales, dolphins, and porpoises. Many species of cetaceans undertake extensive migrations and exhibit very large geographic ranges, often encompassing one hundred thousand square miles or more in an individual's lifetime. Smaller cetacean species found in the study area, including dolphins and porpoises, generally have smaller ranges. Only one sirenian (the group that includes manatees and dugongs) inhabits the study area: the Florida manatee (*Trichechus manatus latirostris*), a sub-species of the West Indian manatee. Although manatees' ranges are generally not as extensive as other marine mammal species in the study area, they can travel

hundreds of miles in search of warm water habitat and food resources. Four species of pinnipeds (seals and sea lions) are also known to occur in the SAB region.
Sea turtles are also an important component of north Atlantic coastal and ocean ecosystems because they are highly migratory, long-lived, slow growing, and utilize a diverse array of oceanic, neritic, and terrestrial environments. For these reasons, sea turtles present a unique conservation challenge. While they have been the focus of a multitude of international treaties and conventions, national laws, and regulatory protection strategies, there is still a clear need for greater understanding of their temporal and spatial distribution and migratory patterns, degree and relevance of threat sources on all life stages, and population trend analyses via international monitoring and research efforts. Five sea turtle species were chosen for inclusion in this analysis.

Distribution information on marine mammals and sea turtles is challenging to collect due to the broad geographic areas frequented by these species and the expense of data collection. In addition, these animals spend significant portions of their lives below the surface, and some of them are relatively small compared to the survey techniques used to detect them. Although the distribution information presented in this report is imperfect and likely underestimates the number of places where these species are found, it is based on the best information available. The mapped information presented in this analysis is only appropriate for decision making at the regional or state level and should not be used for making decisions at the 10-minute or 100-minute scale.

Box 4.1. Marine Mammals and Sea Turtles Technical Team Members

The Marine Mammal Technical Team was comprised of internal and external resource experts who helped identify and categorize target species, validate analyses and review the chapter.

Melissa Clark, The Nature Conservancy, Eastern Division
Mary Conley, The Nature Conservancy, South Atlantic Marine Program
Mark Dodd, Georgia Department of Natural Resources
Clay George, Georgia Department of Natural Resources
Laura Geselbracht, The Nature Conservancy, Florida Chapter
Jennifer Greene, The Nature Conservancy, North America Region
Robert Newton, The Nature Conservancy, South Atlantic Marine Program
Mark Swingle, Virginia Aquarium & Marine Science Center

Selection of Target Species

Technical team members worked together to identify the target marine mammal and sea turtle species to be included in this assessment as well as the most appropriate data sources and approaches for documentation and analysis. Several factors were considered when selecting the target species, including population status (threatened and endangered species are all included), distribution in the region, and data availability. The home ranges of the species included in this assessment extend through part or all of the region (and in many cases well beyond), from the inland to offshore waters of the South Atlantic Bight region. The list of target species is far from a comprehensive list of marine mammals and sea turtle species that occur in the region; for a complete list see Appendix 3. The target species included in this assessment are as follows:

Sea Cows

- Florida manatee *(Trichechus manatus latirostris)*

Baleen Whales

- Fin whale (*Balaenoptera physalus*)
- Humpback whale (*Megaptera novaeangliae*)
- North Atlantic right whale (*Eubalaena glacialis*)

Toothed Whales

- Beaked whales (family Ziphiidae)
- Bottlenose dolphin (*Tursiops truncatus*)
- Oceanic dolphins (genus *Stenella*)
- Common dolphin (*Delphinus delphis*)
- Pilot whales (long-finned pilot whale, *Globicephala melas* and short-finned pilot whale, *Globicephala macrorhynchus*)
- Risso's dolphin (*Grampus griseus*)
- Sperm Whale (*Physeter macrocephalus*)

Sea Turtles

- Loggerhead turtle (*Caretta caretta*)
- Green turtle (*Chelonia mydas*)
- Leatherback turtle (*Dermochelys coriacea*)
- Hawksbill turtle (*Eretmochelys imbricata)*
- Kemp's ridley turtle (*Lepidochelys kempii*)

Appendix 4 summarizes the current understanding of the biology of each of the target species and groups listed above.

Population Status of Target Species

Populations of the target mammal and turtle species addressed in this chapter are threatened in some way; for many, their populations are protected by federal and even international recognition of their status. The fin, humpback, North Atlantic right, sei, and sperm whales and the Florida manatee are listed as endangered by the U.S. Endangered Species Act. The IUCN Red List documents the fin and North Atlantic right whales and the Florida manatee as endangered, the sperm whale as vulnerable, and the humpback whale and common, bottlenose, Risso's, and oceanic dolphins as species of least concern (IUCN 2014). Due to limited data, a determination of the population status of many target species is not yet available. The majority of existing data are derived from marine mammal aerial and ship surveys, with a large portion of the data consisting of a low abundance or single occurrence sightings.

The North Atlantic right whale is a species of particular concern in this region. It is considered to be one of the most critically endangered large whales in the world and could be facing extinction (Clapham and Mead 1999; Kenney 2002). Recent observations offer some encouragement. Based on 2010 observations, the western North Atlantic right whale stock was estimated to be at a minimum 455 individuals and an examination of the minimum number alive population index over the previous 10-year period revealed an increasing population trend of 2.8% (geometric mean growth rate; Waring et al. 2014).

In the United States, all five sea turtle target species are federally listed as endangered or threatened. Leatherback, hawksbill and Kemp's ridley sea turtles are considered endangered throughout their ranges; the loggerhead is considered threatened in the SAB region and either threatened or endangered in other parts of the world; green sea turtles are considered threatened except for breeding populations in Florida and on the Pacific coast of Mexico which are considered endangered. According to the International Union for Conservation of Nature (IUCN) Red List (IUCN 2014), both the loggerhead and green turtles are categorized as endangered while the leatherback turtle is considered vulnerable (Wallace et al. 2013; Seminoff 2004). The hawksbill sea turtle is categorized as critically endangered as a result of declines at index monitoring sites in all major ocean basins. All of these species are protected against international trade (CITES 1973).

Importance of U.S. South Atlantic Bight Waters to Target Species

Marine mammals targeted by this assessment use the waters of the U.S. South Atlantic for a variety of purposes including feeding, breeding, nursing and migration. Most of the baleen species found in the region breed either outside of the area or their breeding location is unknown (Jonsgård 1966). The North Atlantic right whale uses the area offshore of Georgia and North Florida as calving grounds (NMFS 2006a). Some of the small toothed whales and the Florida manatee are known to use the region for breeding, calving, nursing and feeding (Haubold et al. 2006; Sargent et al. 1995; Waring et al. 2003). Dolphins (*Stenella* spp. and *Tursiops truncatus*) are by far the most numerous marine mammals found in the study area (Department of Navy 2008). Unlike the other species of marine mammals found in the region, the primary range of the Florida manatee is Florida coastal waters with some migration north of the state in the summer months (Fertl et al. 2005; Powell and Rathbun 1984; Rathbun et al. 1982).

Sea turtle species also use the SAB region at a variety of ecological stages; for some species, the SAB population represents a significant proportion of the species' overall population. One of the two primary global loggerhead nesting aggregations with greater than 10,000 nesting females per year is in South Florida (the other is in Masirah, Oman, on the Arabian Sea; Baldwin et al. 2003; NMFS USFWS 2008). A comprehensive three-year study of the distribution of loggerheads in the Northwest Atlantic estimated that the total summer loggerhead population was between 2,200 and 11,000 individuals (Shoop and Kenney 1992). More recent studies in Virginia coastal waters documented up to 10,000 loggerheads in Chesapeake Bay and tens of thousands in ocean waters (spring estimate > 60,000; Swingle 2014). In the SAB region, the most loggerhead nesting is concentrated along the coast from southern Virginia to Florida (Conant et al. 2009). Over the past decade, estimates for U.S. nesting aggregations have fluctuated between 47,000 and 90,000 nests per year, with 80% of nesting occurring in eastern Florida (NMFS USFWS 2008). While loggerhead nesting in Florida has been cyclical over the 25-year observation period, over the most recent 15-year period (1998 to 2013) no demonstrable trend has been observed (FWC, FWRI 2014c).

Despite the global decline of green turtles over the past 150 years, in the IUCN's Western Atlantic Ocean and Caribbean Region, representing approximately 30% of the overall global population of nesting females, all but one of the subpopulation index sites (Venezuela, Aves Island) witnessed increases including the United States (Florida). In the SAB region nesting primarily occurs in Florida, where green turtle nest counts have increased approximately one hundredfold since counts began in 1989 (n = 267). The most dramatic growth occurred in 2013 (n=25,553) when the nest count was more than twice that of the next highest year (FWC, FWRI 2014b).

Leatherback population decreases and collapse have been documented in major nesting areas in the Pacific region. The most recent global assessment of leatherback turtle nests estimated a 40% decline over the past three generations (approximately 90 years) from 90,560 to 54,260 nests in 2010. However, the assessment also predicts that global population will increase in the future (3% by 2030 and 104% by 2040), primarily because of increasing populations in the Northwest Atlantic region. Shoop and Kenney (1992) estimated that the total summer population of leatherbacks in the Northwest Atlantic was between 100 and 900 individuals. A more recent study of nesting leatherbacks conducted in 2004 - 2005 estimated the Florida stock (nesting stock in the SAB area) of adult leatherbacks to be between 320 and 920 individuals (5^{th} to 95^{th} percentile; TEWG 2007). In the SAB region, nesting is limited to Florida where standardized counts suggest that the population has been increasing between 1989, when the nest count was 27, and 2013, when 896 nests were counted (FWC, FWRI 2014b).

Globally, the hawksbill turtle has experienced an extensive population decline, estimated at 80% over the past three generations (approximately 105 to 135 years). Declines have been observed for all subpopulations in all major ocean basins. Numerous populations, especially some of the larger ones, have continued to decline since the last assessment of the species (Meylan and Donnelly 1999), however, some protected populations are stable or increasing. In the SAB region, the hawksbill turtle nests only rarely. During the period 1979 to 1992, 0 to 2 hawksbill nests were recorded annually (Meylan et al. 1995). More recently, 4 nests were observed during the years 2009 to 2013 on one Florida Keys beach (FWC, FWRI 2014b). These observations are likely an underestimate because females in the process of laying eggs have rarely been encountered and tracks left in the sand resemble loggerhead tracks, hatchlings are difficult to distinguish from loggerhead hatchlings, and some nesting takes place beyond the standard monitoring period.

Kemp's ridley turtles are distributed throughout the Gulf of Mexico and along the U.S. Atlantic coast from Florida to New England (NOAA 2014a). This species is highly vulnerable due to the manner in which it nests and the very limited geographic range of its primary nesting population. The Kemp’s ridley nests in arribadas, or large nesting aggregations, the main locations of which are three beaches in the Tamaulipas state of Mexico. Since the 1940s, the Kemp's ridley has experienced a dramatic population decline. At an arribada video-taped in 1947, turtles created an estimated 42,000 nests in a single day. Between 1978 and 1991, only about 200 Kemp's ridleys nested annually. In recent years, the Kemp’s ridley has seemed to be in the early stages of recovery. In the SAB region, the Kemp’s ridley turtle only rarely nests. During the period 2009 to 2013, one to three Kemp’s ridley nests were observed on 22 Florida index beaches, five of which were on the Atlantic Coast (FWC, FWRI 2014b). Rare nesting has also been documented in Virginia, North Carolina, South Carolina and Georgia (Georgia Conservancy 2012; Hampton Roads 2012; NOAA 2014a).

Ecosystem Interactions and Ecological Dependencies

Relationships between marine mammals and sea turtles and their environment are complex and can vary by ecosystem. The sections below review the current state of our knowledge of these complex interactions.

Marine Mammals

While the exact ecological function of marine mammals is not fully known, insights into their role in the marine ecosystem have emerged through large-scale studies of species-ecosystem interactions and community structure (Bowen 1997; Haubold et al. 2006). Katona and Whitehead (1988) hypothesized that marine mammals could play a major role in determining the behavior and life history traits of their prey species, affecting nutrient storage and cycling and altering benthic habitats. Further information about the ecological role of each group of marine mammals is provided below.

CETACEANS

As predators, cetaceans are major consumers at most trophic levels, specifically feeding on zooplankton, invertebrates, and forage fish in the region. Mysticetes (baleen whales), including fin, humpback, minke, right, and sei whales, are migrating animals that move (in the case of the Northwest Atlantic stocks) from northern feeding grounds in the summer to warmer waters in the fall and winter to breed and reproduce (Jonsgård 1966; Garrison 2007). They typically forage for pelagic prey, consuming large quantities at one time, including zooplankton (e.g., copepods), euphausiids (e.g., krill), and small fish (e.g., sand lance, herring, mackerel) (Nemoto 1959; Jonsgård 1966; Mitchell 1975; Kawamura 1982; Mizroch et al. 1984; Kenney et al. 1985; Haug et al. 1995; Flinn et al. 2002; Perrin and Brownell 2002). Some baleen species like sei and right whales are dependent on euphausiids and copepods when feeding in the North Atlantic, while other species are less selective in their diet (Nemoto 1959; Kraus et al. 1988).

Odontocetes (toothed whales) typically prefer larger prey than baleen whales, consuming individual organisms, and typically feed at higher trophic levels (Pauly et al. 1998). Unlike the mysticetes, not all odontocetes are migrating animals, and they feed year-round (Lockyer and Brown 1981). Primary food sources for toothed whales are cephalopods (e.g., small and large squid), small fish (e.g., smelt, herring, mackerel), and demersal fish (e.g., cod, skate) (Smith and Whitehead 2000; Archer 2002; Sergeant et al. 1980; Katona and Whitehead 1988). For members of this suborder that migrate seasonally, food availability appears to be a driver of this behavior (Irvine et al. 1981) but migrations do not exhibit a consistent pattern as seen in the mysticetes (Lockyer and Brown 1981). Some of the smaller odontocetes, in particular estuarine stocks of the bottlenose dolphin, have strong site fidelity with no observed migration (Odell and Asper 1990; Caldwell 2001; Grubbins 2002; Zolman 2002; Mazzoil et al. 2005;

Speakman et al. 2006; Mazzoil et al. 2008). The lack of migration may be because some species are able to employ a variety of feeding techniques and rely on a number of prey items (Leatherwood 1975). Within the boundaries of the study area both baleen and toothed whales have few predators, which include large sharks, killer whales, and potentially, false killer whales (Perry et al. 1999; Heithaus 2001; Perrin and Brownell 2002; Horwood 2002; Swingle 2014).

SIRENIANS, THE FLORIDA MANATEE

The only sirenian found in the SAB region is the Florida manatee, an herbivore that feeds on a variety of vegetation types including seagrass in shallow marine areas, floating and emergent vegetation, and vegetation along banks (Haubold et al. 2006). Macroherbivores can have a profound effect on the distribution and productivity of the vegetation they feed on, on other grazers and fauna associated with the plants they feed on, and on chemical and decompositional processes occurring within their feeding areas (Thayer et al. 1984). The Florida manatee is found in a variety of coastal aquatic habitats from freshwater canals in highly urbanized areas to coastal lagoons, estuaries, and shallow seagrass and coral reef areas in marine waters (Smith 1993). It migrates seasonally hundreds of kilometers between a warm-season range and a cold-season range; great variability in movement patterns has been described (Deutsch et al. 2003). A small percent (approximately 12% in one study) of Florida manatees do not migrate, but rather stay year-round in a relatively small area (< 50 km (31 miles); Deutsch et al. 2003). Manatees are sensitive to cold water (< 20°C; 68°F) and seek warm water refugia in the winter months (Haubold et al. 2006).

Sea turtles

The sea turtles occurring in the SAB region are highly migratory and use a wide range of habitats during their lifetimes (Seminoff 2004). Their diets vary by species, life stage and habitat zone (i.e., oceanic, neritic). During the loggerhead's post-hatchling transition stage, individuals hatched on U.S. beaches migrate offshore and become associated with floating *Sargassum*, driftlines, and other convergence zones (Carr 1986; Witherington 2002). During this period, they forage on organisms associated with the *Sargassum* including hydroids, copepods, coelenterates and salps (Witherington 2002; Bjorndal 1997, 2003). As juveniles transition from oceanic to neritic habitats, diets become more diverse and shift according to season and geographic position. In the North Atlantic, neritic stage adults forage primarily on mollusks and benthic crabs. The diet of oceanic stage adults is currently unknown (NMFS USFWS 2008).

Only limited information is available on green turtle ecosystem interactions during the juvenile oceanic stage. Evidence suggests that hatchlings from disparate natal sites outside of the Caribbean enter the North Atlantic gyre and form mixed stock feeding aggregations in the Eastern Caribbean before returning to feeding areas closer to their natal rookeries (Luke et al. 2004). Upon recruitment back to coastal areas, neritic juveniles subsist primarily on seagrasses and marine algae (NMFS USFWS 2007a). The availability of food items within coastal foraging areas may vary seasonally and interannually. The diet of migratory oceanic adults is currently unknown.

Leatherbacks forage primarily on pelagic gelatinous organisms including jellyfish (medusae), siphonophores, and salps in temperate and boreal latitudes (NMFS USFWS 1992, 2007b). They are also known to eat crustaceans, vertebrates, and plants (Eckert et al. 2012; Dodge et al. 2011; Jones and Seminoff 2013). Surface feeding is the most commonly observed foraging habit for leatherbacks, but dive data indicate that they may forage throughout the water column. Based on satellite telemetry and stable isotope studies, leatherbacks appear to associate with highly productive ecosystems and have been observed transiting low productivity areas at high speed until they reach more productive foraging areas (Fossette et al. 2010).

As juveniles, hawksbill turtles may forage in coral reefs or other hard bottom habitats, seagrass, algal beds, mangroves (Musick and Limpus 1997) or mud flats (R. von Brandis unpubl. data as reported in Mortimer and Donnelly 2008). These foraging habitats may be located hundreds or thousands of kilometers away from natal beaches. Hawksbills are known to be an important component of healthy coral reef ecosystems. In the Caribbean (SABMA area), they may support coral reef health by controlling sponges, their primary local food source (Hill 1998; Meylan 1988; León and Bjorndal 2002; Bjorndal and Jackson 2003).

Kemp's ridley turtles may have limited ecological significance in the SAB region due to their current population size. Adults are found in neritic habitats with muddy or sandy bottoms. Their diet consists mainly of swimming crabs, but may also include fish, jellyfish, and an array of mollusks (NOAA Fisheries 2014b). Little is known of the feeding habitats of the juvenile, oceanic stage.

U.S. South Atlantic Distribution and Important Areas

Methods

In-water Distribution – Sighting per Unit Effort (SPUE) Model

Two effort-corrected methods of observation have been used over the past several decades to estimate where cetaceans and sea turtles are distributed in offshore areas: shipboard and aerial surveys. Correcting observations for effort is essential to minimize the bias that would otherwise result for heavily surveyed areas. While opportunistic sightings of cetaceans and sea turtles in the SAB region have been recorded for over one hundred years, this information is less valuable for improving our understanding of cetacean and sea turtle distribution in the study area. Consequently, we have focused our analysis on data sets that are corrected for effort (see below for more detail about how data are corrected for effort). The most complete source for this information in the SAB region is the data collected, assembled, and processed by the U.S. Navy for the Charleston/Jacksonville Marine Resource Assessment (Department of Navy 2008). Geospatial analyses of cetacean and sea turtle sightings were obtained from the U.S. Navy (see Department of Navy 2008). These analyses were completed for the Navy's Marine Resource Assessments (MRA), a program used to develop comprehensive data and literature concerning protected and managed marine resources found in Navy operating areas for use in environmental and biological assessments prepared in accordance with various federal laws (e.g., Marine Mammal Protection Act, National Environmental Policy Act). Data were from the Navy's Charleston/Jacksonville MRA study region, which covers only the northern portion of the SABMA study area, extending south to waters just north of the Indian and Banana River Complex, Florida. Data for areas south of the Charleston/Jacksonville MRA study area were not available for this analysis.

The sightings used in the Navy's analysis were taken from National Marine Fisheries Service-Southeast Fisheries Science Center (NMFS-SEFSC) aerial surveys, NMFS-SEFSC shipboard surveys, and the North Atlantic Right Whale Consortium database (See Table 4.1 for a complete listing). The surveys used covered the years 1978 – 2005. Data used in these analyses were primarily collected via aerial and shipboard surveys during daylight hours, weather permitting. The data were provided in a seasonal format where the seasons covered the following dates: winter, December 6 – April 5; spring, April 6 – July 13; summer, July 14 – Sept 16; and fall, September 17 – December 5.

Table 4.1. Sources for marine mammal and sea turtle data (Department of Navy 2008)

Shipboard Sighting Surveys	DATA YEAR(S)
NMFS-SEFSC R/V Oregon II Cruise 92-01 (198) 1992	1992
NMFS-SEFSC R/V Relentless Cruise 98-01 (003) 1998	1998
NMFS-SEFSC R/V Oregon II Cruise 99-05 (236) 1999	1999
NMFS-SEFSC R/V Gordon Gunter Cruise GU-02-01 (021) 2002	2002
NMFS-SEFSC R/V Gordon Gunter Cruise GU-04-03 (028) 2004	2004
NMFS-SEFSC R/V Gordon Gunter Cruise GU-05-03 (062) 2005	2005
CETAP Shipboard Survey 1978-1982	1978 - 1982
Aerial Sighting Surveys	
DoN-Continental Shelf and Associates, Inc. (CSA)	1996-1999
DoN SEAWOLF Mayport Shock Trial	1995, 1997
DoN Winston S. Churchill Shock Trial	1999
NMFS-SEFSC Southeast Cetacean Aerial Surveys (SECAS)	1992, 1995
New England Aquarium (NEA) (pre-Early Warning System [EWS])	1984 - 1993
New England Aquarium (NEA) (EWS)	1993-2005
New England Aquarium (NEA) Core of Engineers (COE)	1989-1993
Georgia Department of Natural Resources (GADNR) (EWS)	1993-2002
Florida Marine Research Institute (FMRI) (EWS)	1992-2005
Associated Scientists at Woods Hole Oceanographic Institution (ASWHOI) Airship (blimp) Survey	1991-1993
CETAP Aerial Survey	1978-1982
Offshore Surveys (GADNR and FMRI)	1996-2002
University of North Carolina at Wilmington (UNCW) Aerial Survey (EWS)	2001-2002
University of Rhode Island (URI) Aerial Survey	1987
Wildlife Trust (WLT) Aerial Survey (EWS)	2002-2005

One issue with interpreting marine mammal and sea turtle data is the bias introduced by uneven survey coverage or “effort.” For example, an area may have few sightings because of the absence of a given species or there just may be little survey effort in that location. Figure 4.1 illustrates the seasonal survey effort for the surveys used in this analysis (exception is the North Atlantic right whale). A standard approach to overcoming this bias is using effort-corrected sightings data (Kenney and Winn 1986; Shoop and Kenney 1992). Calculating sightings per unit effort, or SPUE, an index of relative density, allows for comparison of data spatially and temporally within a study area (Shoop and Kenney 1992). SPUE is calculated as:

SPUE = 1000*(number of animals sighted)/effort

Geospatial analysis obtained from the U.S. Navy included shapefiles of valid cetacean and sea turtle sightings and pre-calculated effort grids for each season. The validity of sightings was carefully screened and verified by Navy contractors before inclusion in the model. Invalid records were not included in the analysis. Data included in the density estimates were restricted to sightings collected during defined census tracks (i.e., “on-effort”). Sightings collected during transits to or from a survey area, on cross-legs between census tracks, or while the ship or aircraft has left a census track to investigate a sighting were considered to be “off-effort” and were not included in the density estimates. Only datasets that included the following data fields were included in the Navy SPUE analysis:

- Assessment of the sighting conditions encountered during each segment of the survey track, including visibility and sea state
- Observer watch status
- Altitude (aerial surveys only)
- Sufficient records (time and position) for the survey track, in addition to the sighting locations, to adequately reconstruct the platform track.

The Navy SPUE analysis only included track segments completed with at least one observer on watch, clear visibility of at least two nautical miles, Beaufort sea state of less than or equal to three, and an altitude of less than 366 m.

Using the formula above, SPUE was calculated for each target species/species group in each of the four seasons in all ten-minute squares (TMS) within the project area. The SPUE grid cell values were converted to rank-based z-scores representing each TMS SPUE value in relation to the mean. The rank-based z-scores are interpreted in the same manner as standard z-scores. That is, a rank-based z-score of 1 indicates that the grid cell value is 1 standard deviation greater than the mean of all the grid cells. Refer to Appendix 5 for more details about calculating z-scores. We assigned all rank-based z-scores to the following categories:

- Far Above Average: > 2 Standard Deviations (SD) above the mean
- Above Average: > 1 SD
- Slightly Above Average: 1 to 0.5 SD
- Average: 0.5 to -0.5 SD
- Slightly Below Average: -0.5 to -1 SD
- Below Average: < -1 SD
- Far Below Average: < 2 SD

The z-scores were then mapped using the same methodology for all species/species groups.

SPUE was calculated for hardshell turtles (loggerhead, green, hawksbill and Kemp's ridley) and leatherback turtles. Data for hardshell turtles was combined in recognition of the difficulty of identifying these turtles to species level from the distances associated with aerial and shipboard sightings. In addition, sea turtles are more likely to be on the surface during fall and winter when water temperatures are cool and the sun is out (behavioral thermoregulation; Dodd 2014). As a result, observed seasonal variations in abundance are more likely an artifact of this behavior than movements of animals in and out of an area seasonally. The data set precludes an assessment by turtle life stage (adult, juvenile) and does not allow examination of use of larger coastal estuaries in the SAB region.

Box 4.2. Additional Data and Information

- New shipboard and aerial survey data have been or are in the process of being collected that will improve our knowledge of cetacean and sea turtle distribution in the SAB region but were unavailable for this analysis. Some of this new data collection is being driven by pre-development environmental monitoring of identified offshore wind energy areas within and adjacent to the study area. In addition, passive acoustic monitoring of cetaceans is now taking place in some areas and when combined with the survey data may provide a more complete picture of distribution along the U.S. mid-Atlantic Coast.

- Other information will be available soon through the Cetacean Density and Distribution Mapping Working Group (CetMap). This group has been working on creating "comprehensive and easily accessible regional cetacean density and distribution maps that are time- and species-specific, ideally using survey data and models that estimate density using predictive environmental factors." For more information visit the CetMap website at: http://cetsound.noaa.gov/cda-index.

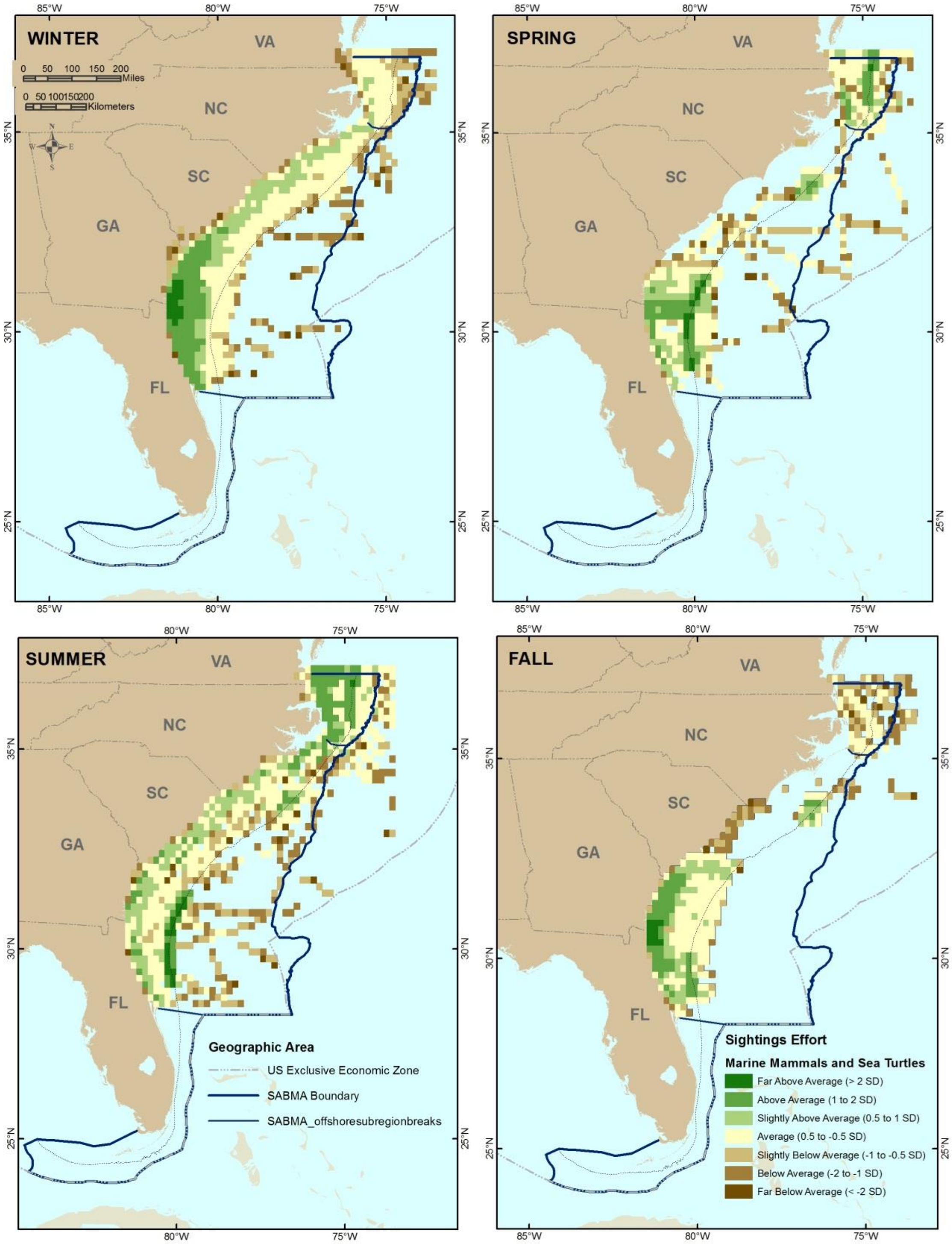

Figure 4.1. Effort grid for in-water cetacean and sea turtle observation surveys utilized in the SPUE Analysis

NORTH ATLANTIC RIGHT WHALE

A recent analysis of North Atlantic right whale (NARW) distribution (effort-corrected) in the SABMA region was obtained from the Florida Fish and Wildlife Conservation Commission (FWC). FWC compiled and analyzed NARW calving season data for the SAB region from a number of researchers made available through the North Atlantic Right Whale Consortium. The compiled data were for the 1991/1992 - 2012/2013 calving seasons (December – March) when these whales are present in the SAB region. Survey effort is presented in Figure 4.2.

FLORIDA MANATEE

Three types of Florida manatee distribution information were obtained from the Florida FWC to summarize distribution of this species in the SABMA study area: aerial distribution surveys, synoptic surveys, and mortality data. For each type, the data were spatially parsed into 1-minute squares. The 1-minute square resolution was used to accommodate the relatively fine scale of the data collected. Although no formal surveys of manatee distribution are conducted in Georgia, they are known to occur (in relatively low numbers) in all tidally connected waters. Manatees are also occasionally observed in the coastal and inshore waters of the other states in the SABMA region.

AERIAL DISTRIBUTION SURVEYS

The FWC and other agencies use aerial distribution surveys to determine the seasonal distribution and relative abundance of manatees. The surveys utilized in the SABMA analysis were typically conducted in inshore waters around the state. Flights were usually between four and six hours long and were most commonly flown every two weeks for two years (FWC, FWRI 2014a).

Most surveys were flown from small, four-seat, high-winged airplanes (Cessna 172 or 182) flying at a height of 150 m (500 ft) at a speed of 130 km/hr (80 mph). The flights were designed to maximize manatee counts by concentrating on shallow nearshore waters, where manatees and their primary food source, seagrasses, are located. Flight paths were parallel to the shoreline, and when manatees were sighted, the airplane circled until the researchers onboard were able to count the number of animals in each group. Deeper waters were usually not surveyed. In urban areas or where waters are particularly opaque, some studies were made using small helicopters. Manatee distributional survey datasets were available for 12 of Florida's 13 Atlantic Coast counties in the MRGIS database or directly from FWC. In addition, the Palm Beach County data and more recent survey data for Duval County were obtained directly from the survey contractors (Dr. James Powell of Sea to Shore Alliance and Dr. Gerry Pinto of Jacksonville University, respectively). Processing of the data for this analysis entailed summarizing the most recent 2 years of distributional survey data available for each county into 1 min grid cells.

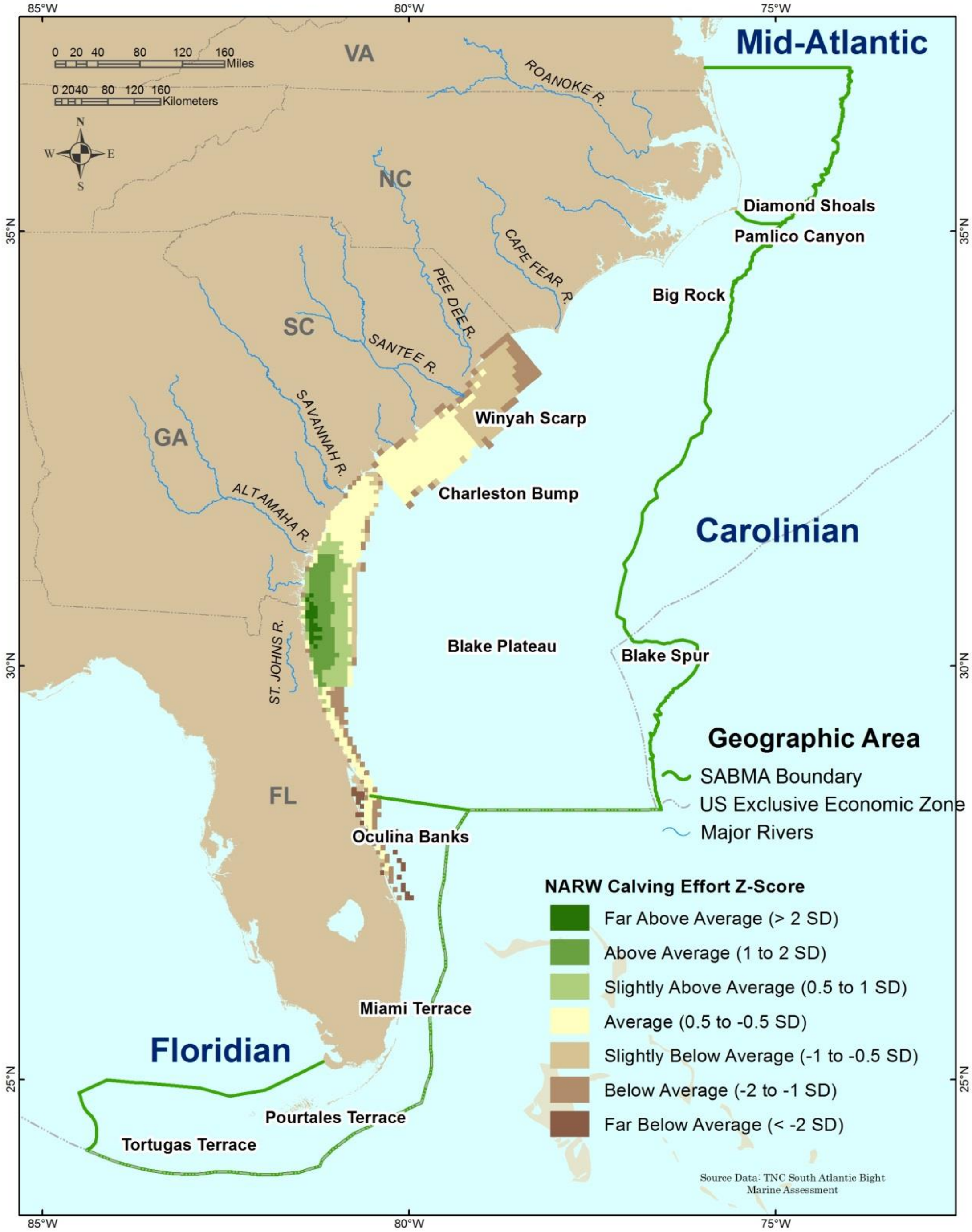

Figure 4.2. Effort map for NARWC aerial survey data from the 1991-2012/2013 calving seasons (December through March)

SYNOPTIC SURVEYS

The FWC also coordinates an interagency team that conducts aerial manatee synoptic surveys. These surveys cover a large area including all of the manatees' known wintering habitats in Florida (FWC, FWRI 2014a). These statewide interagency surveys take place during the winter months and are conducted after cold fronts pass through Florida when manatees gather at warm springs and thermal discharges from power and industrial plants. These surveys are useful in determining minimum estimates of the manatee populations.

Winter synoptic survey data were obtained from the FWC for the years 1991 - 2011. First, abundance for each 1-minute square was calculated. Abundance was measured in numbers of individuals sighted in any given 1-minute square over the years 1991-2011. Persistence is based on the consistency with which a species was observed in the same 1-minute square over time. The weighted persistence score is a variation of the persistence score in which each five-year period is weighted by the average abundance of the species over the five-year period it was present. Because the abundance data were skewed toward low abundances with a few very high abundances, values were log-transformed and mean log abundances were calculated for each five-year period within each 1-square. These five-year mean scores were averaged across all decades to obtain a grand average for each 1-minute square. The grand average was then normalized across all 1-minute squares for manatees to create a metric of abundance ranging between 0.0 and 1.00 for each 1-minute square, with low abundance defined as 0.0-0.49 and high abundance defined as 0.50 – 0.99. The weighted persistence score was calculated by adding the persistence and relative average abundance. In the resulting metric, the integer part of the score is the persistence score while the decimal part of the score is the relative grand average abundance value.

MORTALITY REPORTS

Established in 1974, a network of researchers and law enforcement agencies recover reported manatee carcasses and assist injured manatees. In 1985, field coordination of the rescue program and responsibilities for salvaging and necropsying manatee carcasses were transferred to the state of Florida by the U.S. Fish and Wildlife Service (USFWS) and now rest largely with FWC's Fish and Wildlife Research Institute (FWRI). Manatee mortality data were obtained from the FWC for this study and are current through 2012. While other states in the SAB area also monitor marine mammal mortality, the available data for manatees are not as consistent as Florida's and therefore were not included in the assessment.

SEA TURTLE NESTING

The South Carolina Department of Natural Resources assembled sea turtle nesting information as part of the Governors' South Atlantic Alliance regional geospatial database entitled "Comprehensive Spatial Data on Biological Resources and Uses in Southeastern Coastal Waters of the U.S." Annual state survey data from North Carolina, South Carolina, Georgia and Florida were compiled for 2006-2011. At surveyed beaches mean nesting density per segment of beach was calculated and mapped. We applied a similar approach to sea turtle nesting in the portion of Virginia falling within the SAB region (beaches within the boundaries of the City of Virginia Beach, Virginia). These data were obtained from the Back Bay National Wildlife Refuge. The Northwest Atlantic population of loggerhead sea turtles, which nests primarily within the SAB region, is comprised of several genetic subunits (Shamblin et al. 2011, 2012). The FWC recognizes four genetic subunits in Florida (FWC 2014b) and one in the remainder of the SAB region: Upper SAB (North Carolina to the Florida border), Northeast Florida (Florida border south to Ponce Inlet), Central East Florida (Ponce Inlet south to St. Lucie Inlet), Southeast Florida (St. Lucie Inlet south to Key West), and the Dry Tortugas unit (includes Marquesas) (Figure 4.3). From a genetic/scientific standpoint, the upper SAB subunit of loggerheads is defined as all animals nesting from Ponce Inlet to the northern extent of the range in Virginia (Shamblin et al. 2012), but for geopolitical reasons the subunit is defined as above to facilitate management. For purposes of evaluation, the density of sea turtle nesting on beach segments was compared within the defined genetic subunits (Figure 4.3).

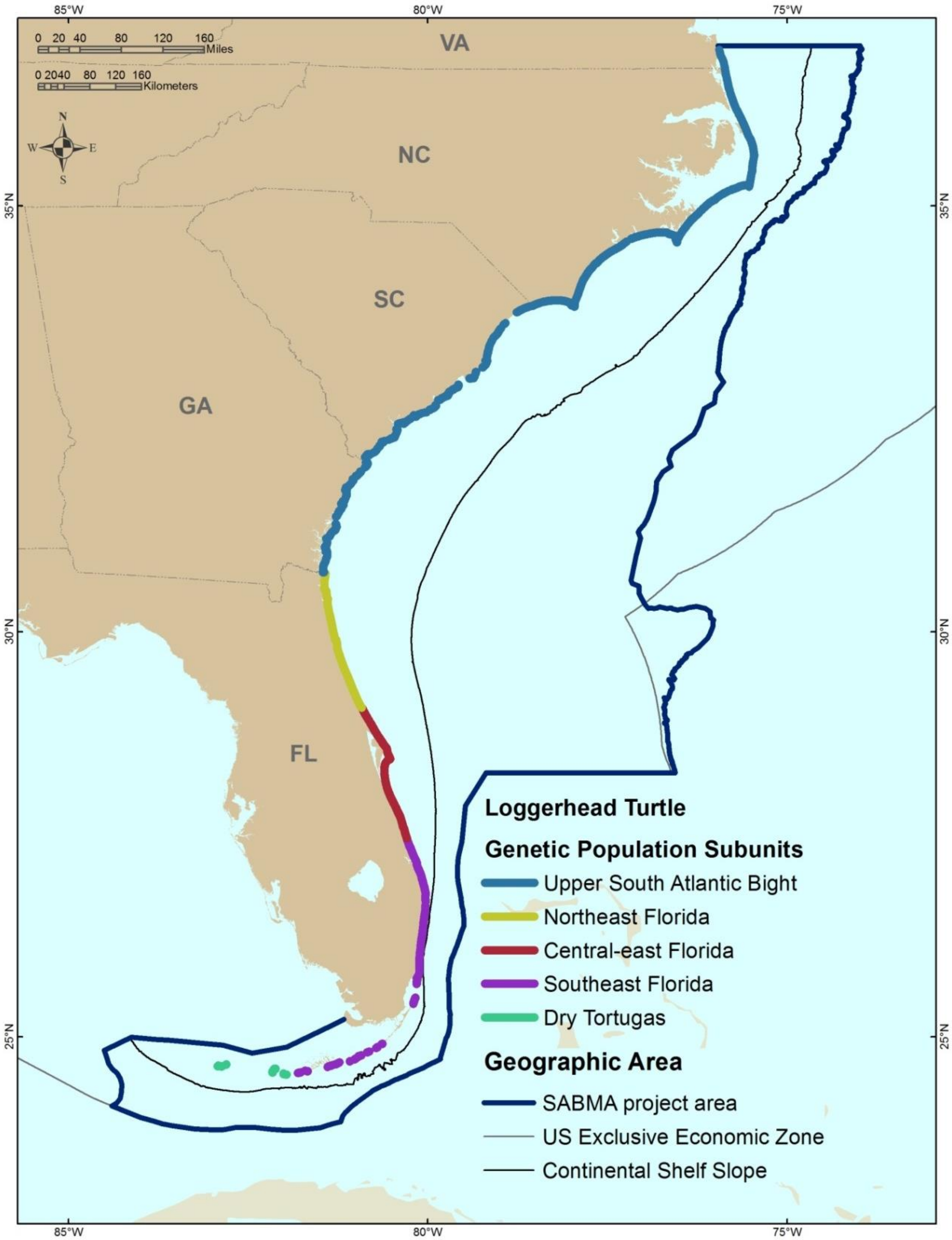

Figure 4.3. Loggerhead turtle genetic subunits within the South Atlantic Bight region

Maps, Analysis, and Areas of Importance

CETACEANS

The number of sightings varied considerably by species (Table 4.2). Due to the limited number of observations for some cetacean species in the study area, results were in some cases compiled into species groups when species shared similar or overlapping distributions (see Table 4.2). The groupings include spotted dolphins, pilot whales, and beaked whales. While long-finned and short-finned pilot whales overlap in range in the mid-Atlantic, the short-finned pilot whale's distribution is more southerly and the long-finned pilot whale's is more northerly.

Species displayed separately due to unique distribution patterns and/or listed status under the ESA includes the humpback, fin, North Atlantic right and sperm whales, and the Risso's, bottlenose and common dolphins. Distributions of species groups and individual species are described below. Cetacean distributions are mapped by season with the exception of the North Atlantic right whale which is only mapped for the season in which it appears in the study area, winter. Maps for all the in-water distributions are presented as z-scores (mean and standard deviations from the mean). The table in Appendix 6 provides a translation map between the z-scores and the sightings per unit effort. Absence of observations, especially in lightly surveyed areas, should not be interpreted to mean that the species, species group, or cetaceans in general do not occur there.

Table 4.2. Species/species groups displayed in the in-water distribution maps including number of sightings in the SAB region from the Navy Marine Resource Assessment (Department of Navy 2008)

Species/ Species Group Mapped	Sight-ings	Group Members	Scientific Name
North Atlantic Right Whale	1,299		*Eubalaena glacialis*
Fin	32		*Balaenoptera physalus*
Humpback	106		*Megaptera novaeangliae*
Spotted Dolphin/*Stenella* Group (Oceanic dolphins)			
	522	Atlantic Spotted Dolphin	*Stenella frontalis*
	7	Clymene Dolphin	*Stenella clymene*
	43	Pantropical Spotted Dolphin	*Stenella attenuata*
	5	Spinner Dolphin	*Stenella longirostris*
	92	Unidentified Spotted Dolphin	*Stenella spp.*
	19	Striped Dolphin	*Stenella coeruleoalba*
	439	Unidentified Stenella spp.	
Risso's Dolphin	113		*Grampus griseus*
Bottlenose Dolphin (Coastal & Oceanic)	55,454		*Tursiops truncatus*
Pilot Whales			
	275	Long-finned Pilot Whale	*Globicephala melas*
	76	Short-finned Pilot Whale	*Globicephala macrorhynchus*
Common Dolphin	78		*Delphinus delphis*
Sperm Whale	132		*Physeter macrocephalus*
Ziphiidae [Beaked Whales]	41	Beaked Whale grouping	family *Ziphiidae*

HUMPBACK WHALE

Humpback whales are most prevalent in the study area in winter, when they appear to be concentrated in two areas: within approximately 75 miles of shore offshore of Georgia and northern Florida to the southern limit of the available data, and offshore of northern North Carolina and southern Virginia (the northern boundary of the SABMA study area; Figure 4.4). Based on the Navy SPUE data, humpbacks were not observed in the study area during the summer and fall and only a very limited number of sightings were recorded in spring off the coast of northern North Carolina, however, documented sightings and strandings of this whale have been recorded in the study area in all seasons (Swingle, pers. comm.).

FIN WHALE

Fin whales are most prevalent in the study area in winter and spring (Figure 4.5). During these seasons, they are most concentrated off northern North Carolina and southern Virginia (to the northern boundary of the SABMA study area). In the spring, observations are most concentrated near the shelf break. During winter, fin whales are somewhat more dispersed in this same general area with another small concentration of sightings off northern North Carolina. Fin whales were not observed in the study area during fall and were only sighted a few times in the extreme north of the study area in summer.

NORTH ATLANTIC RIGHT WHALE

In the SABMA region, North Atlantic right whales are regularly found in coastal waters from South Carolina to Florida during their calving season (December to mid-March) with the highest concentrations off north Florida and southern Georgia (Figure 4.6; Winn 1984; Kraus et al. 1986; IWC 1986). In early to mid-March, North Atlantic right whales leave their calving grounds and head to feeding grounds in Cape Cod Bay and Gulf of Maine (Kenney and Winn 1986, Mitchell et al. 1986, Kenney et al. 1995). In the spring, the area between their calving grounds and southern feeding grounds around Cape Cod Bay has been identified as a primary migratory corridor for this whale (Firestone et al. 2008). While the endpoints of their migration are known, little is known about the seasonal movements of right whales within this migratory corridor (Wiley et al. 1995).

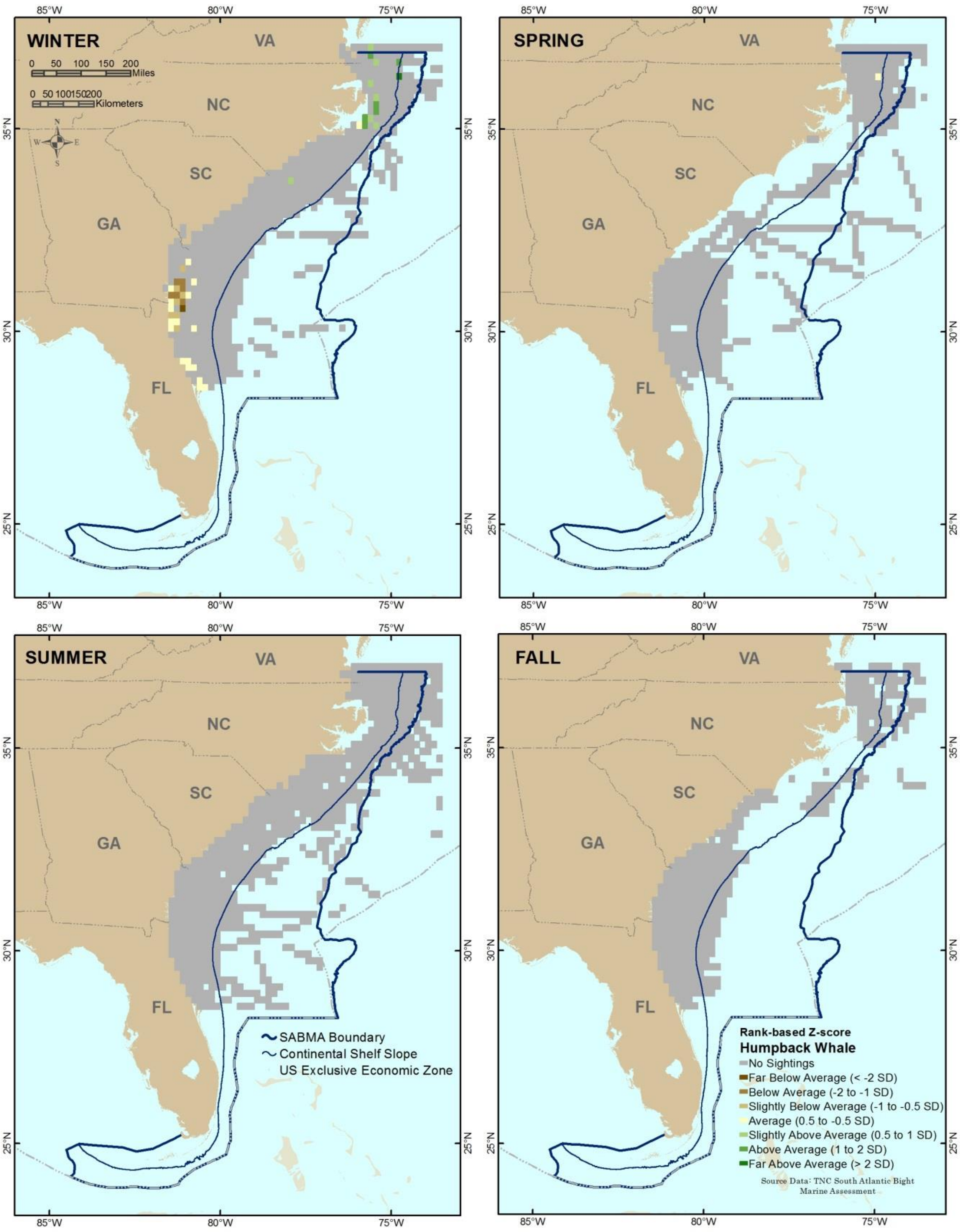

Figure 4.4. Humpback whale distribution maps by season

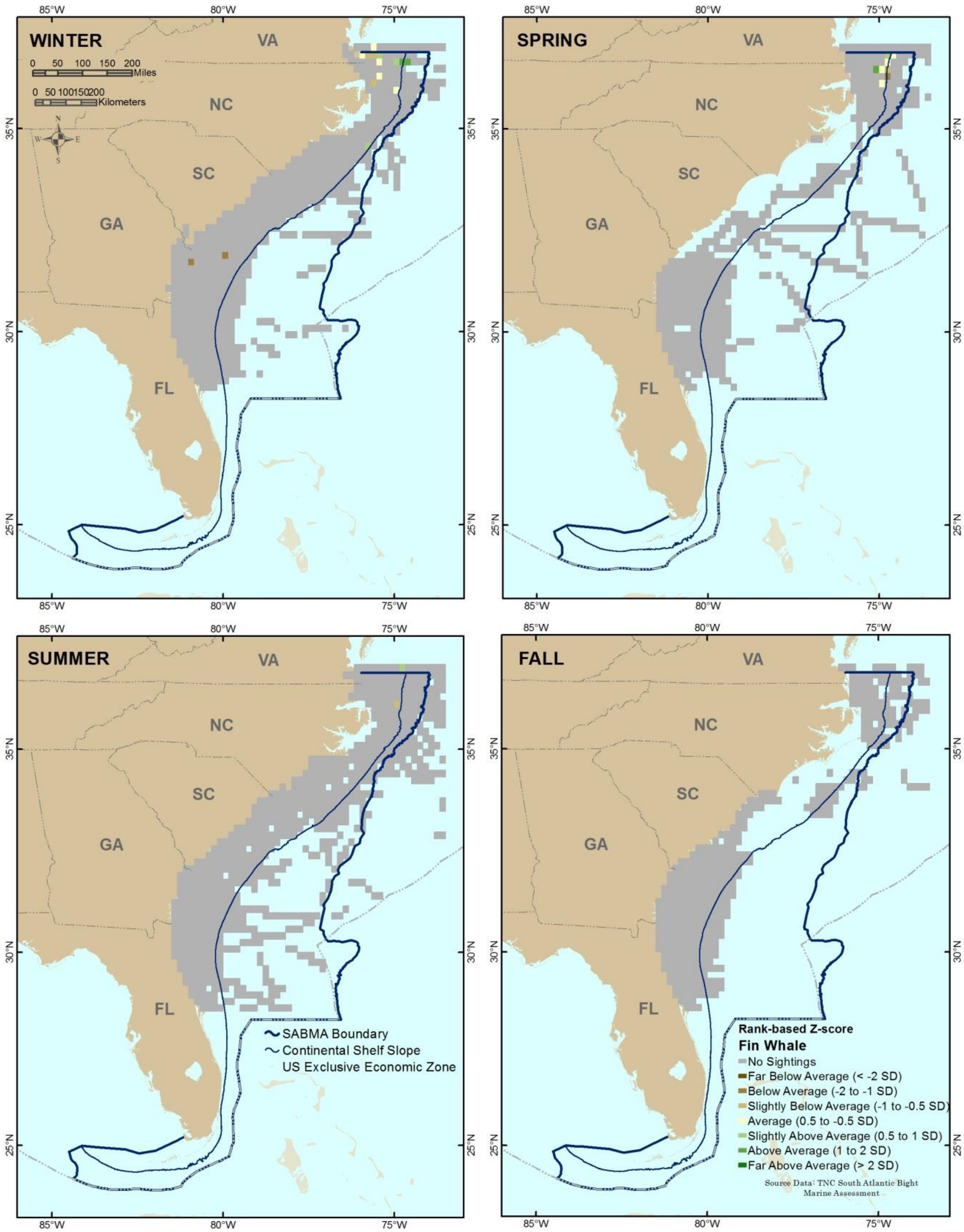

Figure 4.5. Fin whale distribution maps by season

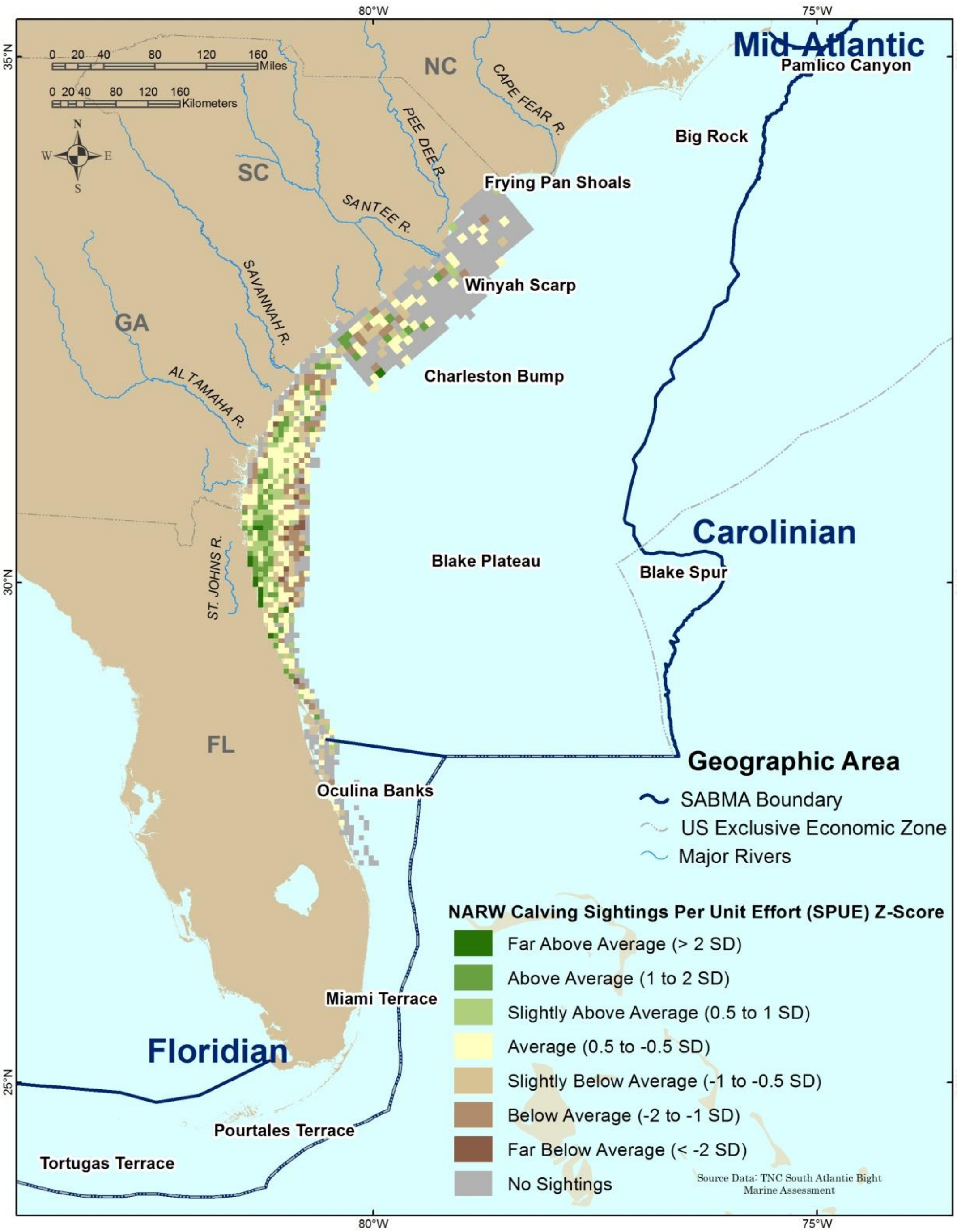

Figure 4.6. Map of North Atlantic Right Whale distribution during the 1991/1992 - 2012/2013 calving seasons (December through March)

BOTTLENOSE DOLPHIN

Two morphologically and genetically distinct bottlenose dolphin morphotypes are found in the Northwest Atlantic Ocean (Duffield et al. 1983; Duffield 1986): the coastal and offshore forms. The coastal form has been differentiated into a number of coastal populations based on genetic analyses, each of which is managed as a separate stock by NMFS. The data utilized for this study only evaluated offshore and nearshore populations of bottlenose dolphins, not those that inhabit the estuarine portion of the study area. In the winter, bottlenose dolphin sightings were the highest, with greatest concentrations of sightings in offshore areas off North Carolina and nearshore areas off northern Florida (Figure 4.7). In the summer, bottlenose dolphins were present in both nearshore and offshore areas throughout most of the study area. In fall and spring, they were mostly found off Cape Hatteras in the northern portion of the study area and off the South Carolina, Georgia and northern Florida coasts.

OCEANIC DOLPHINS

Oceanic or Atlantic and pantropical spotted dolphins (*Stenella* spp.) are found throughout the SABMA study area year-round and display movement patterns that appear to vary by season (Figure 4.8). A large number of spotted dolphin sightings were recorded in the winter and summer, a smaller number of sightings were recorded in spring, and there were relatively few sightings in fall. In winter and summer, spotted dolphins were located throughout the study area in relatively large numbers. In spring, most sightings were recorded off northern Florida, Georgia and South Carolina, northern North Carolina and southern Virginia. Survey effort off the southern portion of North Carolina was very limited. In fall, relatively fewer spotted dolphins were recorded where surveys took place. Little is known of these species' migratory patterns.

RISSO'S DOLPHIN

Risso's dolphins were present in the study area year-round, primarily in deeper waters of the Continental Slope (Figure 4.9). They were more widely distributed in spring and summer. In the fall Risso's dolphins were only documented in the northern portion of the study area in Continental Slope waters off southern Virginia and North Carolina.

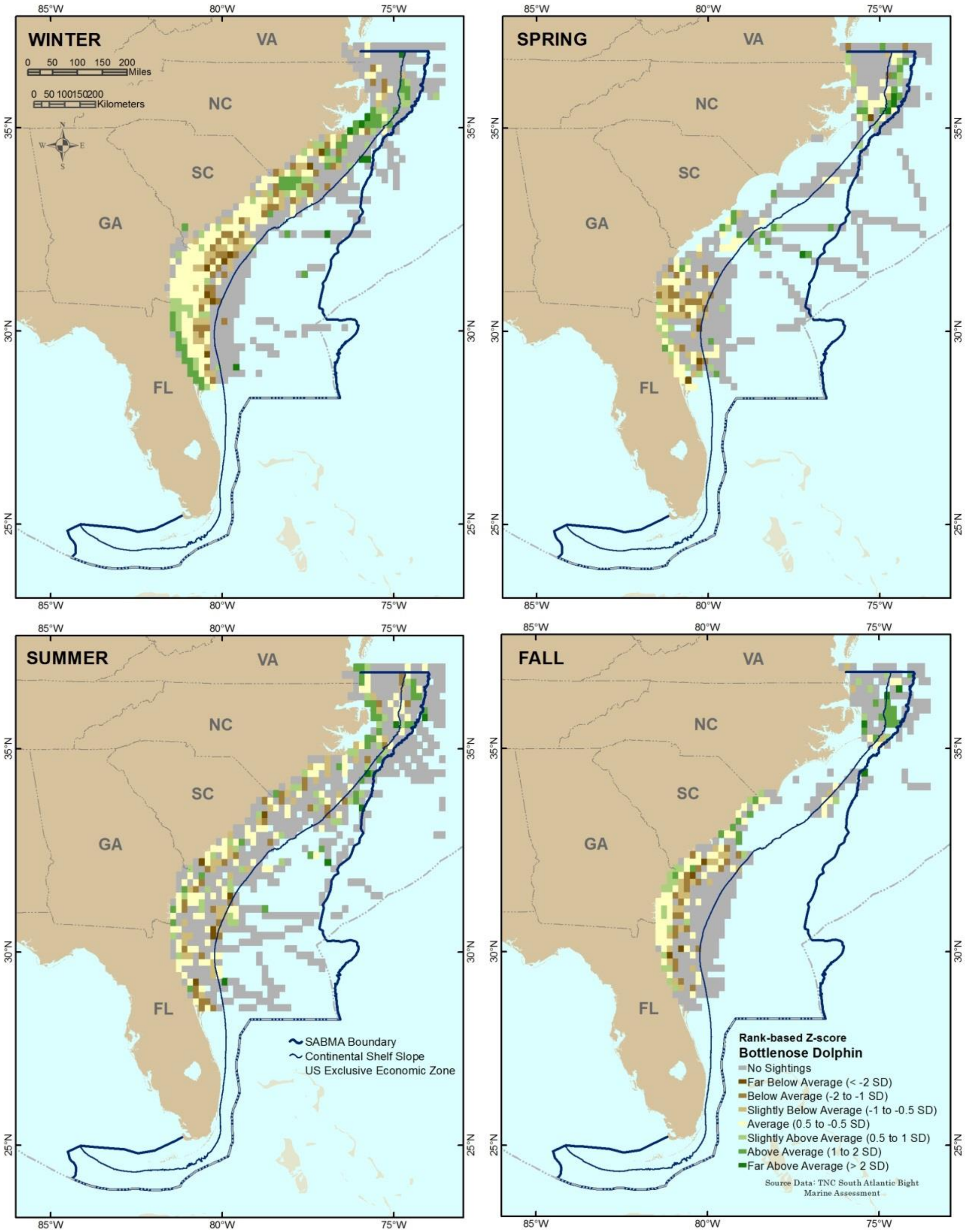

Figure 4.7. Bottlenose dolphin distribution maps by season

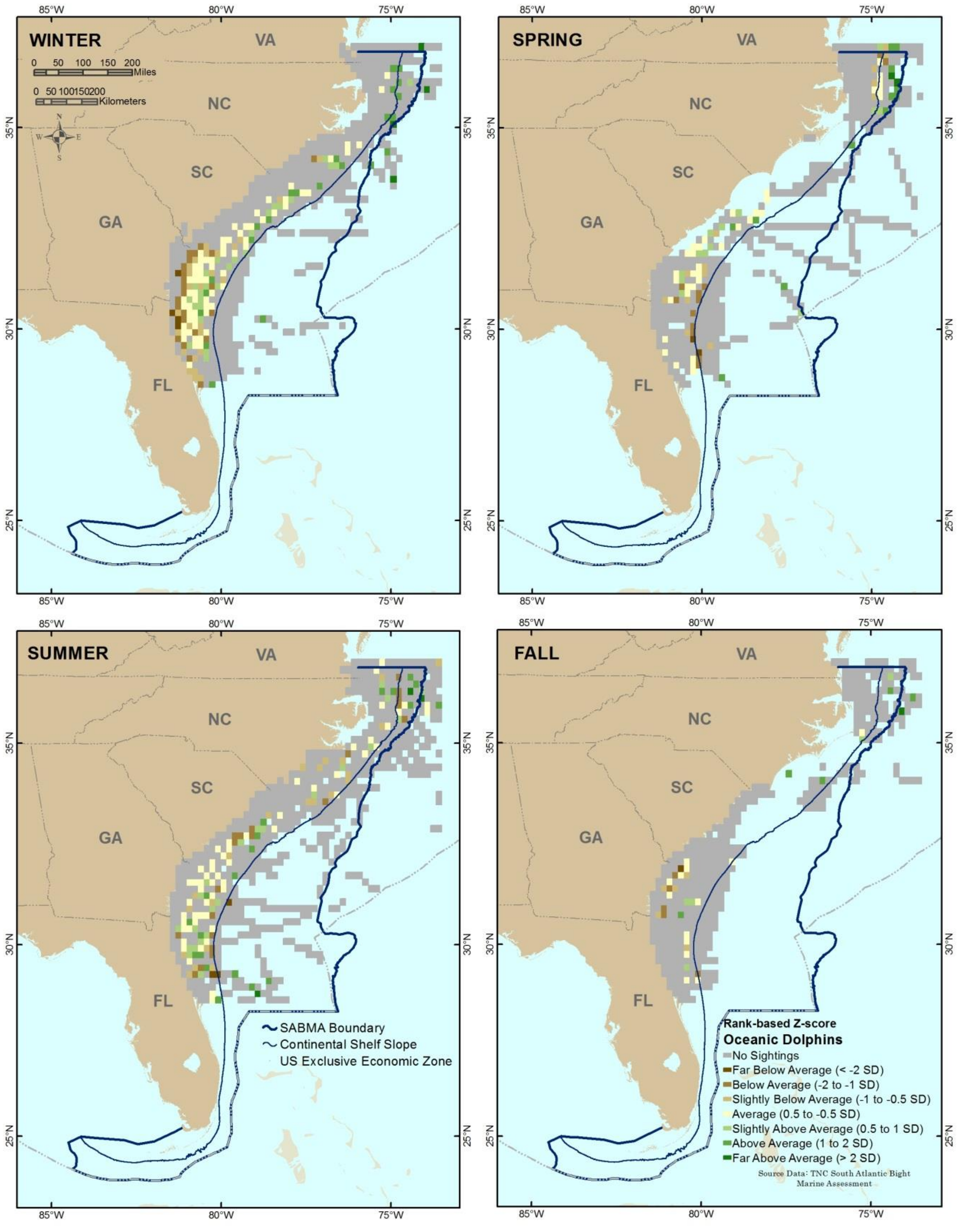

Figure 4.8. Oceanic dolphins (*Stenella* spp.) distribution maps by season

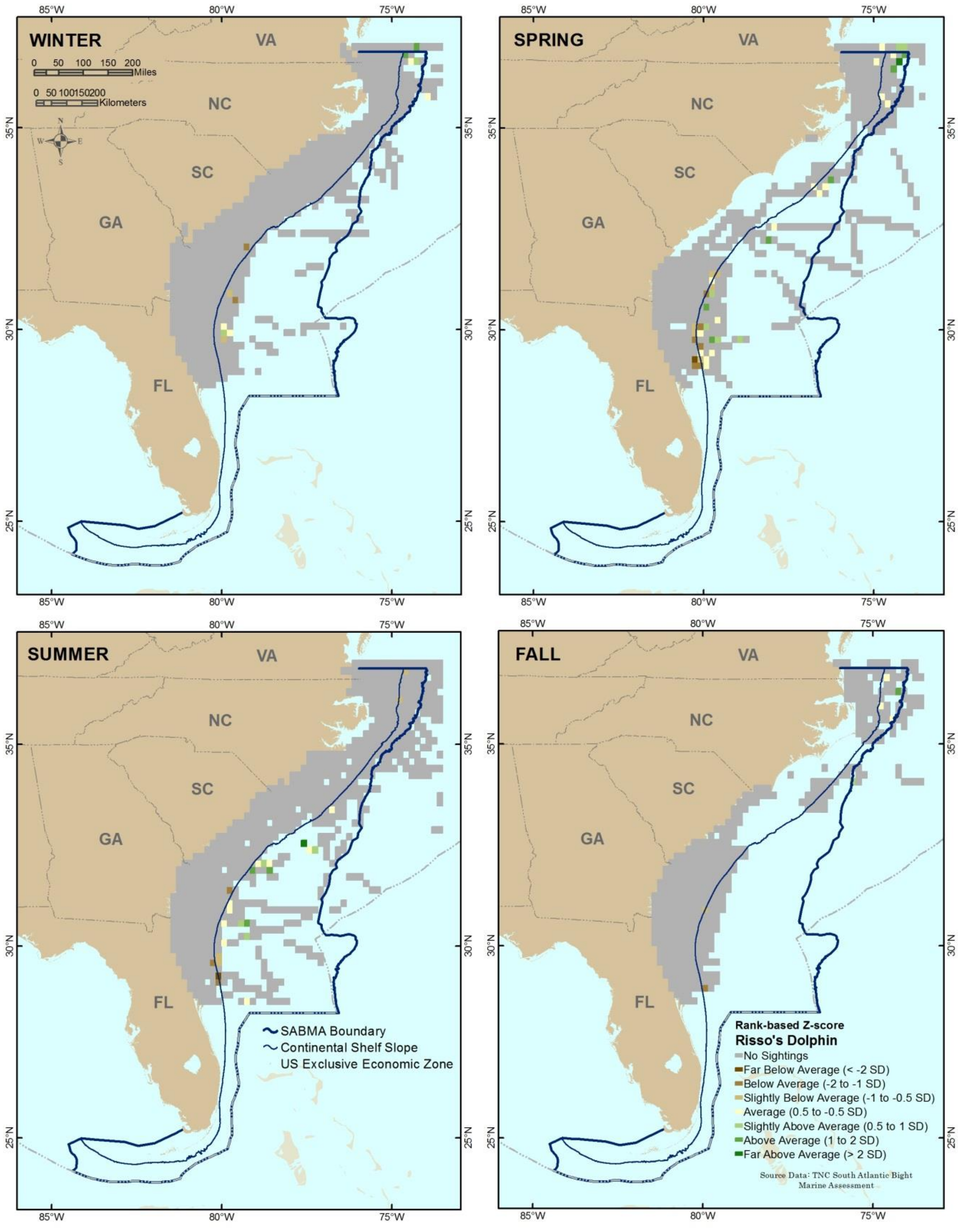

Figure 4.9. Risso's dolphin distribution maps by season

COMMON DOLPHIN

Data used in this assessment indicated that the common dolphin is primarily found in the northern portion of the study area from North Carolina north in the vicinity of shelf break waters (Figure 4.10). Prevalence was greatest in winter, particularly in shelf and shelf break waters off North Carolina and southern Virginia. Sightings declined in spring and were relatively low in summer and fall.

PILOT WHALES (LONG-FINNED AND SHORT-FINNED)

Pilot whales were prevalent in the SAB region in all seasons (Figure 4.11). A year-round concentration area for these whales appears to be shelf break and slope areas off Cape Hatteras. In the winter, pilot whales had a second concentration area off the northeast Florida coast. In all seasons, a portion of the pilot whales observed were broadly distributed in shelf slope waters off north Florida to the SABMA boundary (southern Virginia).

SPERM WHALE

Data indicated that sperm whales are present along the shelf-slope break in the northern portion of the study area, primarily between 200 and 2000 m depth off North Carolina (Figure 4.12). Other studies have indicated similar patterns in sperm whale distribution, reporting that sightings are centered along the Continental Shelf break and over the Continental Slope from 100 to 2000 m deep and in submarine canyons and edges of banks (Waring et al. 2008). In winter, North Atlantic Stock whales are concentrated east and northeast of Cape Hatteras. In spring, summer, and fall their distribution shifts northward and out of the SABMA study area (NOAA 2014b).

BEAKED WHALES (CUVIER'S, BLAINVILLE'S, GERVAIS' AND TRUE'S BEAKED WHALES)

Beaked whales were infrequently encountered in the SABMA region. The data suggest that their distribution is diffuse in Continental Shelf and Slope waters (Figure 4.13). Members of this family group were present in every season except fall. Cuvier's and Blainville's beaked whales are known to have a cosmopolitan distribution (NOAA 2014b).

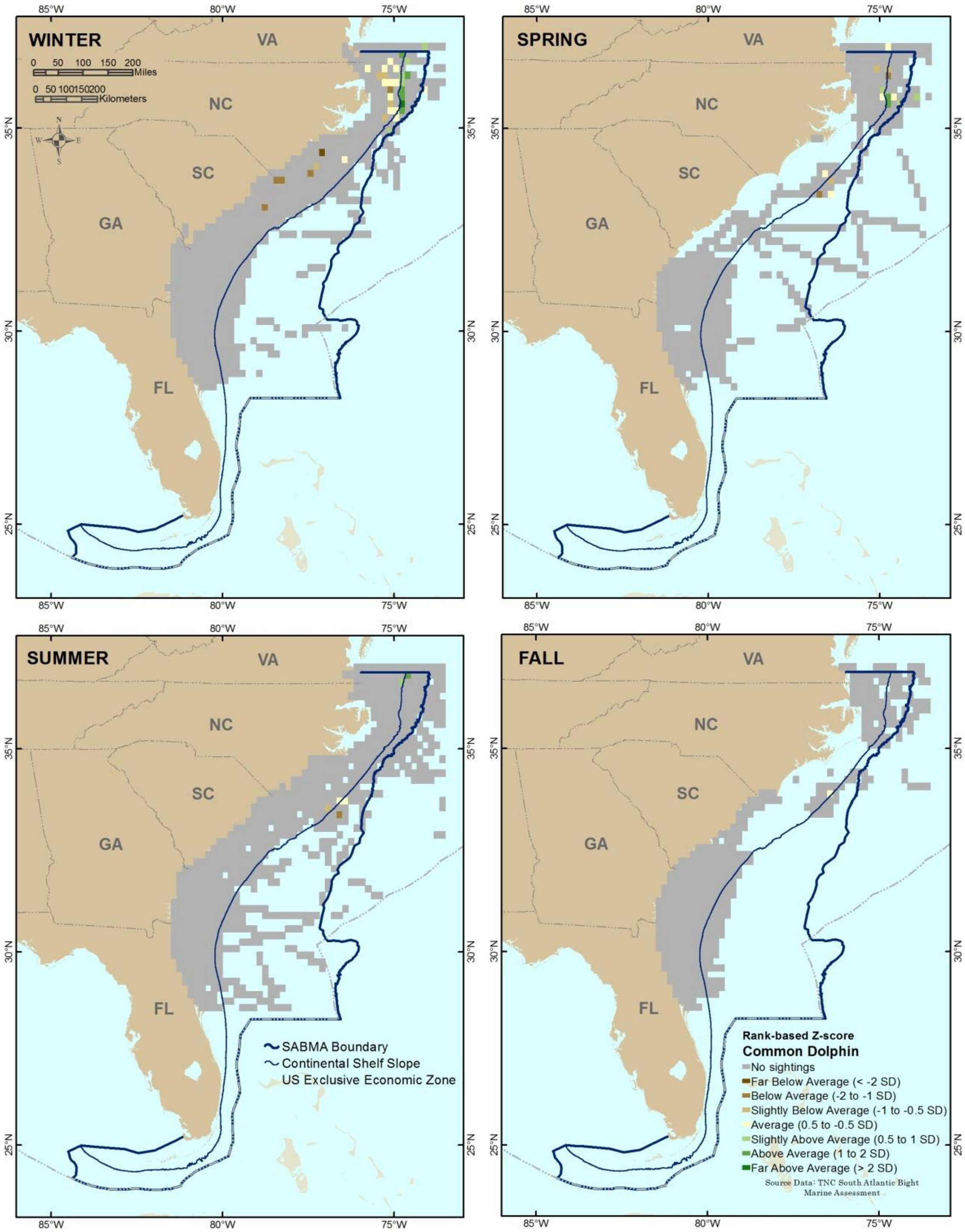

Figure 4.10. Common dolphin distribution maps by season

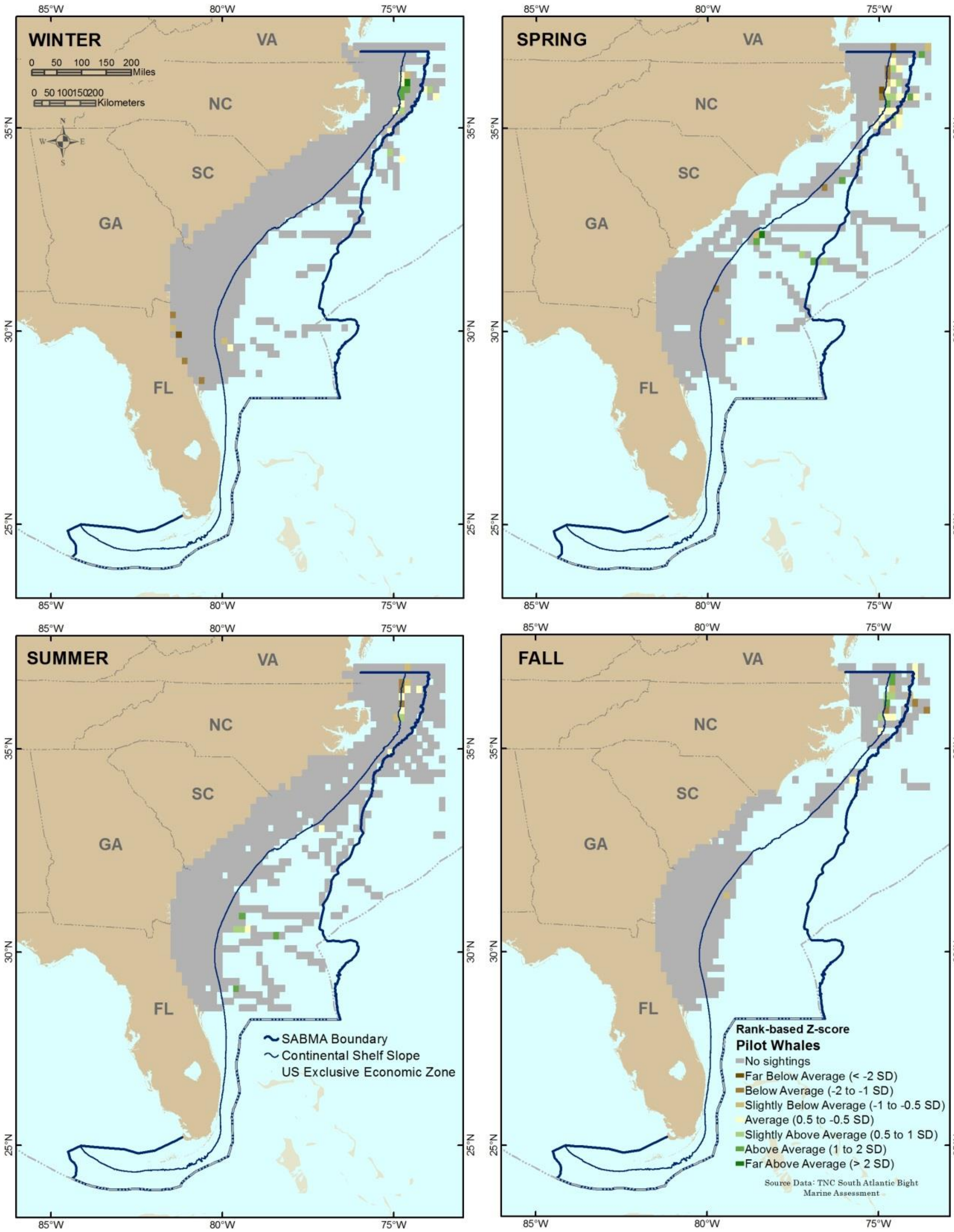

Figure 4.11. Pilot whale distribution maps by season

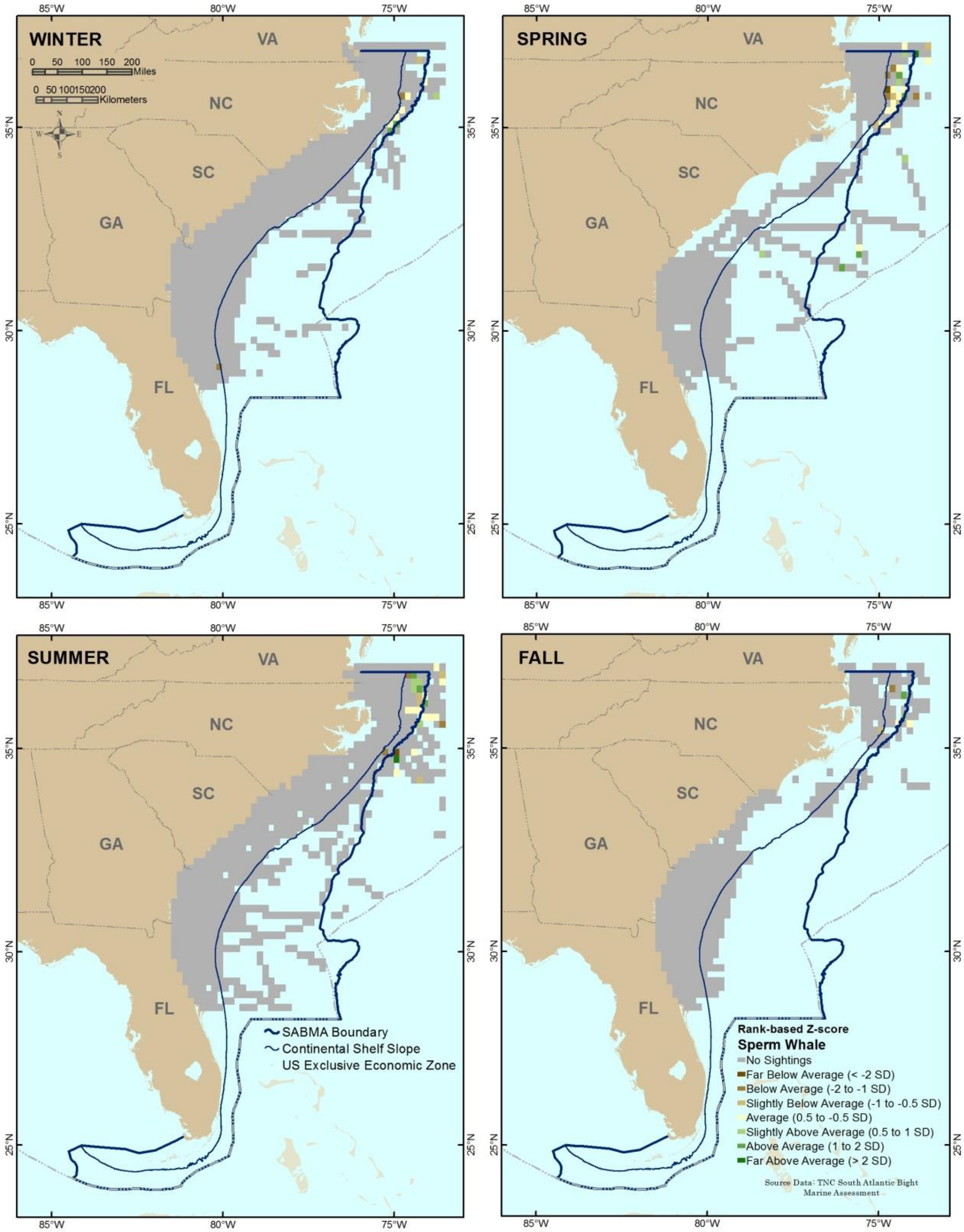

Figure 4.12. Sperm whale distribution maps by season

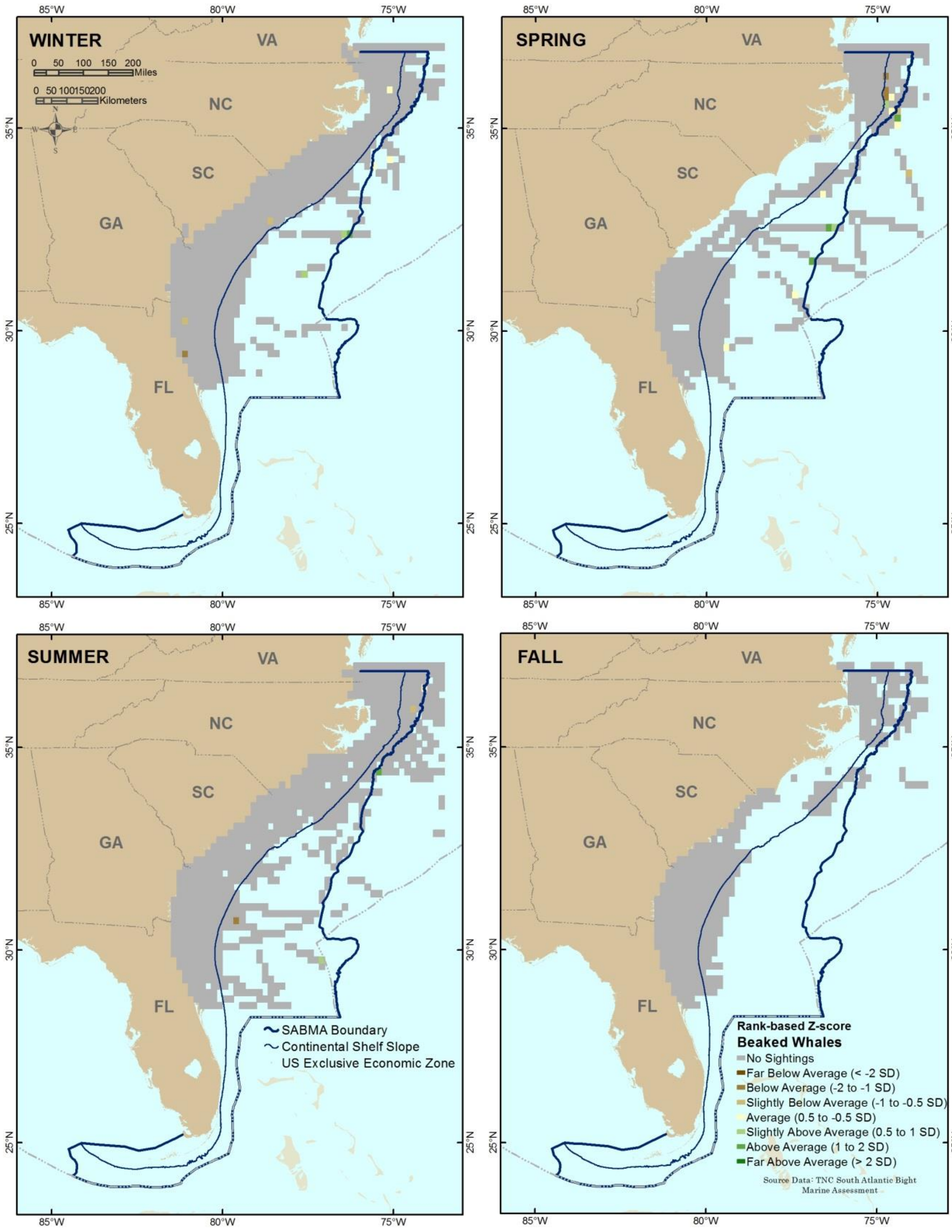

Figure 4.13. Beaked whales (family Ziphiidea) distribution maps by season

Box 4.3. Comparison to Northwest Atlantic Marine Ecoregional Assessment Results

While the cetacean species selected for analysis in the Northwest Atlantic Marine Ecoregional Assessment (NAMERA; Greene et al. 2010) and for this assessment do not completely overlap, there are several whale species whose sightings can be compared: the fin, humpback, and North Atlantic right whales and the bottlenose dolphin. In general, the large whale species were sighted more frequently in the NAMERA study area (Cape Hatteras in North Carolina to the northern limit of the Gulf of Maine in Canadian waters) whereas bottlenose dolphins were sighted more frequently in the SABMA study area. The greatest difference in effort-corrected sightings was for the humpback whale, for which average sightings across all seasons in the NAMERA study area were nearly 100 times greater than for the SABMA study area (3120 versus 32 SPUE, respectively). Effort-corrected fin whale sightings were more than 20 times greater in the NAMERA study area as compared to the SABMA study area over the same period (2707 versus 110 SPUE, respectively). North Atlantic right whale sightings were more than 15 times greater in the NAMERA study area (2065 versus 132 SPUE, respectively) and sperm whale sightings were approximately 31% greater in the NAMERA versus SABMA study area (2294 versus 2294 SPUE, respectively). Approximately 86% more bottlenose dolphin sightings were observed in the SABMA study area versus the NAMERA study area (75,774 versus 40,646 SPUE, respectively).

FLORIDA MANATEE

Analysis of the three sources of Florida distribution information used in the assessment revealed that the Florida manatee was generally present throughout tidally connected waters. The winter synoptic survey results for the years 1992 through 2011 are illustrated in a weighted persistence format. Table 4.3 below provides the abundance ranges used to categorize high and low abundance in each of the persistence categories. The weighted persistence maps (Figures 4.14-4.16) highlight that the most important overwintering areas for the Florida manatee in the SABMA region are in southern Florida from the upper Florida Keys to the St. Lucie Inlet with a few additional isolated important areas including Vaca Key in the Florida Keys, a few locations along the Indian River Lagoon, and the spring-fed Blue Springs area of the St. Johns River more than 100 miles upstream (south) of where the river meets the ocean.

The available distributional survey results (Figures 4.17 through 4.19) suggest that the upper St. Johns River (northern portion) and the east-central Florida coast from Cape Canaveral south to Palm Beach County have the greatest concentration of high abundance areas along the Florida coast.

Results of the mortality recovery locations (Figures 4.20-4.22) are more difficult to interpret as they may indicate both where manatees are concentrated as well as where manatees are most vulnerable to human impacts (e.g., boat strikes). The mortality location maps display a spatial pattern similar to the distributional survey maps, with the exception that mortality also appears to be high in Broward and Miami-Dade counties.

Table 4.3. Abundance ranges used to categorize high and low abundance categories for the Florida manatee winter synoptic survey weighted persistence maps

Persistence Category	Abundance Category	Abundance Range (animals per cell)
Occurred in All 4 Five Year Periods	High Abundance	2022 to 46.5*
Occurred in All 4 Five Year Periods	Low Abundance	77.25 to 1.75
Occurred in 3 Five Year Periods	High Abundance	172**
Occurred in 3 Five Year Periods	Low Abundance	40.7 to 88
Occurred in 2 Five Year Periods	Any Abundance	44 to 1
Occurred in 1 Five Year Period	Any Abundance	247 to 1

** Overlap in high and low abundance categories is a result of normalizing the data and the top range value in this category (77.25) is an outlier caused by a declining trend in abundance.*

***Only one cell in the high abundance category.*

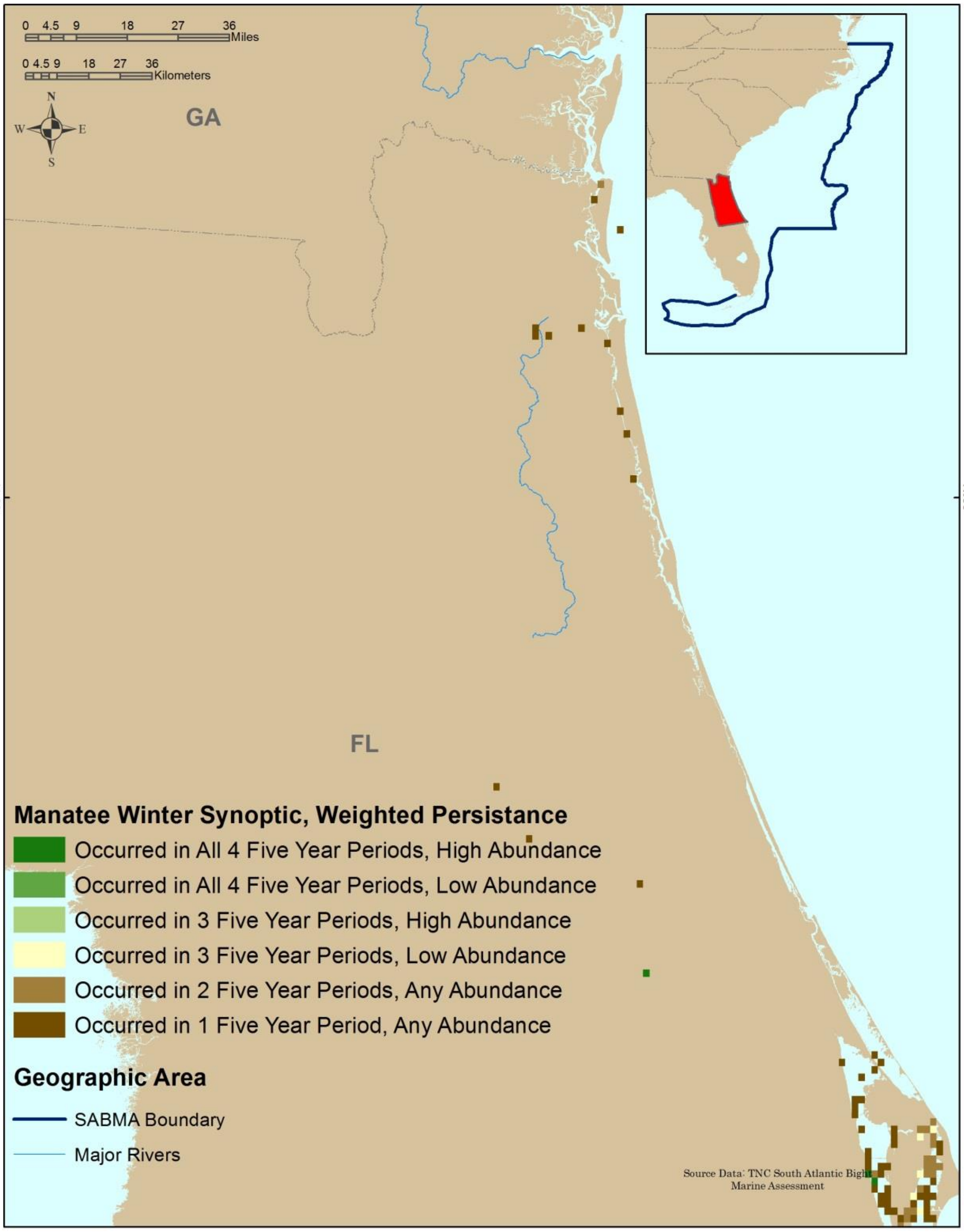

Figure 4.14. Manatee weighted persistence maps developed from winter synoptic aerial survey data, Northeast Florida. The St. Johns River extends further south than what is shown on the map.

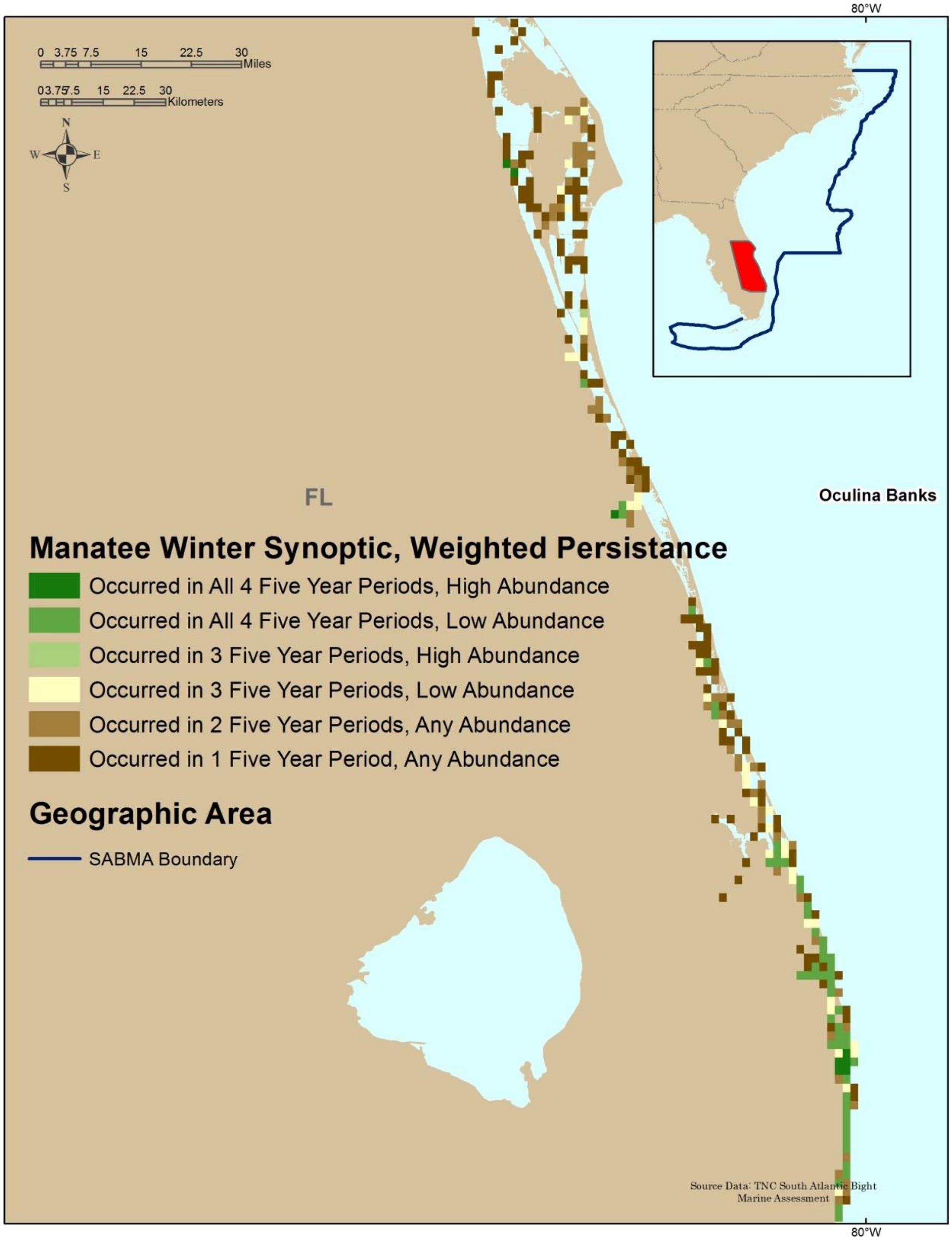

Figure 4.15. Manatee weighted persistence map developed from wither synoptic aerial survey data, east-central Florida

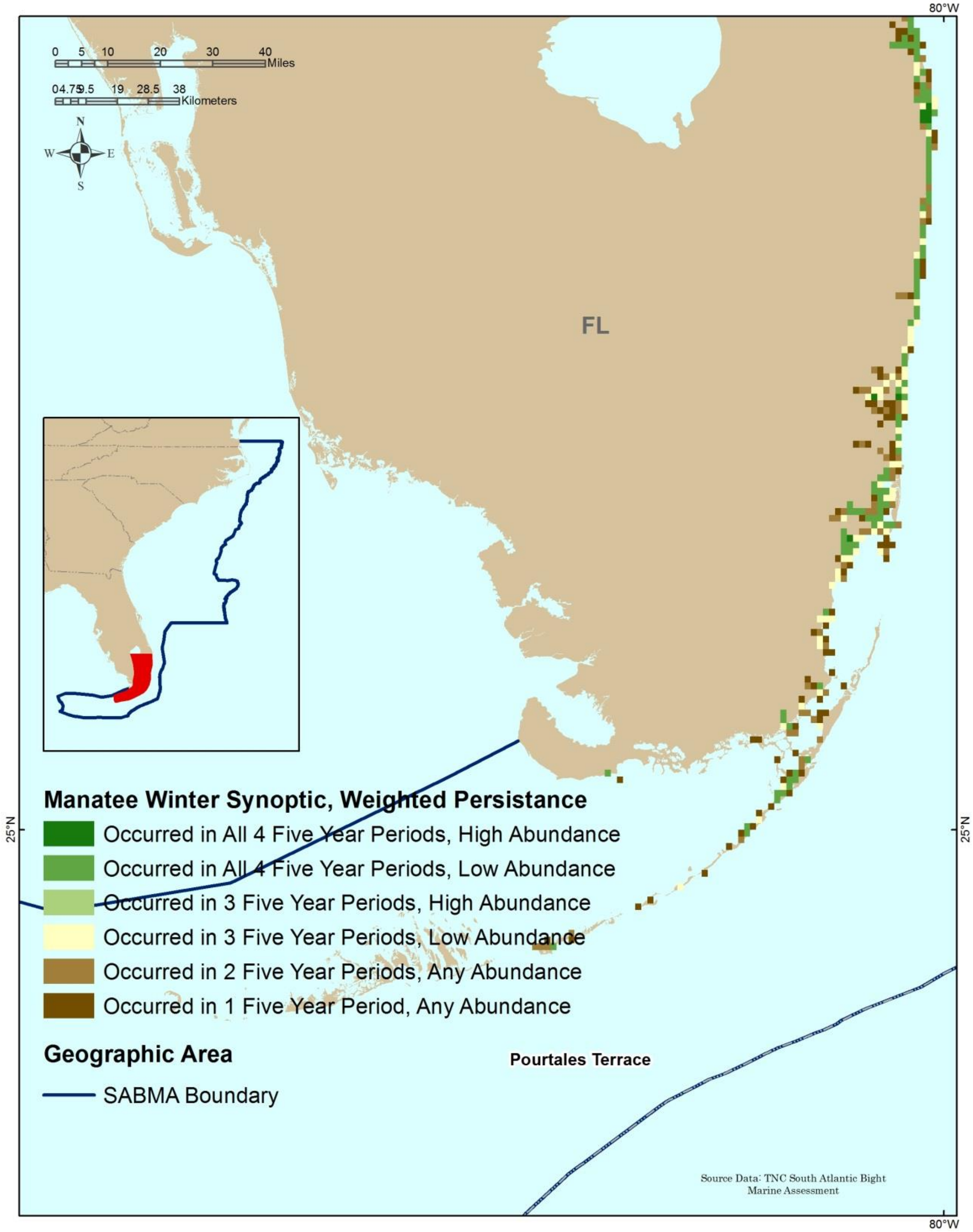

Figure 4.16. Manatee weighted persistence map developed from winter synoptic aerial survey data, southeast Florida

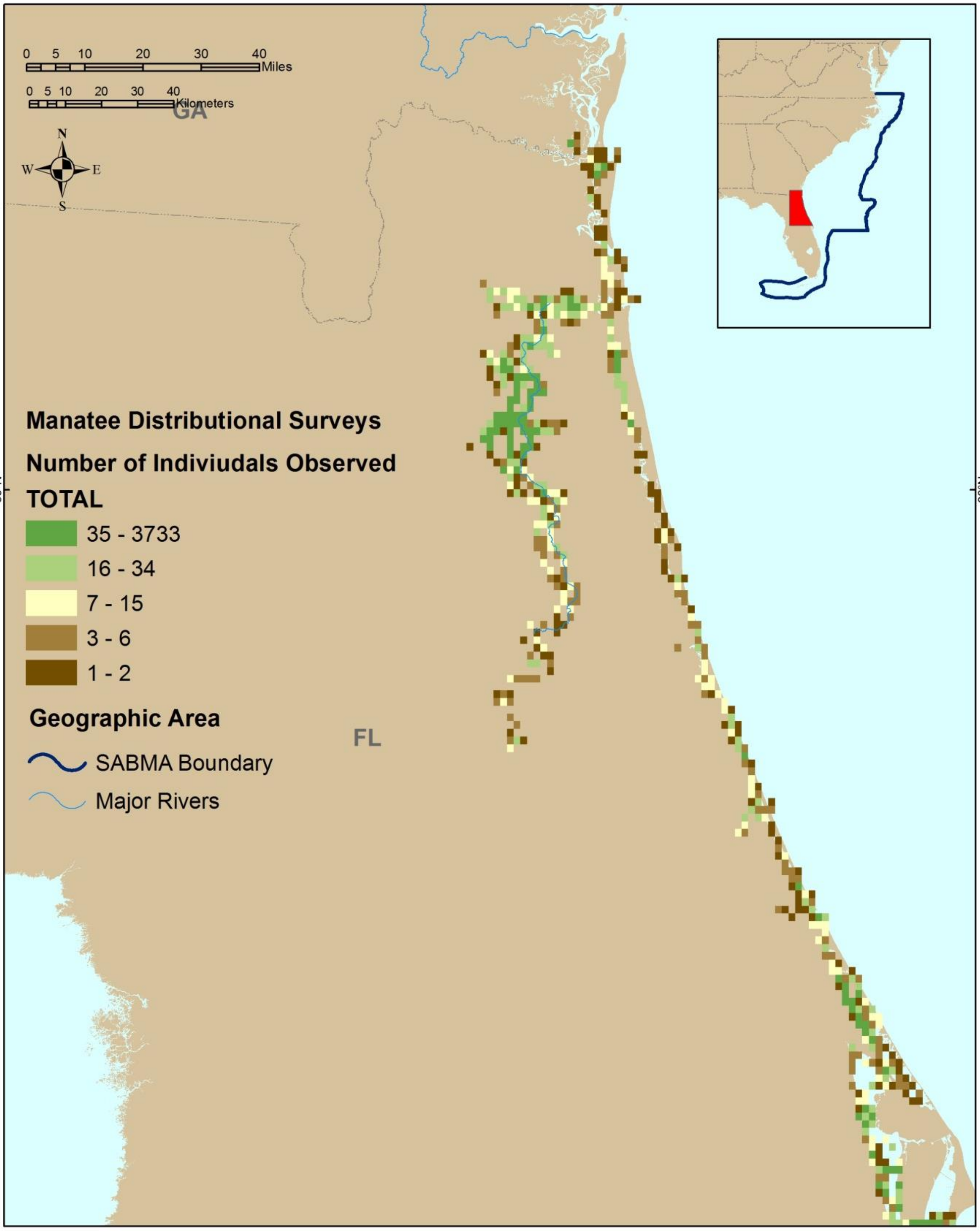

Figure 4.17. Manatee abundance map developed from distributional survey data, northeast Florida

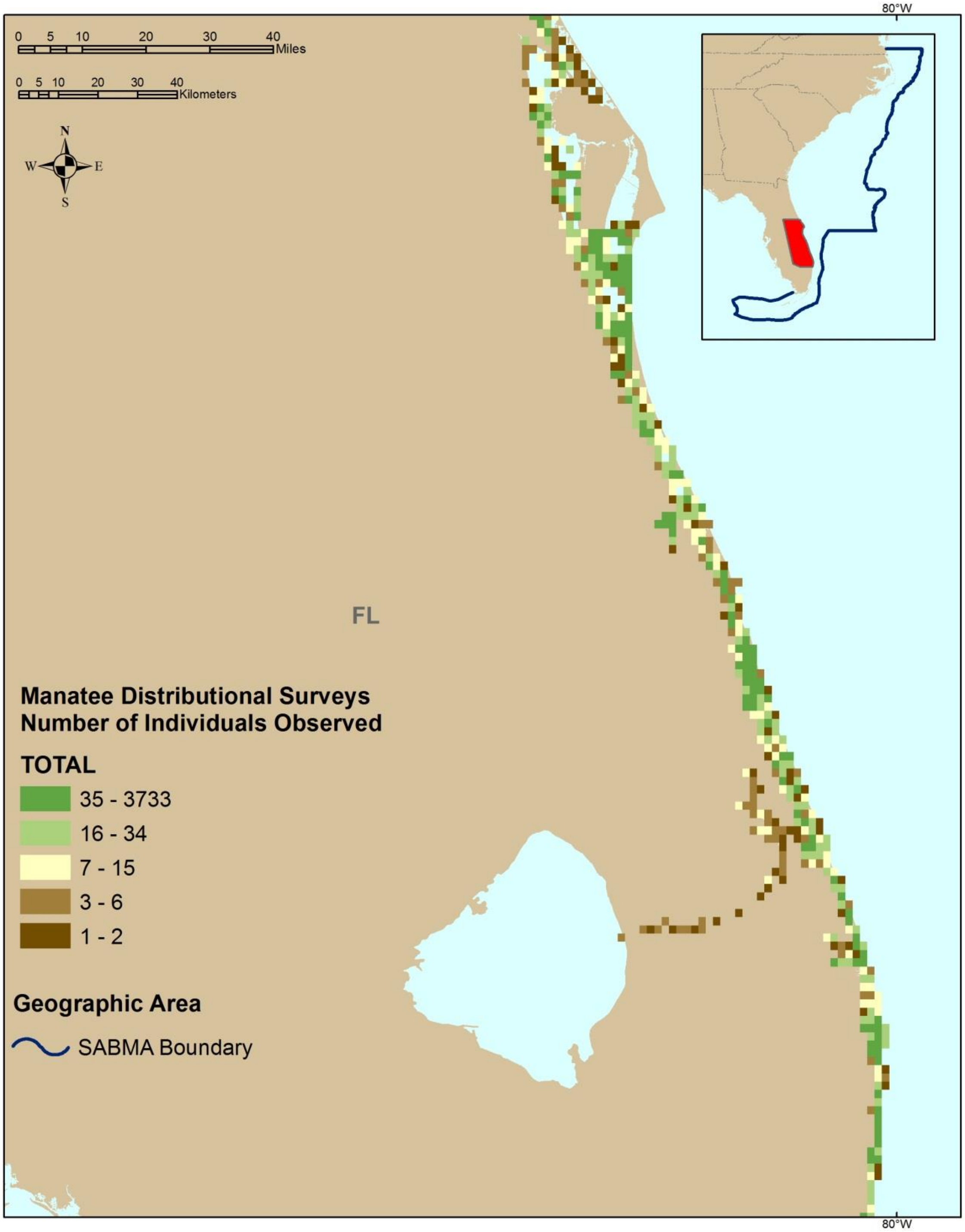

Figure 4.18. Manatee abundance map developed from distributional survey data, east-central Florida

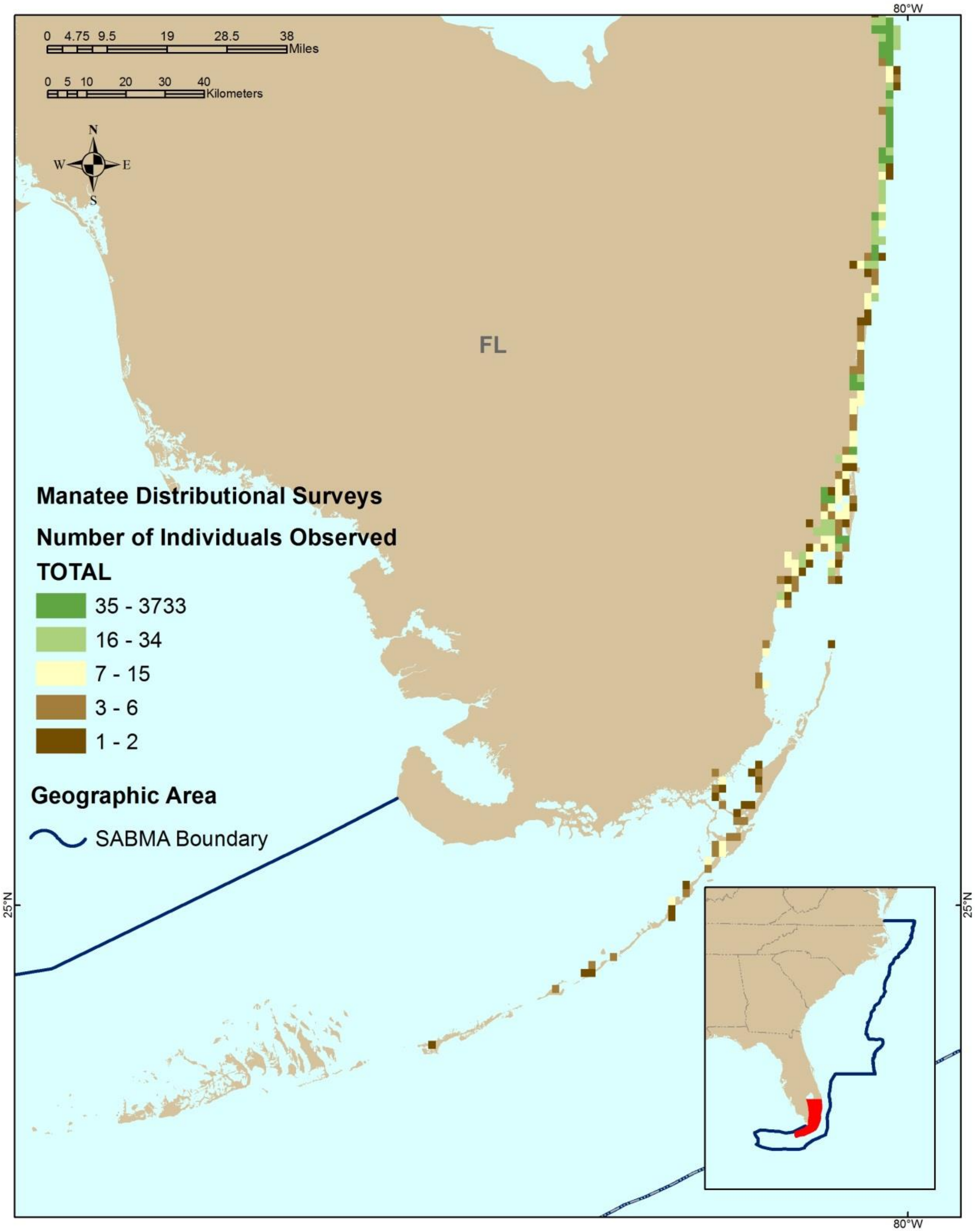

Figure 4.19. Manatee abundance map developed from distributional survey data, southeast Florida

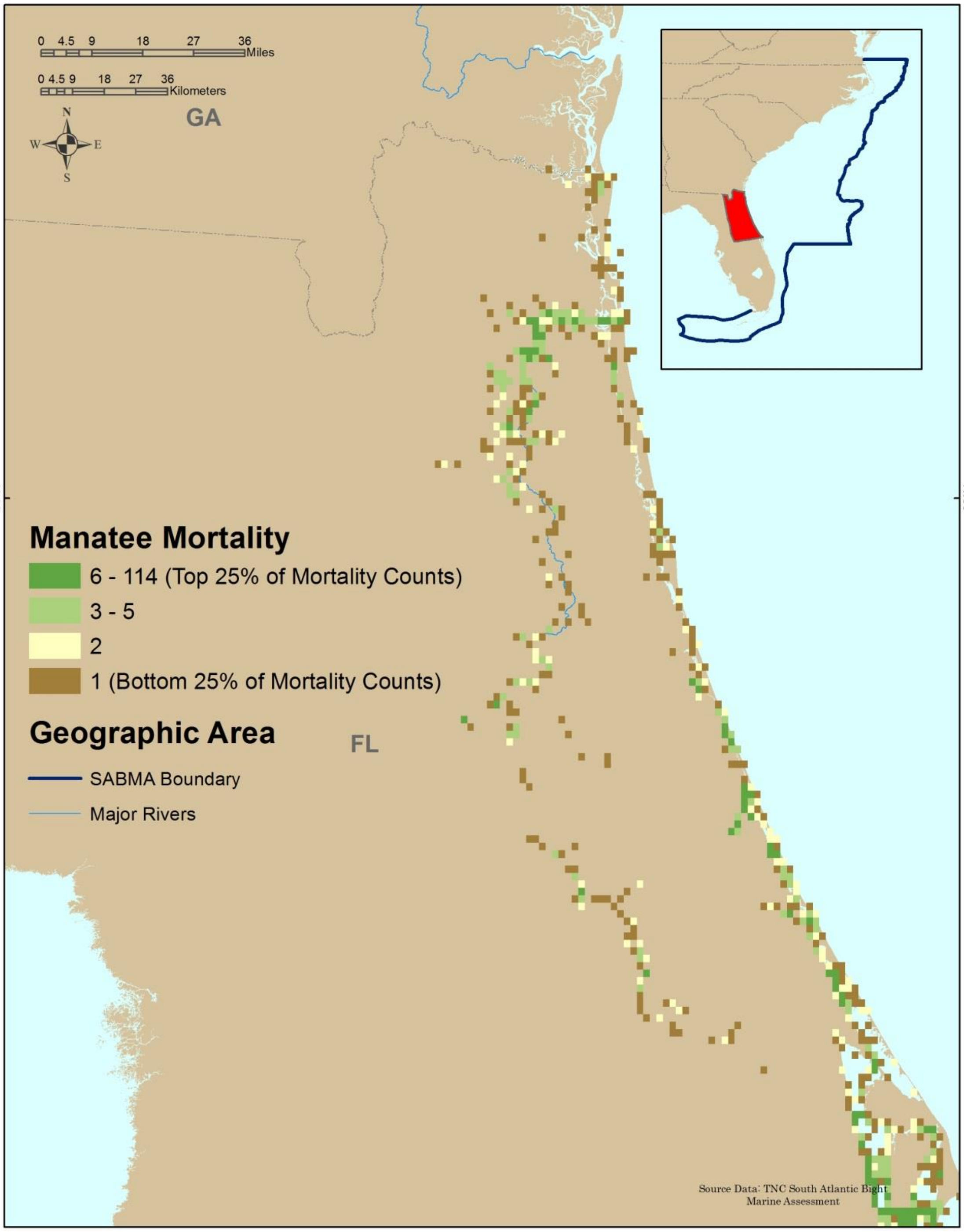

Figure 4.20. Manatee mortality location map, northeast Florida

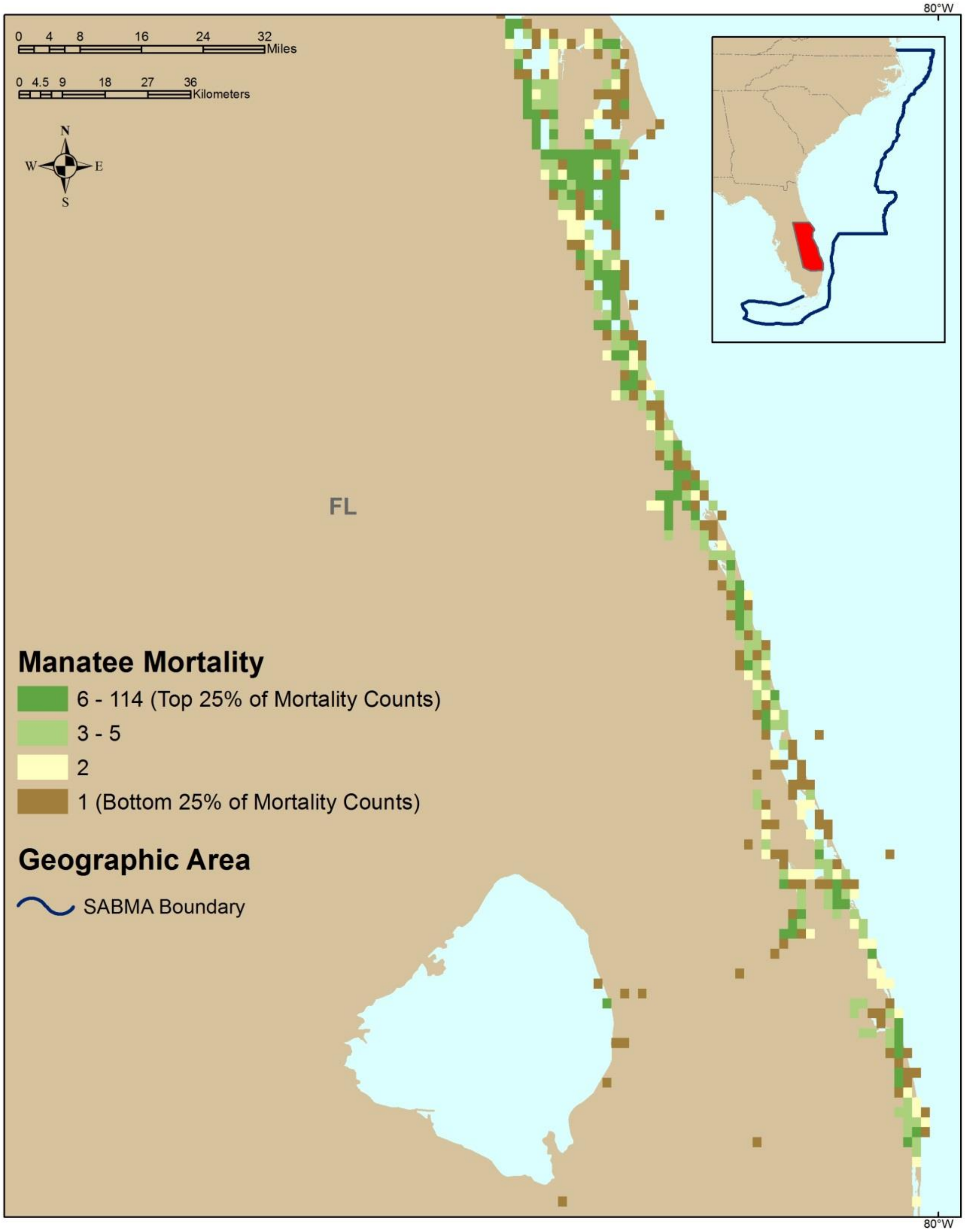

Figure 4.21. Manatee mortality location map, east-central Florida

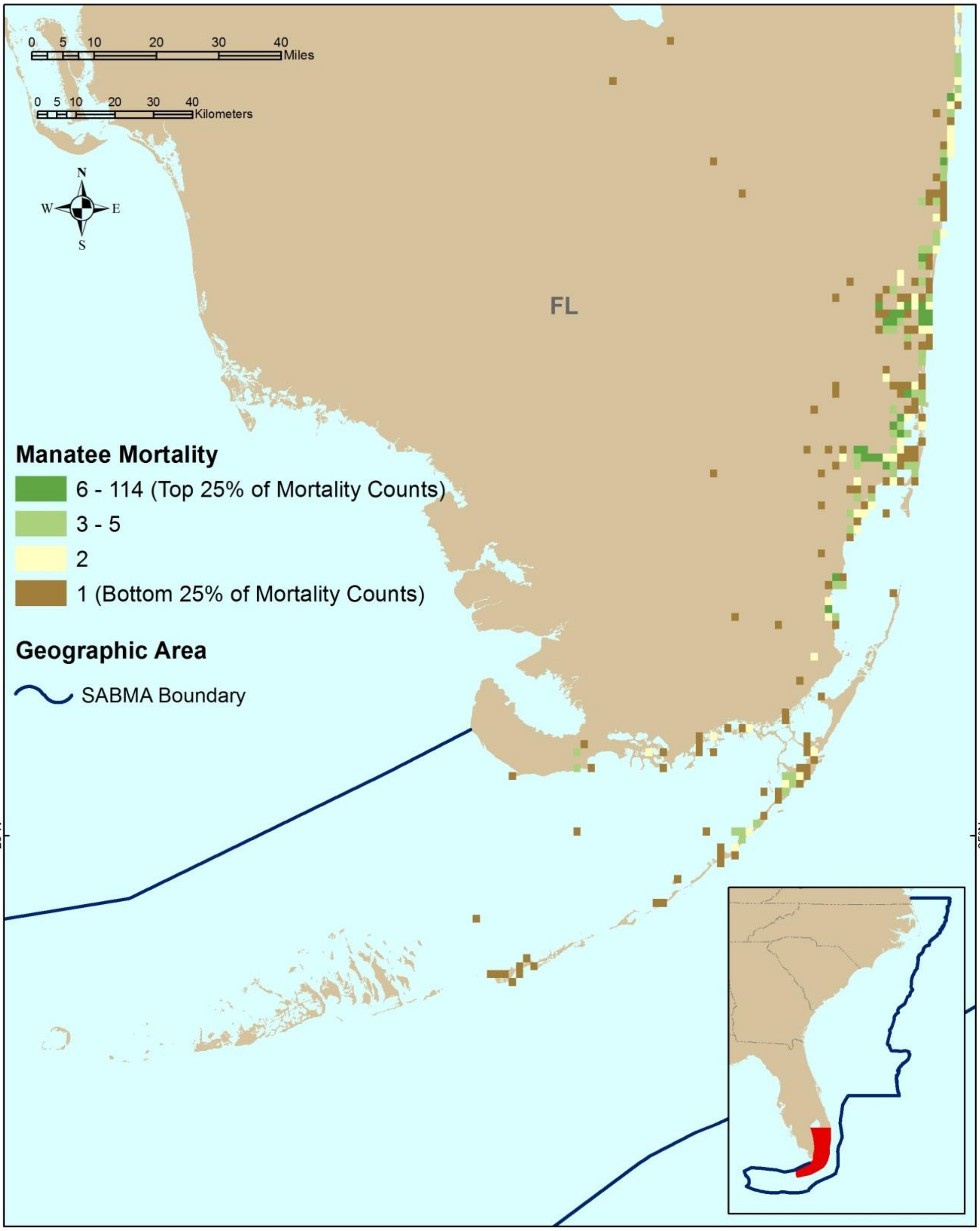

Figure 4.22. Manatee mortality location map, southeast Florida

SEA TURTLES: IN WATER DISTRIBUTION

HARDSHELL SEA TURTLES (LOGGERHEAD, GREEN, HAWKSBILL AND KEMP'S RIDLEY)

For the in-water sea turtle distribution analyses, it is important to note that survey effort is lacking for large portions of the survey area and there are issues with detectability/availability of turtles during warmer water seasons. Consequently, the in-water sea turtle maps may be best used to assess presence or absence of hard shelled turtles rather than patterns of abundance. Results suggest that hardshell turtles have broad distribution in SAB Continental Shelf waters in every season although the pattern of distribution varies (Figure 4.23).

Depending on the season, the greatest effort-corrected number of observations in any one TMS ranged from 234 to 782 sightings per unit effort. During the spring and summer months (March to May and June to August, respectively), two areas of higher concentration were observed: the area from southern Georgia to the southern survey boundary and the area from northern North Carolina to the northern boundary of the SAB region. Observations during the fall months (September - November) appeared to be primarily concentrated in the northern portion of the study area off northern North Carolina and the southern Virginia coast with a smaller concentration area off northern South Carolina, however, very little survey effort took place off northern South Carolina and southern North Carolina during the fall months. In the winter months (December – February), hardshell turtles appeared to move offshore or south and observations were concentrated along the Continental Shelf off central Georgia to the southern boundary of the survey area (Cape Canaveral, Florida). Variations in seasonal abundance may be related more to thermoregulation behavior (sunning during cold water periods) than seasonal movement of animals. The seasonality of the sightings, with a higher concentration of turtles in the southern portion of the study area in winter, follows the general pattern of decreased turtle sightings as waters in the northern portion of the study area cool and prey resources diminish (Braun-McNeil and Epperly 2002; Braun-McNeil et al. 2008).

LEATHERBACK TURTLE

Based on effort-corrected observations, leatherback turtle distribution varies seasonally in the region, with the greatest number of effort-corrected observations in any one TMS ranging from 35 to 166 depending on the season (Figure 4.24). In the summer months, turtles were diffusely spread throughout the survey area, with an area of high concentration observed on the Continental Shelf offshore of Georgia. In the winter and spring months (December - February and March - May, respectively) most turtles were concentrated in the southern portion of the survey area. In fall (September - November) turtles were most concentrated off the Georgia coast. In spring and fall, limited survey effort occurred off the coast of South Carolina and southern North Carolina. In all seasons, sightings were almost exclusively on the Continental Shelf. The relatively high concentration of sightings offshore of the area between southern South Carolina and the southern boundary of the SAB region suggests that this area is of great importance for the leatherback.

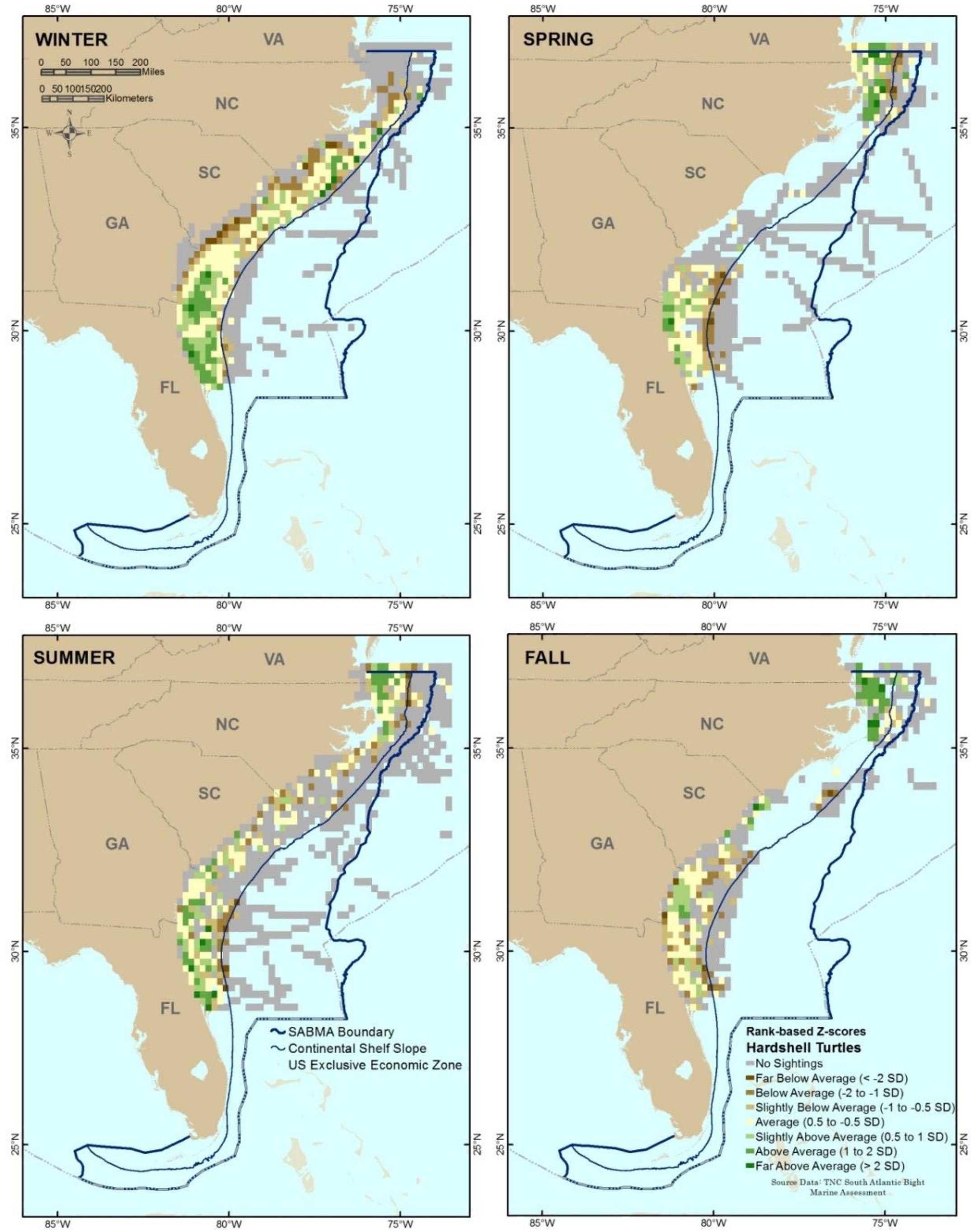

Figure 4.23. Hardshell sea turtle (loggerhead, green, and Kemp's ridley) distribution map by season

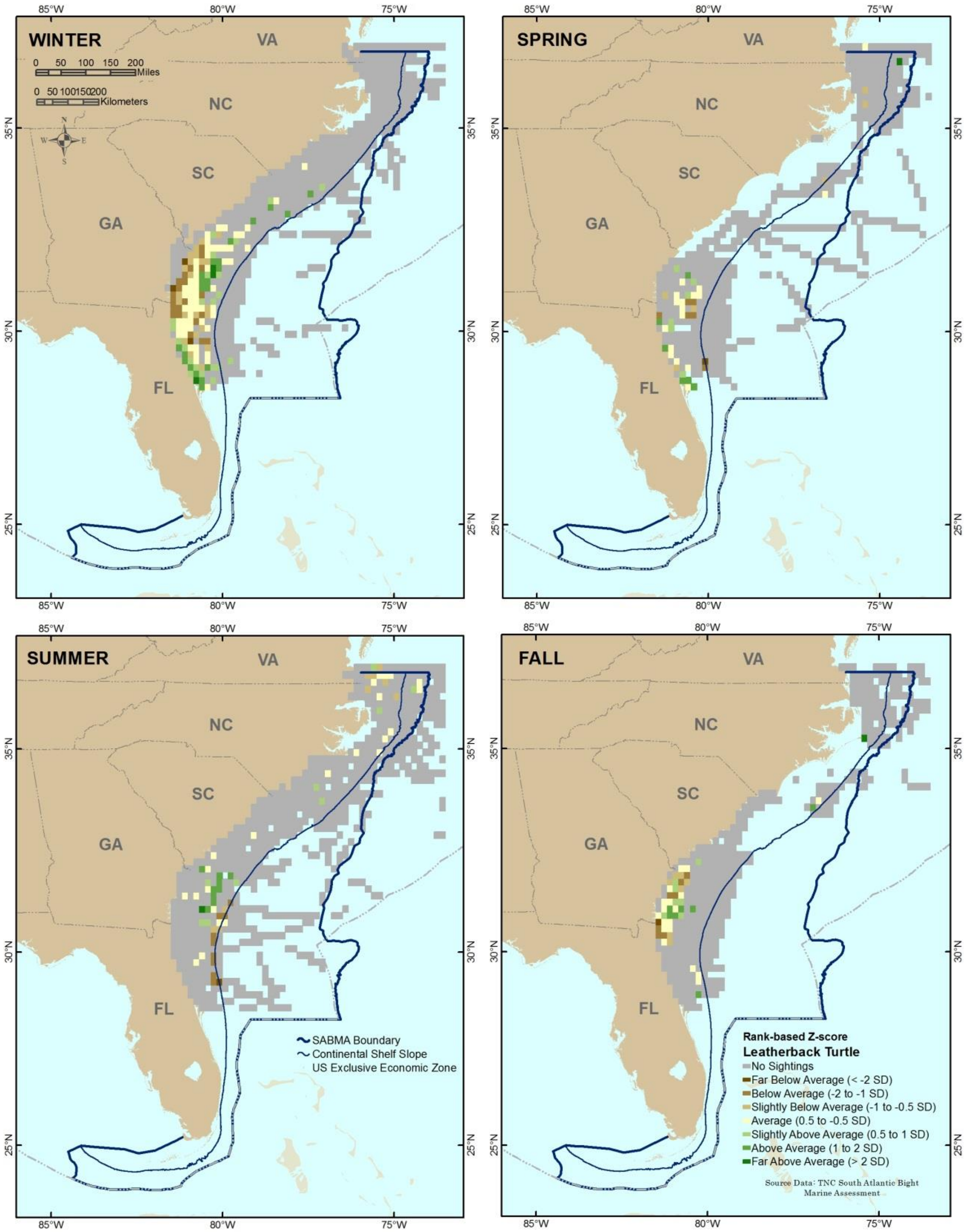

Figure 4.24. Leatherback sea turtle distribution maps by season

SEA TURTLES: NESTING AREAS

Five sea turtle species nest in the SABMA area, however, only the loggerhead turtle nests regularly in the SABMA region outside of Florida. Due to the limited amount of nesting in the SABMA region by two of the target species, the hawksbill and Kemp's ridley turtles, only presence and absence of nests has been recorded. For the three remaining species, loggerhead, green and leatherback turtles, the nesting data are displayed in quartiles to eliminate any subjectivity in selecting the density categories.

LOGGERHEAD TURTLE

Nest densities can exhibit considerable interannual variation in the Northwest Atlantic population (TEWG 2009) as well as among genetic subunits (FWC 2014b); however, there are consistent nesting density patterns in specific regions (Figures 4.25 through 4.29). Nesting density was greatest in the South Florida subunit with values as high as 774 nests per km of beach surveyed (Figure 4.28). This was followed by the Central East Florida subunit where the highest average density for the five-year period reached 336 nests per km (Figure 4.27). The Upper South Atlantic Bight and Dry Tortugas genetic subunits had similar maximum nesting densities of 96 and 109 (Figures 4.25 and 4.29), respectively, per km of surveyed beach. The Northeast Florida genetic subunit had the lowest mean nesting density per km of beach surveyed with a maximum of 16 nests/km (Figure 4.26).

Within the Upper South Atlantic Bight genetic subunit, nesting densities were highest in Georgia and South Carolina and lower further north in North Carolina and Virginia. Within the North Florida genetic subunit, nesting densities were generally low with higher nesting densities interspersed between lower nesting density areas. Highest nesting densities within the East-Central Florida genetic subunit were found south of Cape Canaveral with a second peak area on the north side of the cape. Peak nesting densities within the South Florida genetic subunit were found in the northern portion of this genetic subunit. Nesting dates ranged from May through September with peaks during June and July.

GREEN TURTLE

In the SAB region, an estimated 200 to 1,100 green turtles nest annually, primarily along the central and southeast portions of the Florida coast (NOAA Fisheries 2014a) with nesting extending as far south as the Dry Tortugas in the Florida Keys. Mean nesting densities for the six year period of 2006-2011 along the beach segments surveyed (Florida only) ranged from a high of 207 to a low of 0 nests per km of beach surveyed. The assembled data identify the beaches from Brevard County, FL south to Broward County, FL as major concentration areas for green sea turtle nesting (Figures 4.30 and 4.31). Although nesting survey data are unavailable north of Florida, green turtles are known to nest in small numbers in Georgia, South Carolina, and North Carolina (USFWS 2012).

LEATHERBACK TURTLE

In the SAB region, leatherback turtles nest primarily along the central and southeast portions of the Florida coast; nesting extends south to Key Biscayne (near Miami, Florida) and north to where the St. John's River flows into the ocean (near Jacksonville, Florida). Mean nesting densities for 2006-2011 ranged from a high of 18 to a low of 0 nests per kilometer of beach surveyed. The assembled data identify Florida beaches in Palm Beach, Martin and St. Lucie counties (Southeast Florida) as major concentration areas for leatherback turtle nesting in the SAB region (Figures 4.32 and 4.33). Although no survey dataset is available, leatherback turtles occasionally nest on Georgia, South Carolina and North Carolina beaches (NMFS USFWS 1992; Dodd 2014).

HAWKSBILL TURTLE

Only a few hawksbill turtle nests have been recorded in recent years (2006 – 2011) on Florida index beaches (five beaches along Florida's Central East Coast in Palm Beach County and one in the Florida Keys in Monroe County) (FWC 2014b)). Due to the rarity of nesting of this species in the SAB area, only presence and absence data are presented in Figures 4.34 and 4.35.

KEMP'S RIDLEY TURTLE

Like the Hawksbill turtle, the Kemp's ridley turtle rarely nests within the SABMA Region. From 2006 to 2011, Kemp's ridley turtles were only observed nesting at four Florida index beaches -- two in southeast Florida, and one each in northeast and central-east Florida (FWC 2014b; Figures 4.36 and 4.37). There have been several nests in VA and other states north of Florida in the last few years (Georgia Conservancy 2012; Hampton Roads 2012; Swingle pers. comm.).

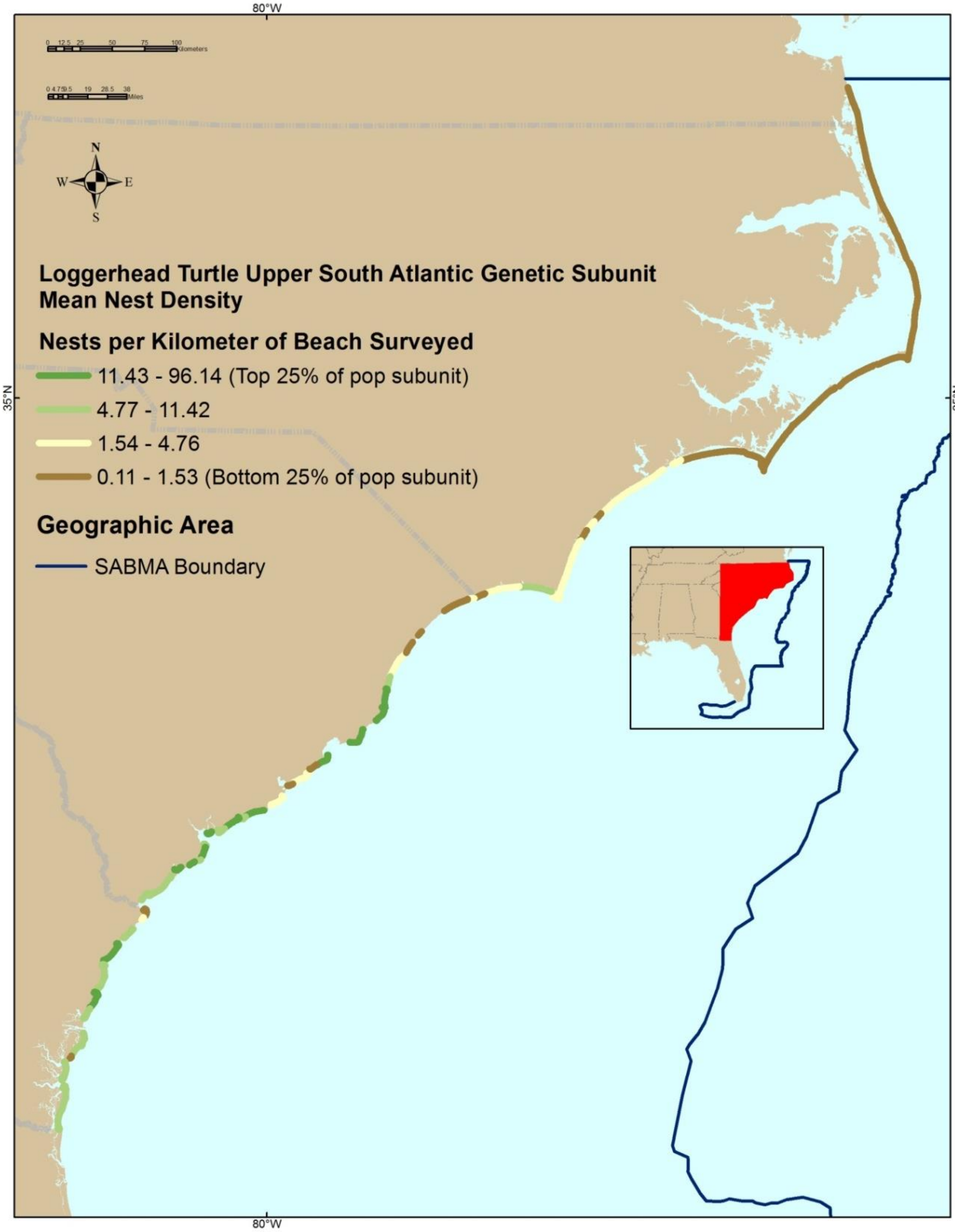

Figure 4.25. Loggerhead turtle nesting density, Upper South Atlantic genetic subunit

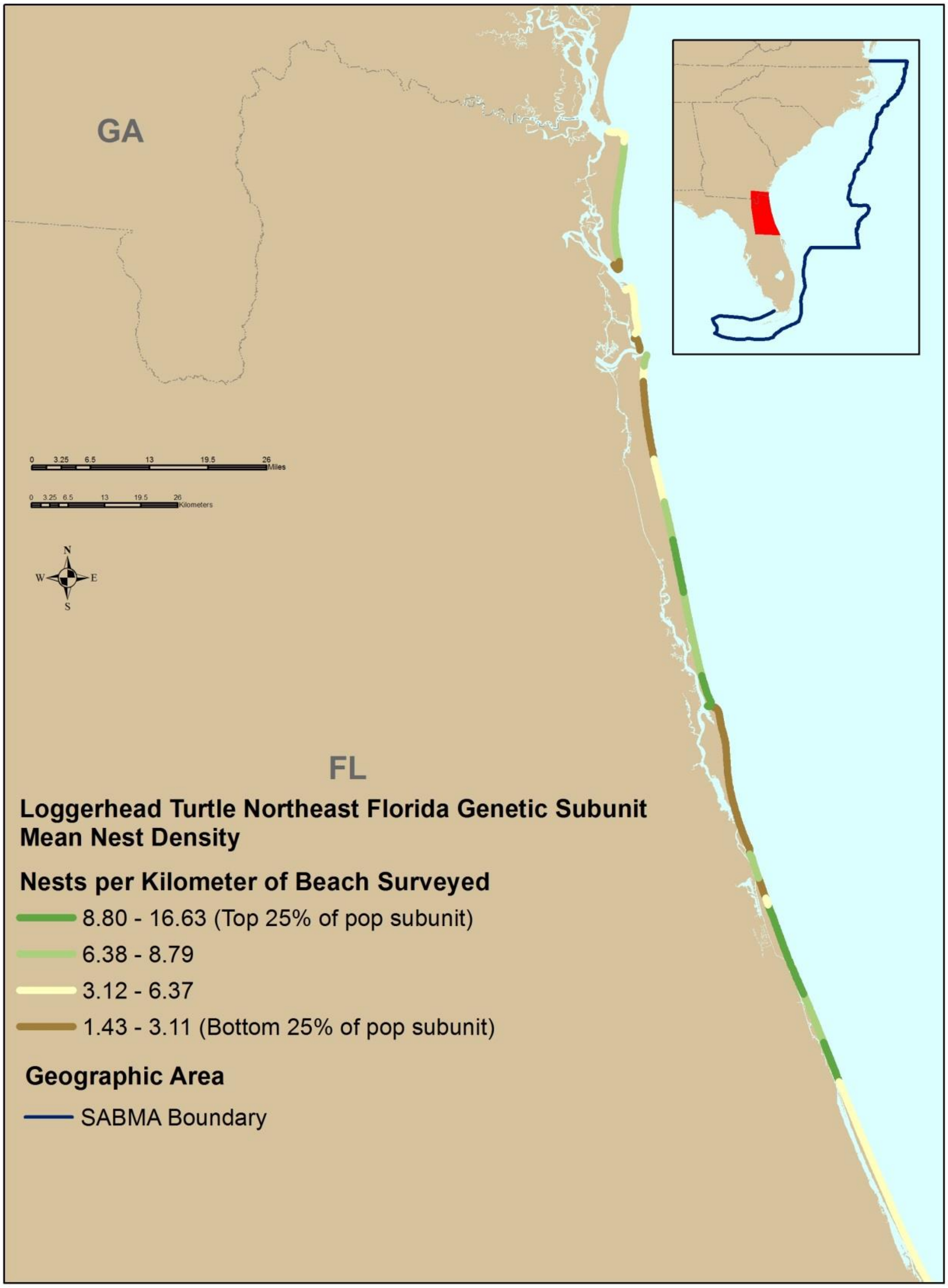

Figure 4.26. Loggerhead turtle nesting, Northeast Florida genetic subunit

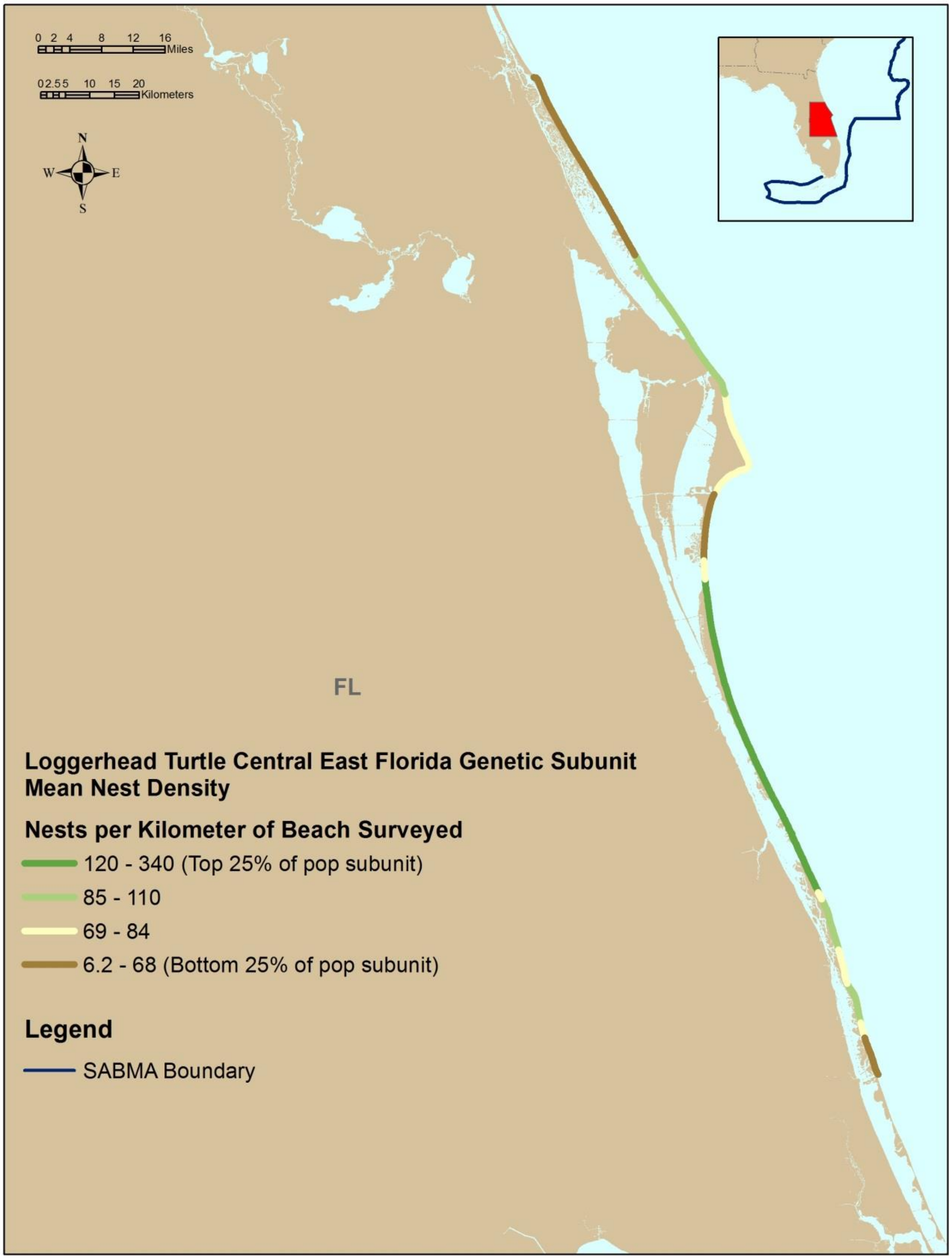

Figure 4.27. Loggerhead turtle nesting density, east-central Florida genetic subunit

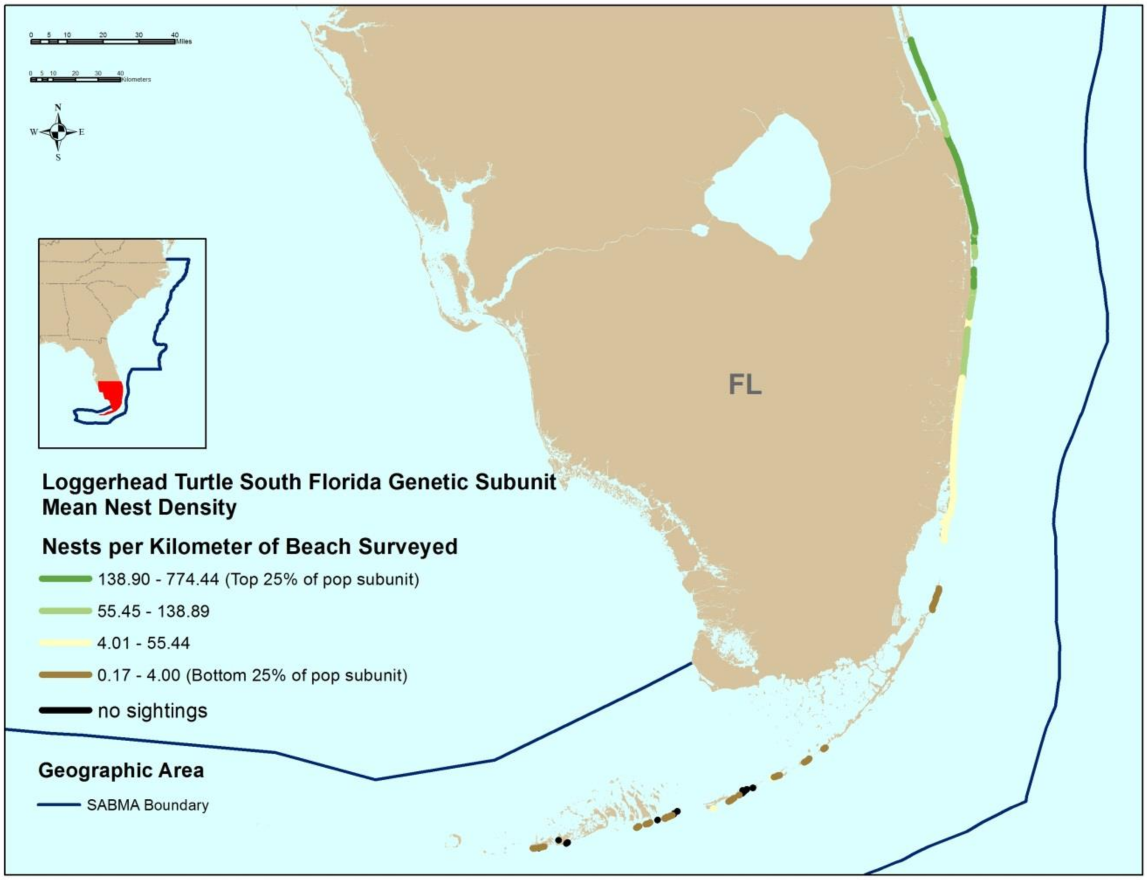

Figure 4.28. Loggerhead turtle nesting density, South Florida genetic subunit

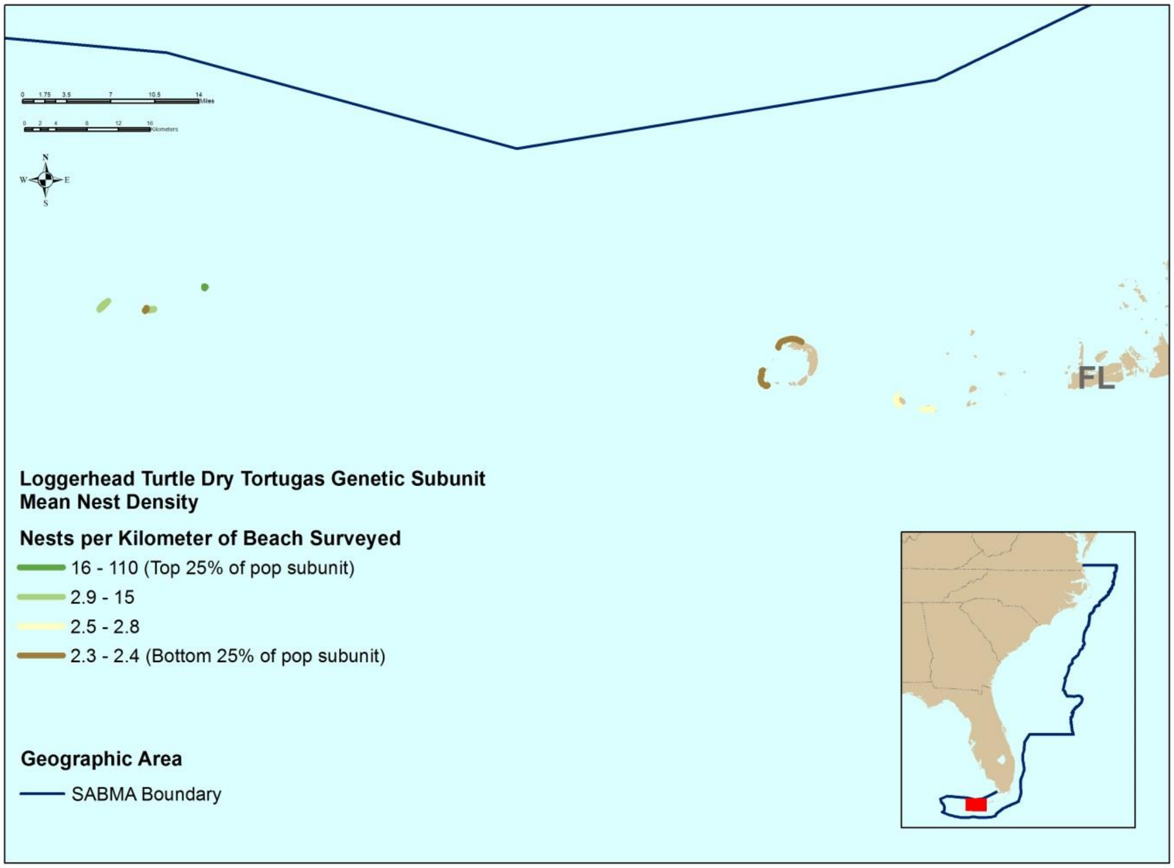

Figure 4.29. Loggerhead turtle nesting, Dry Tortugas genetic subunit

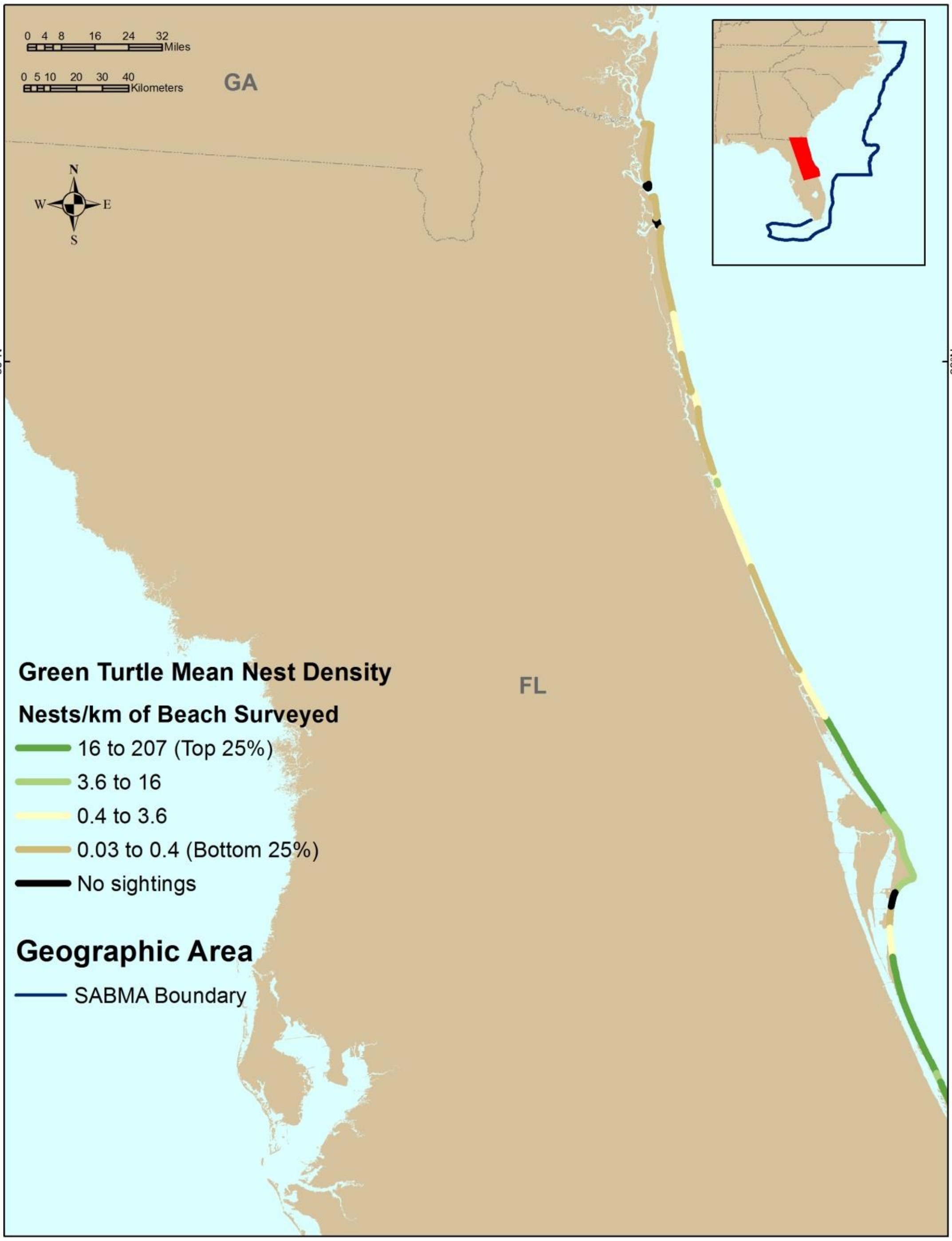

Figure 4.30. Green turtle nesting density, northeast Florida

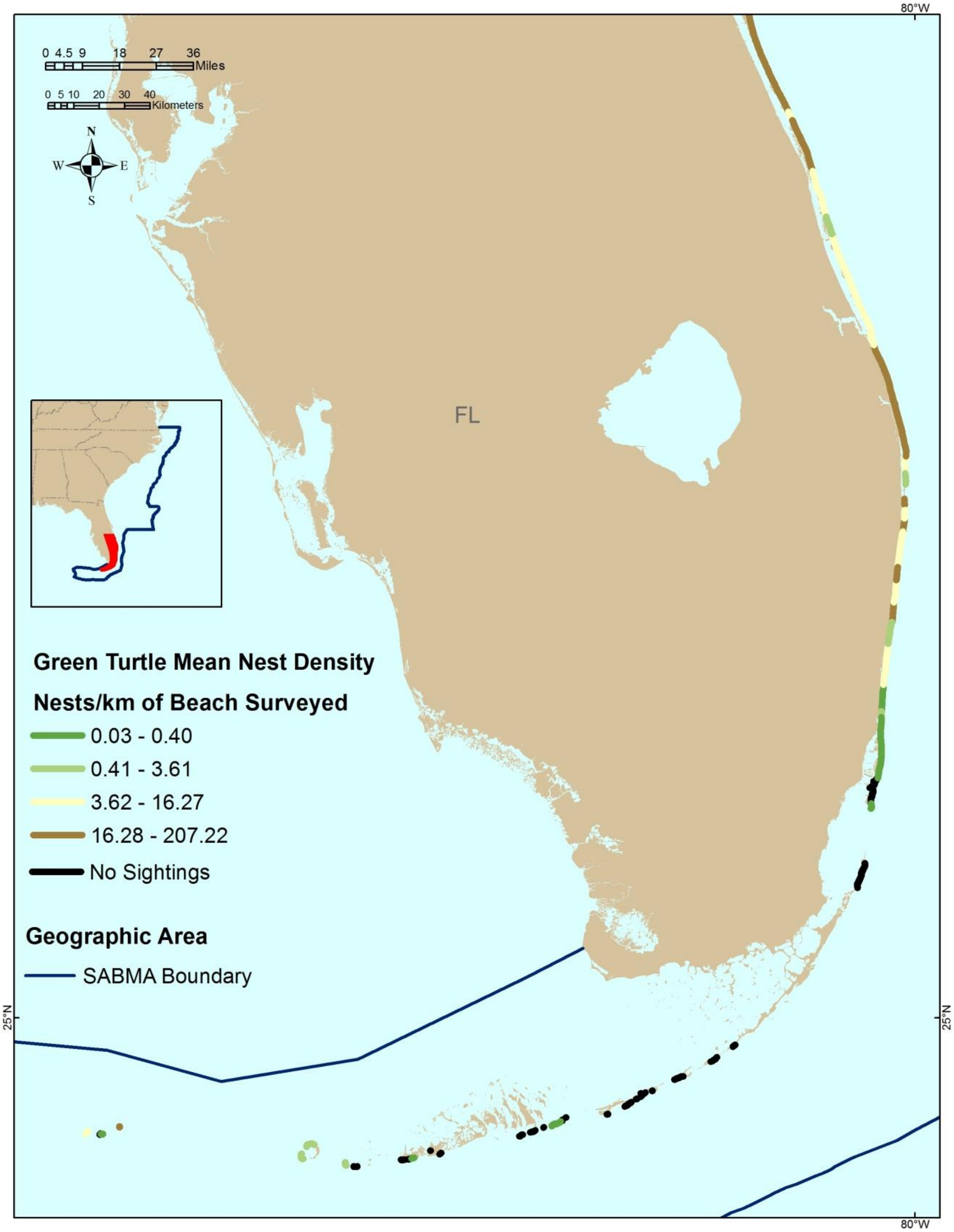

Figure 4.31. Green turtle nesting density, south Florida

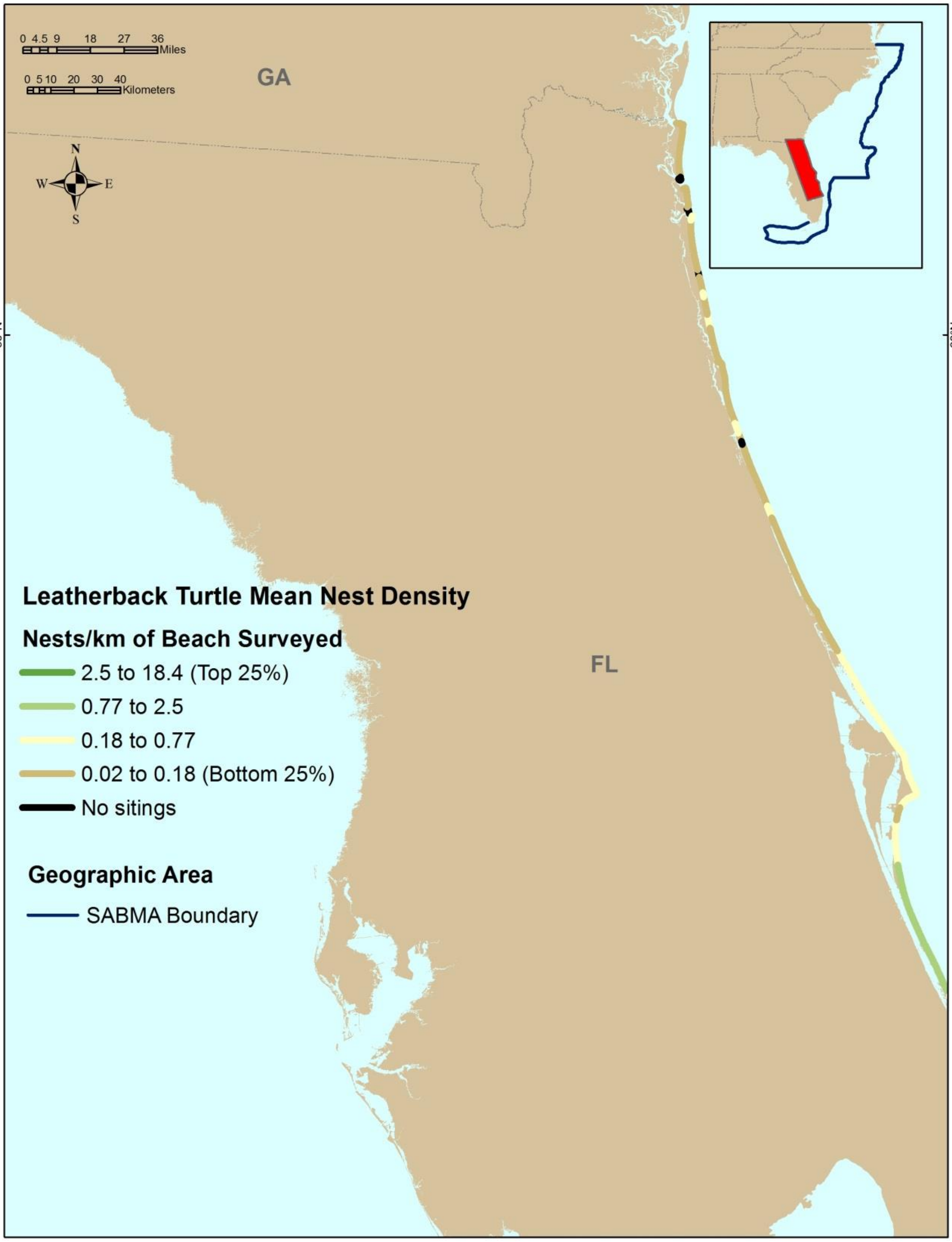

Figure 4.32. Leatherback turtle nesting density, northeast Florida

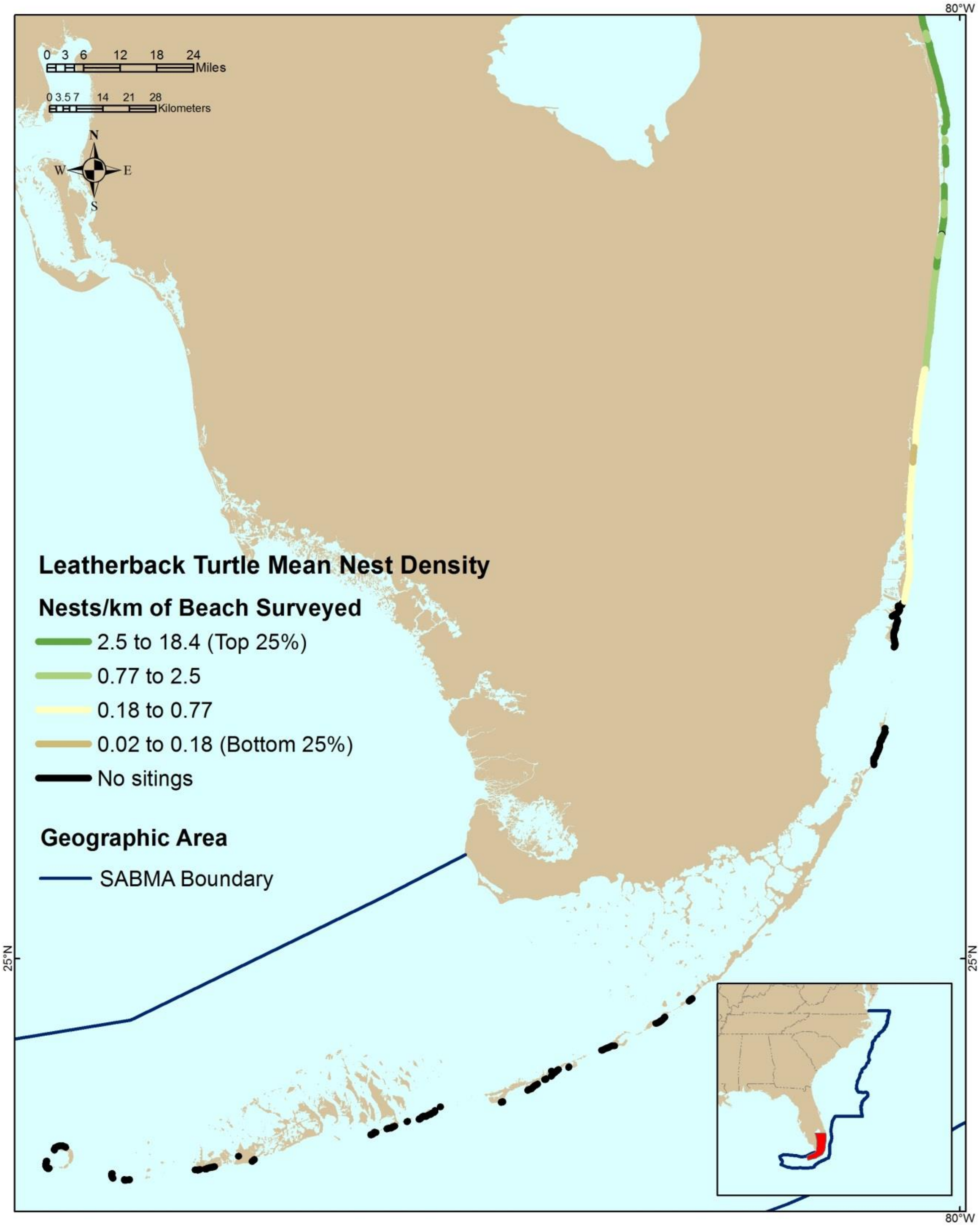

Figure 4.33. Leatherback turtle nesting density, south Florida

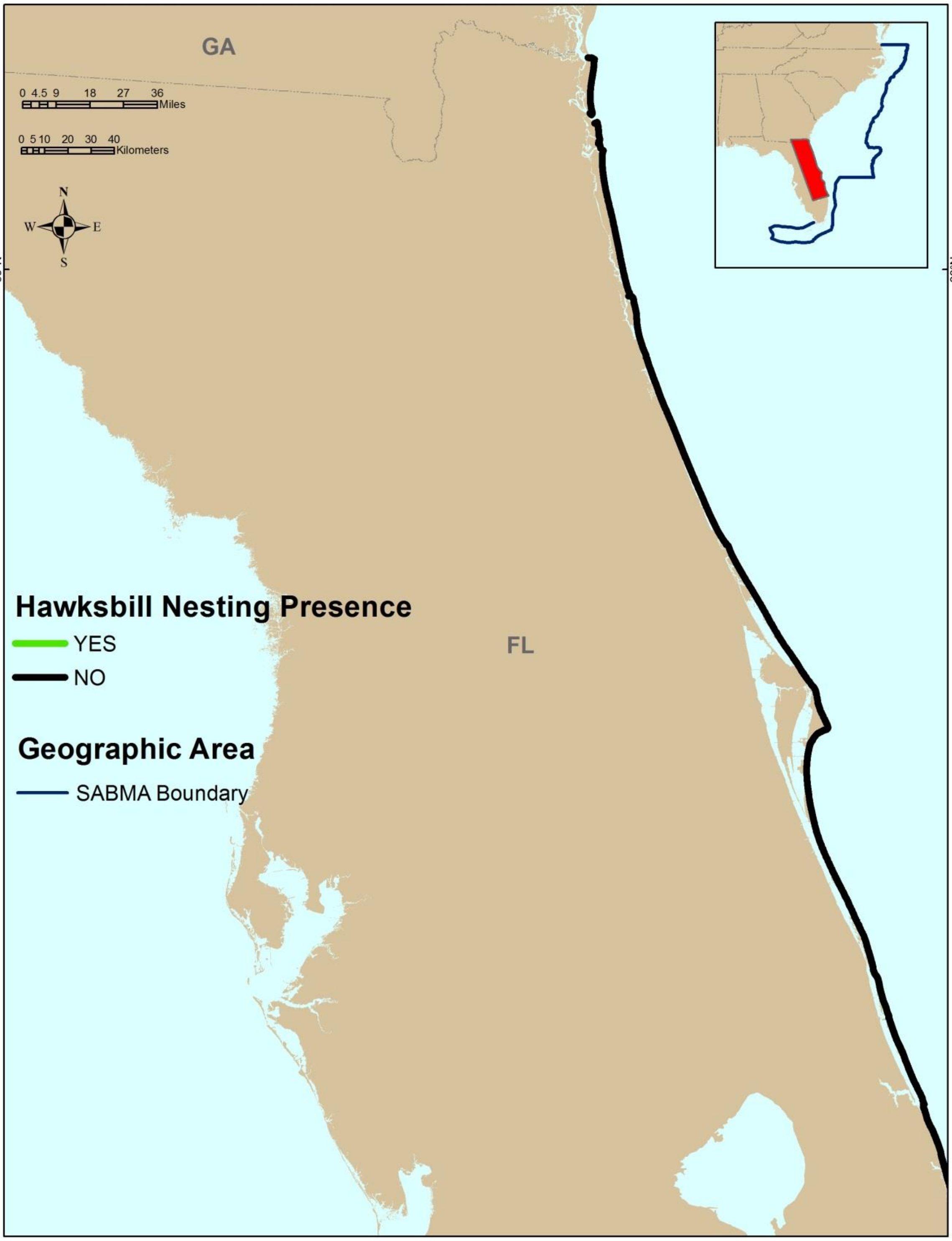

Figure 4.34. Hawksbill turtle nesting presence/absence, northeast Florida

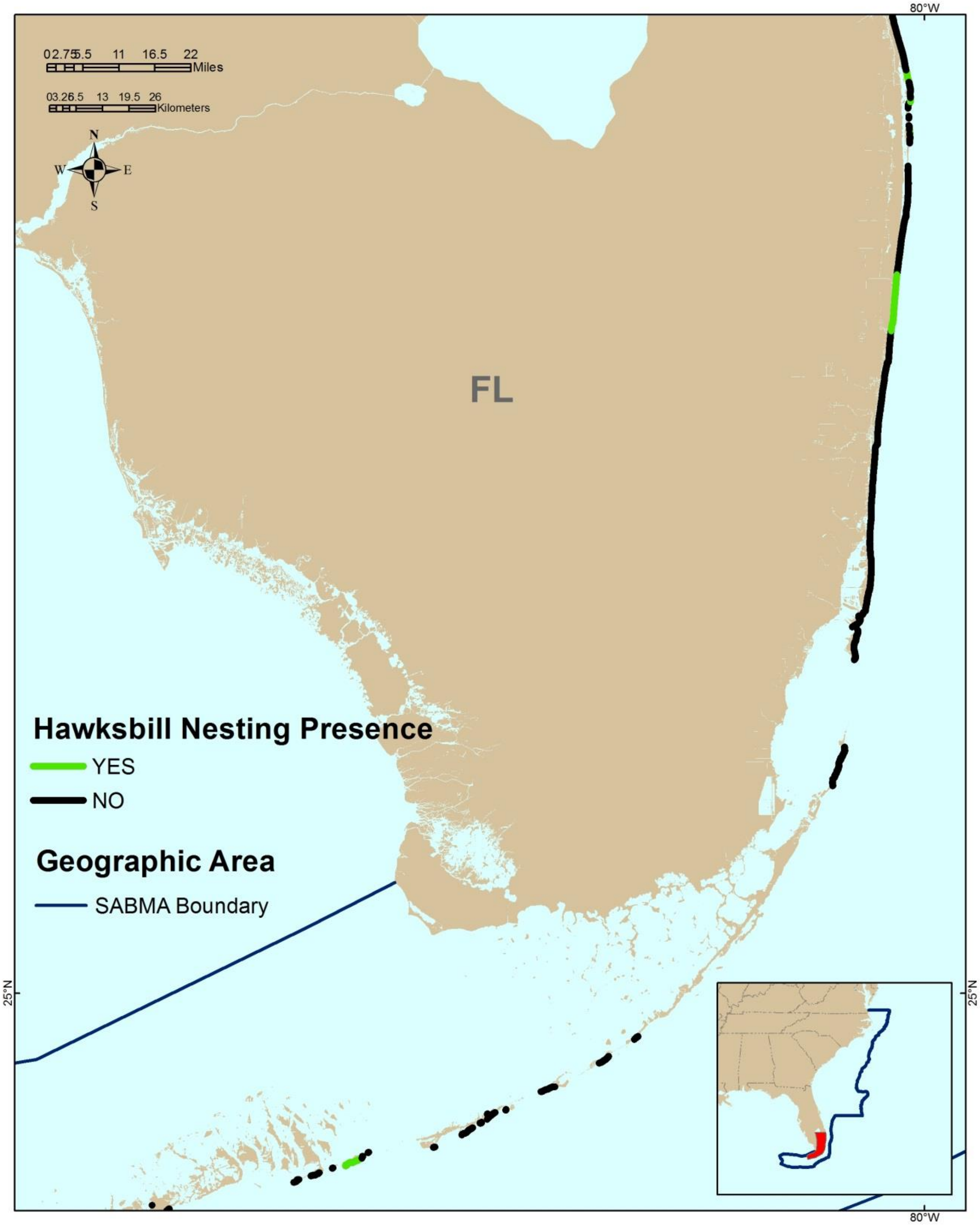

Figure 4.35. Hawksbill turtle nesting presence/absence, south Florida

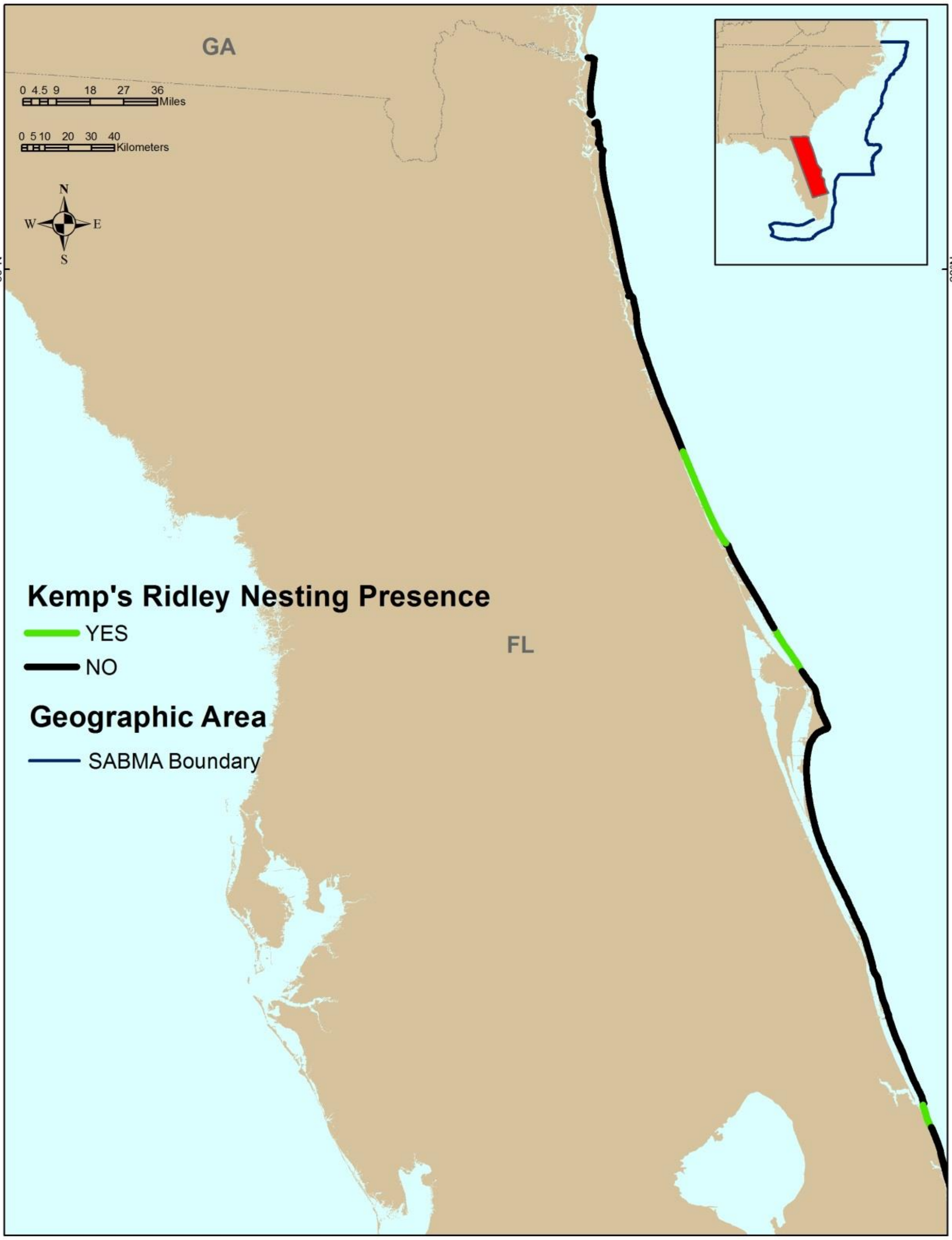

Figure 4.36. Kemp's ridley turtle nesting presence/absence, northeast Florida

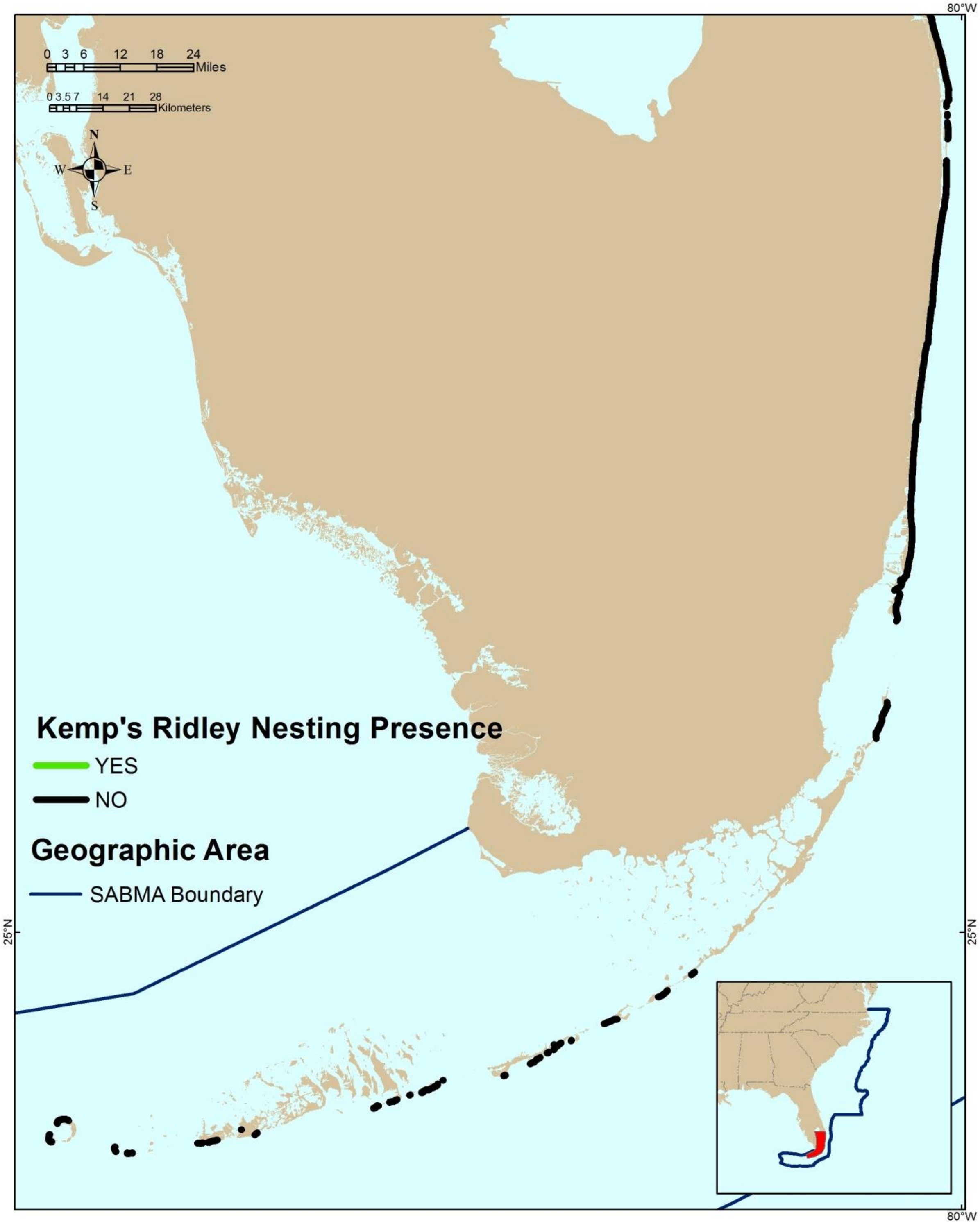

Figure 4.37. Kemp's ridley turtle nesting presence/absence, south Florida

Human Interactions and Other Threats

Marine Mammals

Marine mammals are vulnerable to pressures caused by direct and indirect interactions with humans. Threats to South Atlantic Bight marine mammal populations include collisions with vessels; bycatch and entanglement in fishing gear; depletion of prey resources; acoustic disturbance; exposure to aquatic contaminants; habitat degradation; and climate and ecosystem change (Fertl and Leatherwood 1997; Reeves et al. 2003; NOAA 2014b; O'Shea et al. 1985). As a result of these activities, populations and individuals can have alterations in longevity, reduced fecundity and changes in their migratory nature. The full effects of interactions in the study area are not completely known. However, intensive research on the interactions between cetaceans and humans is taking place (Clark et al. 2009; Hatch et al. 2008; Lightsey et al. 2006, Scheifele and Darre 2005; SBNMS 2009; Wiley et al. 2003; Wiley et al. 2008).

Vessel Strikes

All large whale species in the region are vulnerable to vessel strikes, but the frequency and location of those interactions are poorly understood. Ship strikes accounted for 53% of the resolved deaths in necropsied right whales (Campbell-Malone et al. 2008). There is little evidence that right whales avoid vessels, and whales may even become tolerant to vessel noise and ignore it (Nowacek et al. 2004). A higher frequency of reports of interactions has occurred in recent years, but it is not yet clear to what degree this is due to a greater number of possible observers.

Manatees in the study area are also vulnerable to vessel strikes, usually involving small recreational watercraft in inland waters. A study of recovered dead manatees in Florida between 1993 and 2003 found that watercraft strikes represented the largest percent of identified cause of death at 24% (Lightsey et al. 2006).

Fishing Gear and Entanglement

Interaction between the fishing industry and cetaceans in United States waters has been documented by federal monitoring programs. Entanglement is a documented source of injury and death for a wide range of cetacean species, including endangered large whales in the western North Atlantic (Johnson et al. 2005; Waring et al. 2009; NMFS 2010a). A study of entangled right and humpback whales in the western North Atlantic found that a wide range of gear types was involved, but the vast majority of entanglements (89%) were attributed to pot and gill net gear (Johnson et al. 2005). Small toothed whales, such as bottlenose dolphins, have been observed as bycatch in a variety of fisheries, including those utilizing sink gillnets, bottom trawls, mid-water trawls, and herring trawls (NMFS 2006b; ATGTRT 2007).

Anthropogenic Noise

The effect of human-generated noise on cetaceans remains a controversial and poorly understood conservation issue (see review in Clark et al. 2007 and Parks and Clark 2007; Richardson et al. 1995; NRC 2003). Cetaceans are highly vocal and dependent on sound for almost all aspects of their lives (e.g., food-finding, reproduction, communication, detection of predators/hazards, and navigation), heightening concerns regarding the impacts of human-induced noise (NRC 2003). Human-generated sound in the sea comes from a variety of sources, including commercial ship traffic, oil exploration and production, construction, acoustic research, sonar use and other types of military activities. Sound in the ocean, particularly low frequency sound, can propagate over large distances, thus both spatial and temporal scales of potential impact can be large. A great deal of variation has been observed in noise responses by both cetacean species and individuals of different genders, age classes, and among individuals with different prior experiences with noise and in different behavioral states (Southall et al. 2007).

Observed effects of noise on cetaceans include changes in vocalizations, respiration, swim speed, diving, and foraging behavior; displacement; avoidance; shifts in migration path; hearing damage; and strandings (Parks and Clark 2007). Responses of cetaceans to noise can often be subtle, and there are many documented cases of apparent tolerance of noise. However, marine mammals showing no obvious avoidance or changes in activities may still suffer important consequences. Observed reactions to noise in marine mammals could result in population- level impacts such as decreased foraging efficiency, higher energetic demands, less group cohesion, higher predation, and decreased reproduction (NRC 2005). Much research effort is currently focused on assessing population consequences in better-known cetacean populations that have been exposed to long-term human-induced noise (e.g., North Atlantic right whales, Clark et al. 2009).

Contaminants and Marine Pollution

Cetaceans are exposed to many classes of marine contaminants such as organochlorines, endocrine disruptors, and biotoxins from harmful algal blooms, but the effects on these organisms are not fully known (Weisbrod et al. 2000). Mass stranding events have been documented and connected to ingestion of contaminated food sources. For example, in the winter of 1989, a mass stranding of humpback whales in Cape Cod Bay, Massachusetts was linked to contamination of Atlantic mackerel with saxitoxin produced by the microscopic marine alga *Alexandrium* spp. (Geraci et al. 1989). Determination and tracking of the effects of these contaminants is a rapidly evolving science (see review in Rolland et al. 2007). The size, free-swimming nature, and endangered status of many cetaceans can make it difficult to collect the type of non-lethal samples (e.g., blood and tissue) needed to diagnose diseases or monitor physiological responses to these contaminants.

Climate Change

Adaptability of marine mammals to climate change is currently unknown for most species. Studies have reported that species with limited ranges or dependence on sea ice or that migrate to feeding grounds in polar regions, such as many of the baleen whales, are most vulnerable (Learmonth et al. 2006; Simmonds and Isaac 2007). Other species may largely be affected through changes in prey distribution and abundance, with more mobile (or otherwise adaptable) species perhaps better able to respond to climate change impacts. Based on an analysis of the impact climate change could have on species ranges, Learmonth et al. (2006) hypothesized that the North Atlantic right whale and northern bottlenose whale could potentially experience a range contraction while the pygmy sperm whale, dwarf sperm whale, Gervais beaked whale, short-beaked common dolphin and long-beaked common dolphin could experience a range expansion.

Manatees could be affected by changes in the distribution and abundance of their primary food source, seagrass. With rising average temperature, seagrass meadows could deteriorate due to increases in harmful algal blooms (HABs) such as red tides. HABs can also be lethal to manatees. Seagrasses could eventually move into newly submerged areas, but this will take time and is uncertain. Manatees may also become more susceptible to vessel strikes as their range expands northward into areas without speed zone restrictions or an awareness of the habits of these slow-moving animals. In addition, their sources of freshwater could be compromised as a result of saltwater intrusion (Edwards 2013; Tripp 2014).

Sea Turtles

The five sea turtle species found in the South Atlantic Bight can all be negatively affected by interaction with human activities. Some common threats include fishing gear bycatch and entanglement; loss of critical habitat, particularly nesting beaches; and direct harvest. The relative impacts of these activities on sea turtle populations in the SABMA region vary by species, as discussed below.

Fishing Gear and Entanglement

Many turtle species and life stages are vulnerable to bycatch and entanglement in fishing gear. Comprehensive threat assessments for the Northwest Atlantic population of loggerheads conclude that a principal threat in the Northwest Atlantic is fisheries bycatch, specifically, in the bottom trawl, demersal longline, demersal large mesh gillnet, and pelagic longline fisheries. The Loggerhead Sea Turtle 2009 Status Review also identified mid-water trawl, dredge and pot/trap fisheries as threats. Total mortality from fisheries was not estimated, but is assumed to be significant. Entanglement in derelict fishing gear was also identified as a source of mortality for this species (Conant et al. 2009; NMFS USFWS 2008).

In U.S. waters, the pelagic longline and shrimp trawl fisheries have been identified as the largest documented source of leatherback mortality (NMFS 2001). Alternative methods and gear innovations (e.g., circle vs. J hooks; bait switching, TEDs) have reduced bycatch levels in recent years (NMFS USFWS 2007b). Fixed fishing gear (e.g., gill nets, pot/trap buoy lines, pound nets) is problematic in coastal foraging grounds (James et al. 2005) and in close proximity to nesting areas.

Various assessments also identify bycatch and entanglement as serious threats to green sea turtles (Seminoff 2004), leatherbacks (Wallace et al. 2011 as reported in Tiwari et al. 2013), hawksbill turtles, and Kemp's ridleys. The greatest threat to the Kemp's ridley turtle has been unintentional bycatch in fishing gear, primarily in shrimp trawls, but also in gill nets, longlines, traps and pots, and dredges in the Gulf of Mexico and North Atlantic including the SAB region.

Harvest
Sea turtles are harvested legally and illegally in many places in the world. The greatest current threat to green sea turtles is the global legal and illegal harvest of eggs, juveniles, and adults from both terrestrial nesting beaches and neritic foraging areas. Of particular concern to the recovery of this slow-to-mature species is the harvest of juveniles in the Caribbean Sea, Southeast Asia, Eastern Pacific, and Western Indian Ocean (NMFS USFWS 2007a). For loggerheads, legal harvest of neritic juveniles and adults (in the Caribbean) results in estimated mortality similar to demersal longline and gillnets (Conant et al. 2009; NMFS USFWS 2008). Human consumption of eggs, meat, or other products was found to be the second highest source of mortality for leatherbacks (Wallace et al. 2011 as reported in Tiwari et al. 2013). At one time egg collection was an extreme threat to the Kemp's ridley turtle, but protection efforts in place in the U.S. since 1966 have reduced this threat (NOAA Fisheries 2014b). Harvest of eggs and meat of the hawksbill is also a threat.

Habitat Degradation
Habitat degradation, particularly of nesting habitats, is a serious issue for all turtle species. For green turtles, habitat degradation of nesting areas in the form of beach replenishment and armoring, coastal development, and sand removal have been identified as key threats during terrestrial life stages (Lutcavage et al. 1997). Light pollution at nesting beaches results in disorientation of emerging hatchlings and

decreased nesting success. Declines in suitable coastal estuary habitat for green turtles are also widespread throughout their range including the larger systems along the western Atlantic coast (NMFS USFWS 2007a).

Degradation of nesting habitats has also been cited as a threat for loggerheads (Conant et al. 2009; NMFS USFWS 2008), leatherbacks (Wallace et al. 2011 as reported in Tiwari et al. 2013; NMFS USFWS 2007b), and hawksbills. Modifications from beach replenishment projects and armoring, erosion of active nesting beaches due to climatic events, light pollution on nesting beaches, predation by native and non-native species, accumulation of wood and marine debris (reducing access to the sand) are listed as specific impacts. Many of these impacts can alter habitat indirectly by modifying thermal profile and advancing erosion. Currently, many of the globally significant nesting areas for the leatherback turtle remain remote and are not as subject to these types of activities.

Marine Pollution

Marine pollution, including oil pollution from spills, is a threat to all sea turtle species in the study area. For example, important secondary sources of mortality identified by the Recovery Plan for loggerheads include general marine pollution and, more specifically, oil pollution (Conant et al. 2009; NMFS USFWS 2008). For green sea turtles, degradation of estuarine water quality due to development-related increases in effluent and contaminant loading (PCBs, heavy metals) has been linked to adverse impacts including recent increases in disease (e.g., Fibropapilloma, which results in internal and external tumors) (George 1997). Red tide events in coastal feeding areas have been linked to increased mortality in juveniles and adults (NMFS USFWS 2007a). Oil spills have been of secondary concern for hawksbills, but not so for the Kemp's ridley turtle which has experienced dramatic declines in nesting activity at their primary nesting beaches on the Gulf Coast of Mexico following the Deepwater Horizon BP oil spill in the Gulf, the first declines in more than 20 years (Dodd 2014).

Marine Debris

Sea turtles famously can ingest floating plastic bags, thinking they are jellyfish. Ingestion of marine debris is a threat to most sea turtle species. Entanglement in derelict fishing gear and ingestion of marine debris have been cited as sources of mortality for loggerhead, leatherback and hawksbill turtles, but these threats are likely to affect other species as well.

Vessel Strikes

Turtles resting at the surface are susceptible to vessel strikes. For loggerheads, vessel strikes (propeller and collisions) were identified as a large mortality source for neritic juveniles and adults (Conant et al. 2009). In Florida, boat strikes have been singled out as a large source of injury and mortality for green sea turtles (Singel et al. 2003).

Other Sources

One additional significant threat for hawksbills is the tortoiseshell trade, which threatens hawksbill populations globally (Mortimer and Donnelly 2008). Other threats to hawksbills include hybridization with other species (where population size is particularly low). Resource limitation in the eastern Pacific during cyclical climatic events (El Niño Southern Oscillation) has been linked to decreased reproductive success and increased vulnerability to anthropogenic mortality (NMFS USFWS 2007b). This is not currently the case in the Northwest Atlantic Ocean; however, future climatic changes may alter oceanic currents that influence prey availability and subsequent reproductive capacity. Increased temperatures at nesting sites have been linked to changes in hatchling sex ratios on some beaches (NMFS USFWS 2007b).

Management and Conservation

Marine Mammals

Regulatory Authorities

The species selected for this assessment are federally protected under the Marine Mammal Protection Act (MMPA). The MMPA prohibits, with certain exceptions, the "take" of marine mammals in United States waters and by U.S. citizens on the high seas, and the importation of marine mammals and marine mammal products into the United States (NOAA 2007). The Endangered Species Act (ESA) lists the Florida manatee and fin, humpback, sei, sperm, and North Atlantic right whales as endangered. This designation prohibits "take" of these species; requires the development and implementation of species recovery plans; and mandates, where appropriate, designation of critical habitat. Where these species are found within National Marine Sanctuaries, they are also protected under the United States National Marine Sanctuaries Act. At the state level, the Florida manatee is also protected by the Florida Manatee Sanctuary Act (§379.2431(2), Florida Statutes).

Current Conservation Efforts

Many ongoing cooperative conservation efforts focus on marine mammals, including those conducted by federal, international, and state agencies, academic institutions, and non-profit organizations. One of the first international protections for whales was the First International Convention for the Regulation of Whaling in 1935 which specifically targeted right whales. Their protected status has been continued by the International Whaling Commission since its founding in 1946 (Donovan 1991).

As noted above, NMFS is required to develop and implement recovery plans for whale species listed as endangered in the U.S. Final recovery plans have been published and are being implemented for most of the large whale species included in this study, including the North Atlantic right, fin, humpback and sperm whales (NMFS 1991 2005, 2010b, 2010c). The plans call for improving knowledge of stock sizes, habitats, and migration patterns; better understanding the impact that threats have on the stocks; and reducing known threats. The North Atlantic right whale recovery plan takes the most comprehensive approach to reducing threats due to the highly vulnerable nature of this population of whales. The recovery plan includes a number of actions to reduce ship collisions (e.g., mandatory vessel speed restrictions and ship reporting systems), entanglement in fishing gear, fisheries bycatch, exposure to contaminants and excessive noise and harassment by whale watching operations (NMFS 2005). Critical habitat has been designated for the North Atlantic right whale, including off the southern coast of Georgia and northern coast of Florida (NMFS 1994). Changes to the critical habitat area were proposed by NMFS in 2015 and are currently under review. The other recovery plans recommend actions to maintain and enhance historical and current known habitats, identify and reduce human related injury and mortality, research population structure, improve administration and coordination, and maximize efforts to obtain scientific information from stranded or entangled individuals (NMFS 1991, 2010b, 2010c, 2011).

Under Section 118 of the Marine Mammal Protection Act, NMFS has developed and implemented several take reduction plans (TRPs) to reduce injury and death of certain marine mammals vulnerable to commercial fishing activities. TRPs typically include both regulatory and non-regulatory measures. The four operating in the SABMA study area include the Large Whale TRP, Bottlenose Dolphin TRP, Pelagic Longline TRP and Harbor Porpoise TRP. Following are examples related specifically to the South Atlantic Bight region:

- Large Whale TRP: Focused on the critically endangered North Atlantic right whale, the Large Whale TRP also takes into consideration humpback, fin, and minke whales. The TRP consists of regulatory and non- regulatory measures related to commercial gillnet and trap/pot fisheries, including broad-based gear modifications, time/area closures, and extensive outreach efforts (NOAA 2010).

- Pelagic Longline TRP: Focused on reducing incidental mortality and serious injury of pilot whales and Risso's dolphins in the Atlantic pelagic longline fishery, the TRP created the Cape Hatteras Special Research Area (CHSRA). Requirements for operating in the CHSRA include specific observer and research participation for fishermen operating in the area year-round (NOAA 2009).

To reduce manatee injury and mortality caused by watercraft collisions, the FWC, US FWS and some local governments have established seasonal and year-round manatee protection areas. Most of these zones require slower vessel speeds but some restrict vessel access into manatee congregation areas (e.g., winter warm water refugia). Slowing vessel speeds provides greater reaction time for the vessel operator and manatee and reduces the severity of injuries to the manatee if hit by the vessel (Calleson and Frohlich 2007).

There are no recovery or management plans that address the common dolphin, beaked whales, dwarf and pygmy sperm whales or spotted dolphins as they are not listed as endangered or threatened under the Endangered Species Act and are not subject to high fisheries-related mortality in the SABMA study area.

Box 4.4. It Takes a Village: Organizations Involved in Marine Mammal Research and Conservation

Research and conservation needs are great for most marine mammal species in the SABMA study area (and beyond). To try to address these needs, a wide range of government agencies, academic institutions and non-profit organizations are actively involved in cetacean research and/or conservation in the region.
U.S. East Coast colleges and universities at which there are research programs studying many aspects of cetacean biology, genetics, and distribution include (but are not limited to) Coastal Carolina University, College of Charleston, Duke University, and University of North Carolina at Wilmington.

Non-profit organizations involved in study area cetacean research or conservation include the American Cetacean Society, American Society for Mammalogy, Cetacean Society International, Ecological Society of America, Georgia Aquarium, Georgia Environmental Policy Institute, Harbor Branch Oceanographic Institution, Hubbs-Sea World, International Fund For Animal Welfare, Marine Mammal Commission, North Atlantic Right Whale Consortium, North Carolina Sea Grant, Ocean Conservancy, Society for Conservation Biology, Society for Marine Mammalogy, South Carolina Marine Mammal Stranding Network, The Humane Society of the United States, The Marine Mammal Center, Virginia Aquarium & Marine Science Center, Whale and Dolphin Conservation Society, WhaleNet and World Wildlife Fund.

State and federal agencies engaged in study area marine mammal research and conservation activities include the Florida Fish and Wildlife Conservation Commission/Fish and Wildlife Research Institute, Georgia Department of Natural Resources/Coastal Nongame and Endangered Wildlife Program and the Office of Naval Research Marine Mammal Program, NOAA Fisheries Services/Office of Protected Resources.

Sea Turtles

Regulatory Authorities

All life stages of the five turtle species included in this analysis are currently protected on U.S. nesting beaches and in U.S. waters by the Endangered Species Act. NMFS and USFWS jointly manage all three species; USFWS has lead jurisdiction on nesting beaches while NMFS has lead jurisdiction for marine waters.

Current Conservation Efforts

Global conservation efforts for the five species included in this analysis are principally comprised of international conventions and treaties. The United States is one of 12 signatory nations on the only international treaty dedicated solely to sea turtles: Inter-American Convention for the Protection and Conservation of Sea Turtles. One of the most significant conservation efforts to date for sea turtle species is the United States embargo (November 21, 1989) on shrimp harvested with commercial gear that may adversely impact sea turtles (Public Law 101-162, Section 609 (16 U.C.S. 12537)). Under authority of the ESA and the Magnuson-Stevens Fishery Conservation and Management Act, NMFS has initiated a series of regulations designed to reduce adverse impacts to sea turtles including requiring use of turtle excluder devices (TEDs) and circle hooks, gillnet closures, and pound net modifications. In 2003, NMFS initiated a program, the Strategy for Sea Turtle Conservation and Recovery in Relation to Atlantic and Gulf of Mexico Fisheries, to identify strategies to reduce bycatch across jurisdictional boundaries for priority gear types on a per-gear basis (instead of by individual fishery) for the Atlantic and Gulf of Mexico (NOAA Fisheries 2003). There are currently NMFS/USFWS Recovery Plans for U.S. populations in the Atlantic (October 29, 1991), Pacific (January 12, 1998), and Eastern Pacific (January 12, 1998) for green sea turtles, and for U.S. Caribbean, Atlantic, and Gulf of Mexico (April 6, 1992) and the U.S. Pacific (January 12, 1998) populations for loggerheads. Five year reviews of these Recovery Plans occurred in 1991 (56 FR 56882) and 2007 (70 FR 20734).

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CHAPTER 5

IDENTIFYING CONSERVATION AREAS

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Introduction

The Nature Conservancy's South Atlantic Bight Marine Assessment assembled a comprehensive regional-scale database of information on ecosystems, habitats, and species of the South Atlantic Bight to inform coastal and marine conservation strategies for the region. The database was designed to help fill critical data gaps, inform planning, and guide decision-making in support of multiple objectives. In this chapter, we synthesize the information to identify important geographical areas to focus on for a suite of *conservation targets*: habitats and species selected to represent biodiversity and ecological functions within the planning region.

The diverse marine ecosystems of the South Atlantic have supported coastal economies and sustained recreational and commercial fishing for centuries. Data indicate, however, that the productivity and diversity of these systems are in decline due to pollution, overfishing, and coastal development, and that these problems are further exacerbated by climate change and fractured governance. Still, goods and services provided by the oceans are growing rapidly to include many new or non-traditional uses such as aquaculture, sand and gravel mining, and exploration and development of energy sources. As these changes increase the complexity of ocean management it is essential to develop multi-objective management approaches that integrate decision-making across sectors and utilize objective information on the abundance, distribution and vulnerability of marine resources.

Marine assessments are designed to inform multi-objective ocean planning, and inform strategies for area-based management while sustaining biodiversity (Beck et al. 2009, Greene et al. 2010). Agencies and organizations around the world are now using this approach to address the expanding human activities in the marine environment, activities that are increasingly in conflict with one another and affecting the health of the ocean and the ecosystem services upon which we depend. The methodology and priority areas described here can be used to help develop biodiversity conservation objectives in ocean planning, although we fully recognize that objectives for other management sectors are critical to taking a comprehensive approach in the South Atlantic Bight (e.g., renewable energy, fishing, recreation, transportation).

This analysis begins with the premise that all areas in the ocean are not equivalent with respect to biodiversity or ecosystem service values. Thus, the objective identification of high priority conservation areas on which to focus management attention is critical for maintaining the region's natural resources and related ecosystem services. This report highlights regionally significant areas for coastal and marine biodiversity with the intent of providing useful information to inform decisions regarding compatible human uses, and to stimulate and guide decisions on where to initiate or accelerate conservation efforts. We anticipate that spatial planning efforts will identify areas where human uses are ecologically compatible with priority conservation areas identified here.

The Conservancy's identification of high priority areas for marine conservation makes no presumption about the best strategies for conservation at individual sites. Before identifying conservation strategies, The Nature Conservancy will work with our partners to better understand the present and likely future threats to marine diversity, as well as the biological, socioeconomic, and political circumstances at each site. No single strategy works everywhere, and at any site multiple strategies will be needed. We recognize that conservation actions will always be influenced by factors complementary to objective ecological ranking, factors such as feasibility, opportunity, funding, and the values held by coastal community residents and other stakeholders.

Identifying and protecting a selected portfolio of high priority places from incompatible human uses is necessary but not sufficient for achieving all goals for a healthy marine system. Sustaining coastal and marine ecosystems will require substantial new actions to abate land-based and atmospheric pollution threats, and marine resource management measures will continue to be needed (e.g., permit conditions for offshore energy operations or fish harvest rules such as catch and size limits). Consistent with current U.S. ocean policy emphasizing an ecosystem-based management approach, we anticipate contributing to future processes to identify societal goals for the condition of the South Atlantic Bight ecosystem and to help implement the comprehensive suite of land and sea based strategies that will be necessary to reach those goals. Efforts are continuing to bring ecosystem-based management concepts into ocean planning and decision making at the state and federal level.

Objectives

The primary objective of this chapter is to identify a set of areas that merit the highest conservation and management attention to meet broad goals for conserving the coastal and offshore marine ecosystem from Cape Hatteras, North Carolina to the Florida Keys. The Conservancy refers to this set of areas as a "portfolio."

The priority conservation areas that comprise the portfolio were selected using objective and transparent criteria to explicitly define ecologically critical locations for our conservation targets, both within their sub-groups (such as baleen whales or hard-shelled sea turtles) and combined across all groups. We believe this approach also implicitly defined areas that are critical for maintaining key ecological processes and representative biodiversity.

The portfolio was selected based on ecological factors and without presumption of specific types of actions or levels of protection that may be needed to meet conservation goals. *It should not be viewed as a marine protected area blueprint, nor should areas that are not selected be viewed as having no ecological value*. The size of each area is large (approximately 100 sq. mi. minimum) and areas that emerge as important through this analysis will likely require finer-scale planning to develop effective conservation actions. The SABMA database is designed to facilitate further exploration within specifically-identified priority conservation areas. It gives users the flexibility to examine individual sites as well as the suite of sites across the region to inform ocean planning processes designed to meet multiple conservation and management objectives. The database is maintained by the Conservancy's Eastern Conservation Science office and is available to the public.

Priority-Setting Approaches

In the sea as on land, The Nature Conservancy has over 15 years' experience identifying important areas for the conservation of biodiversity through a participatory, data-driven ecoregional assessment process. While a systematic regional planning approach has consistently been used for all marine ecoregional assessments led by The Nature Conservancy (see Beck 2003), several different methods for identifying high priority marine conservation areas have been used.

Nature Conservancy scientists on the West Coast have favored the use of site selection algorithms such as MARXAN (Possingham et al. 2000) or C-Plan (Pressey et al. 1994), which produce spatially optimized solutions that meet numerical goals for biodiversity representation. Examples of MARXAN-based portfolios include Beck and Odaya (2001), Floberg et al. (2004), DeBlieu et al. (2005), Ferdaña (2005), Vander Schaaf et Al. (2006), The Nature Conservancy of California (2006), and Tallis et al. (2008).

Another method is the optimized site selection approach, which focuses strongly on the representation of an “optimal” or “irreplaceable” set of features, incorporating established conservation planning principles including replication and redundancy, heterogeneity and co-occurrence, viability, suitability, and clustering (see Ward et al. 1999, Leslie et al. 2003, Ball et al. 2009). Input parameters and weighting schemes reflecting these principles and representation goals for each target type are developed based on expert opinion. The software evaluates thousands of potential scenarios to identify spatially efficient solutions that are then subject to extensive peer and expert review. The results are expected to fully represent biodiversity within the planning area if all conservation goals are met. Many assessments also incorporate human uses and impacts in identifying the most efficient spatial footprint whereby human activities were avoided while conservation goals were met.

More recently, on the East Coast, Nature Conservancy scientists have developed marine planning approaches that emphasize ecological coherence over optimized representation goals (Anderson et al. 2010, Greene et al. 2010). To create a portfolio with ecological coherence, planners map both the physical structure of the region and the variety of ways that individual species groups use the region. By relating patterns of species use to physical characteristics such as depth zones, topographic features, and substrate types, portfolios can be developed that link representative sites into a configuration that reinforces multi-scale processes. For example, biological diversity in the South Atlantic is strongly associated with patches of reef and hardbottom that create structure on the Continental Shelf, and with the shelf-slope break that separates cold, murky shelf water from warm, clear slope water. The locations of these influential features are relatively fixed, making them suitable for place-based conservation. The approach is designed to identify areas where structure and processes create and sustain marine diversity, and there may be tradeoffs between ecological coherence and the most efficient representation of conservation targets.

The ecological coherence approach was developed in the Northwest Atlantic Marine Ecoregional Assessment (Greene et al 2010, Anderson et al. 2010), and we used it here to revise and expand on two previously completed optimization-based portfolios (DeBlieu et al. 2005, Geselbracht et al. 2009). We did not attempt to include human use or impact data while identifying priority conservation areas. In the case of NAMERA, a follow-up study identified patterns of human uses and compared them with the sensitivities, recovery time, and cumulative impacts of the marine habitats. The results confirmed the assumption that some places were irreplaceable and others were interchangeable. Irreplaceable areas contain key physical structures, perform essential functions, or have long recovery times after a disturbance. Interchangeable areas have ecologically equivalent examples of common environments or recover quickly from disturbance. This type of information provides planners with the tools and information necessary for negotiating a balance between sustaining marine biodiversity and meeting human use demands.

Priority Conservation Areas: Key Habitats, Species and Processes

Conservation areas may be important for a variety of reasons: a species, a sensitive habitat, an ecological function, or an oceanographic process (Anderson et al. 2010). Following is an introduction to the process used in establishing criteria for the identification of conservation areas. This includes the four key ecological components discussed below. In later sections, we show how we applied these criteria flexibly to different targets and thematic groups (e.g., seafloor habitats, migratory species). In practice, the best available data were not always sufficient to directly map each attribute with confidence but we found that the analysis of spatially explicit geophysical and biodiversity data described below did, at the least, indirectly reveal important areas containing many of these attributes.

<u>Important areas for the conservation of target species.</u> Target migratory and coastal species were identified with the intention of representing the breadth of life histories characteristic of the region. Specific geographic areas necessary for these species were identified using analysis of survey data spanning several decades. The co-occurrence of such areas for multiple target species may be used to indicate ecological or biodiversity "hot spots;" these may often coincide with the ecological and physical features described below. We hypothesize that persistent concentrations of target species indicate habitats with resources that support these processes, such as the shallow water calving areas for baleen whales or the squid-rich deep canyon region used by toothed whales.

Examples: whale concentration areas, sea turtle nesting areas.

<u>Known locations of rare and/or particularly sensitive habitat types.</u> These are structure-forming marine fauna (e.g., eelgrass beds, oyster reefs, and coral reefs) or structurally complex habitat types (hardbottom, boulder fields, submarine canyon heads). The types of habitats important to the region were identified using literature review and expert guidance, and their locations were determined using sample points from existing surveys.

Examples: hardbottom habitat, cold-water corals, coral reefs and coral mounds, seagrass habitat.

<u>Representative biological habitats and ecological features with demonstrated significant function in supporting target species and biodiversity in general.</u> The locations of these features were revealed, or suggested, through correlation of species-level data with habitat conditions, such as the connection between specific estuaries

and the diversity of estuary-dependent fish. Specifically, measurable links between a group of organisms and a physical setting were sought to understand the variation within common environments and partition them into ecologically meaningful units.

Examples: estuarine fish associated with saltmarsh and eelgrass habitats; demersal fish associated with hardbottom habitat; benthic communities associated with a certain sediment type, topographic form and depth zone combination.

Oceanographic features and processes that influence the distribution, abundance and behavior of conservation target species. Ecologically important oceanographic features and processes include major currents that drive source-sink dynamics (larval release and settlement locations), vertical processes like upwelling, and ecotones at different scales (e.g., shorelines, the shelf-slope break, biogeographic boundaries) where pronounced shifts in natural communities occur. Some of these features and processes are relatively stable in their location while others are more dynamic. Some of these areas, such as the shelf-slope break, were indirectly identified through analysis of migratory species survey data, but we did not identify any priority conservation areas based solely on oceanographic data.

Portfolio Data Themes

Spatial data were compiled for each of three thematic areas – coastal habitats, seafloor habitats, and migratory species – and eight conservation target categories (Table 5.1). A portfolio of conservation areas was developed individually for each theme, and a combined portfolio was subsequently developed based on areas identified by one or more themes. The coastal, seafloor, and migratory portfolios may be used separately to inform decision-making processes that are geographically or thematically focused.

The methods used to define the thematic and combined portfolios are described below. In each section, the criteria used to identify important places are described with respect to the conservation targets. The nature of the targets, ranging from deep-water corals to migrating whales, dictated that criteria be developed specifically for each target group. Moreover, criteria were designed to be appropriate to the ecology of the target and to the type of data available for the region. Our goal was to make each criterion straightforward, transparent, and justifiable. Interpretation, however, becomes complex as results accumulate across many targets. All data sources and processing steps are described in detail in the other chapters of this report.

Sub-regions and the Stratification of data

To guide the analysis and ensure full geographic representation of priority areas, the South Atlantic Bight's three ecological sub-regions (Mid-Atlantic, Carolinian, and Floridian) were used in applying the selection criteria (Spalding et al. 2007). This allowed us to locate, for example, the largest seagrass bed in each sub-region, or the highest concentration of hardbottom reefs in each sub-region. Additional discussion of the sub-regions is provided in the Introduction.

Table 5.1. Thematic groups, target categories, and attributes

Category	Attributes	Coastal Portfolio	Benthic Portfolio	Migratory Portfolio
Coastal				
Coastal habitats	Ocean beach	X		
	Salt marsh	X		
	Tidal freshwater marsh	X		
	Tidal forest	X		
	Mangrove	X		
	Tidal flat	X		
	Seagrass	X	X	
	Oyster reef	X		
Coastal Species	Diadromous fish	X		
	Estuary-dependent fish	X		
	Sea Turtles (Loggerhead)	X		X
	Manatees	X		
Coastal Condition	Land use and shoreline	X		
Seafloor				
Hardbottom (rock substrate)	Fish diversity		X	
	Cold water corals		X	
	Concentration areas		X	
Coral reef	Shallow reefs (patch, platform, pavement)		X	
	Oculina Banks		X	
Softbottom (sand, mud)	Seagrass	X	X	
	Fish diversity		X	
Migratory				
Cetaceans	Baleen Whales			X
	Toothed Whales			X
	Dolphins			X
Sea Turtles	Hard-shelled			X
	Leatherback			X

Analysis units

Two types of analysis units were used for binning and summarizing data: coastal shoreline units for the coastal targets and ten-minute squares for the seafloor and migratory targets. As defined in greater detail in the Coastal chapter, coastal shoreline units (CSUs) represent coastal watersheds and associated estuarine waters. There were 39 CSUs within the project area which ranged in size from Albemarle Sound (1,059,988 ha) to Mosquito Lagoon (31,638 ha). Ten-minute squares (TMS) are a standard marine spatial analysis unit consisting of a square geographic space defined by latitude and longitude and approximately 80-100 square nautical miles (129-161 km) per side. The TMS divided the study region into 1,524 units.

Coastal Portfolio

The coast along the South Atlantic Bight is recognized for its productive estuaries, extensive wetlands, and long stretches of barrier islands. These areas provide juvenile nursery and spawning grounds for fish and shellfish, feeding areas for shorebirds, and nesting beaches for sea turtles. The coasts and estuaries of the South Atlantic Bight have attracted and sustained humans for thousands of years. Today, coasts are where we live, recreate, work, and gather. They help support the economy, providing opportunities for tourism, shipping and transportation routes, and commercial fishing. Coastal systems are also at risk from pollution, habitat destruction, harmful algal blooms, fishery collapses, and increased coastal erosion. In the South Atlantic Bight, these threats continue to increase as coastal populations and uses grow. This growth can not only impact natural resource health, but can also have significant social and financial impacts for coastal communities.

The goal of the coastal portfolio is to identify places of high biodiversity and ecological importance. To do this, we examined a suite of conservation attributes falling under three overarching coastal target categories: habitats, species, and condition. Thirteen target-based attributes were evaluated across all coastal shoreline units (CSUs), serving as the foundation for the portfolio analysis. In some instances, lack of comprehensive data across the full project area (e.g., coastal birds, eutrophication) prohibited us from effectively evaluating the attribute at the regional scale. These attributes (italicized below) are categorized as "rare and exemplary features," helping to describe an individual CSU, but not included in the integrated portfolio calculations.

Habitats

Ocean beach – Total extent (ha)
Salt marsh – Total extent (ha)
Tidal freshwater marsh – Total extent (ha)
Tidal forest – Total extent (ha)
Mangrove forest – Total extent (ha)
Tidal flat – Total extent (ha)
Seagrass Beds – Total extent (ha)
Oyster Reefs – Number of high density oyster reef areas

Species

Diadromous Fish – Average number of species per stream/river kilometer
Estuary-Dependent Fish – Predicted fish diversity
Loggerhead Sea Turtles – High density nesting beaches
Manatees – Average weighted persistence for wintering areas
Coastal Birds – Western Hemisphere Shorebird Network sites

Condition

Land use and shoreline – Watershed condition metric
Water Quality – Eutrophication score
Point Source Pollution – Number of sites
Sea Level Rise Vulnerability – Percentage of CSU under 0.5 m elevation

Methods for the Coastal Portfolio

The Coastal chapter details the data sources and processing steps used to map coastal habitats and species. Straightforward analytical methods were used to identify important areas or reveal spatial patterns relevant to conservation. For all analyses, the region was divided into thirty-nine CSUs which were classified based on estuary type and subregion. This classification enabled us to account for system-based characteristics and ensure full geographical representation. A description of estuary types can be found in the Coastal chapter. The ecosystem role, selected attribute and analytical methods are described below for each target.

Coastal Habitats

<u>OCEAN BEACH (TOTAL EXTENT)</u>

Generally associated with barrier islands, ocean beaches are highly dynamic habitats which serve as important feeding and breeding grounds for a variety of species, including shore birds and sea turtles (Stedman and Dahl 2008; Harrington 1999). The total extent of ocean beach habitat associated with a given CSU was used as the target attribute.

<u>SALT MARSH (TOTAL EXTENT)</u>

Among the most biologically productive ecosystems on Earth, salt marshes are an important component of the estuarine food web, providing food and important nursery grounds for shellfish and finfish (Teal 1962; Odum 1970; Valiela et al. 1976; Nixon 1980, Tiner 1984, Boesch and Turner 1984; Peterson et al. 2000; Stedman and Hanson 2000). With significant tidal ranges and limited coastal development, the coastlines of South Carolina and Georgia include wide stretches of salt marsh. In identifying an attribute for salt marsh, consideration was given to extent of salt marsh relative to shoreline distance, and an analysis of patch size. However, neither provided clear ecological reason for selection while favoring certain subregions and CSU types. The decision was made to use total extent as the target attribute with the assumption that larger extents were generally correlated with a range of patch sizes representing a healthy marsh system.

TIDAL FRESHWATER MARSH (TOTAL EXTENT)

In regions where rivers deliver large quantities of fresh water to coastal habitats, salt water tidal marshes may grade to brackish and even completely freshwater marshes. Brackish and freshwater tidal marshes are important for migrating waterfowl and anadromous fishes and, like salt marshes, contribute considerable carbon to the estuaries of which they are part (Odum et al. 1984). Tidal freshwater marsh systems are dependent on a specific set of conditions and therefore are relatively limited in scope. Thus, total extent was selected as the target attribute.

TIDAL FOREST (TOTAL EXTENT)

For this analysis, we separated tidally influenced freshwater swamps from mangrove systems. Freshwater tidal swamps (tidal forest) are forested or shrub-dominated tidal wetlands that occur along freshwater tidal portions of large river systems (Mitsch et al. 2009). Similar to tidal freshwater marsh, they require specific ecological conditions and are relatively limited in scope. Total extent was selected as the target attribute.

MANGROVE FOREST (TOTAL EXTENT)

Mangroves are primarily found in estuarine waters where they serve as valuable nurseries for recreationally and commercially important marine species (Dahl and Stedman 2013; National Park Service 2010). Found only in the southern portion of the South Atlantic Bight, mangroves are a fringing ecosystem with a limited range. The total extent within a CSU was selected as the target attribute.

TIDAL FLAT (TOTAL EXTENT)

We removed estuarine beaches from the analysis because of the limited coverage within the data set. Tidal flats are foraging grounds for marine organisms such as eels, crabs, fish, snails, and shrimp at high tide and terrestrial organisms, particularly shorebirds, at low tide (Harrington 1999). These non-vegetated, soft sediment habitats, can be ephemeral within the intertidal system and vary in location based on sediment dynamics (Dyer et al. 2000). To provide a general understanding of the presence of tidal flats within a CSU, total extent was selected as the target attribute.

SEAGRASS BEDS (TOTAL EXTENT)

Seagrasses are marine, subtidal, rooted vascular plants found on the bottom of protected bays, lagoons, and other shallow coastal waters along most of the East Coast. The exception is the coastal waters of South Carolina and Georgia where high freshwater input, turbidity, and large tidal amplitude inhibit seagrass occurrence

(Street et al. 2005). The location and extent of seagrass beds within an estuary vary annually. Data necessary to evaluate these changes at the regional level is limited. Recognizing the importance of evaluating the core ecosystem values that seagrass beds provide at a regional scale, the total area (ha) of seagrass, regardless of density, was tabulated for CSUs in North Carolina and Florida.

OYSTER REEFS (NUMBER OF HIGH DENSITY OYSTER REEF AREAS)

Oysters form reefs in subtidal areas to depths of 10 m and in intertidal areas, tolerating a wide range of temperatures and salinity levels. We focused on intertidal oyster habitats which dominate oyster communities across the South Atlantic (except in the Albemarle and Pamlico Sounds) and are the most surveyed oyster populations. Data variation and limitation restricted our ability to evaluate attributes such as total extent of oyster beds at the regional scale. Specifically, the format of the regional oyster dataset posed three challenges: (1) states used different survey approaches, (2) not all coastal areas, especially in Georgia and Florida, were equally surveyed, and (3) we were restricted to working with the vector (polygon) format as converting the small oyster polygons to a raster grid resulted in a loss of critical information. To address these challenges, we developed the following approach (Figure 5.1) which enabled us to identify CSUs with many high-density intertidal oyster areas.

After exploring a variety of grid cell sizes, we created a grid of 100-acre cells across the project area to identify locations with many intertidal oyster polygons clustered together. All 100-acre grid cells that intersected intertidal oyster polygons were selected and the percentage of each grid cell comprised of intertidal oyster habitat was calculated.

To ensure equal comparisons, we transformed the values to z-scores, putting all the units on a relative scale where a score of “0” was equal to the mean score across all units and a score of “1” was equal to one standard deviation above the mean (see Appendix 5 for more details on z-scores). A Box-Cox transformation was used to transform the percent values to an approximate normal distribution and z-scores were calculated from the transformed values. Finally, for each state, the number of grid cells with an above average percent of oyster habitat (1 to 2 standard deviations above the mean) was tallied. This final step was done to account for significant differences in available data across states. The resulting attribute is a metric representing the number of high density areas per CSU (Figure 5.1).

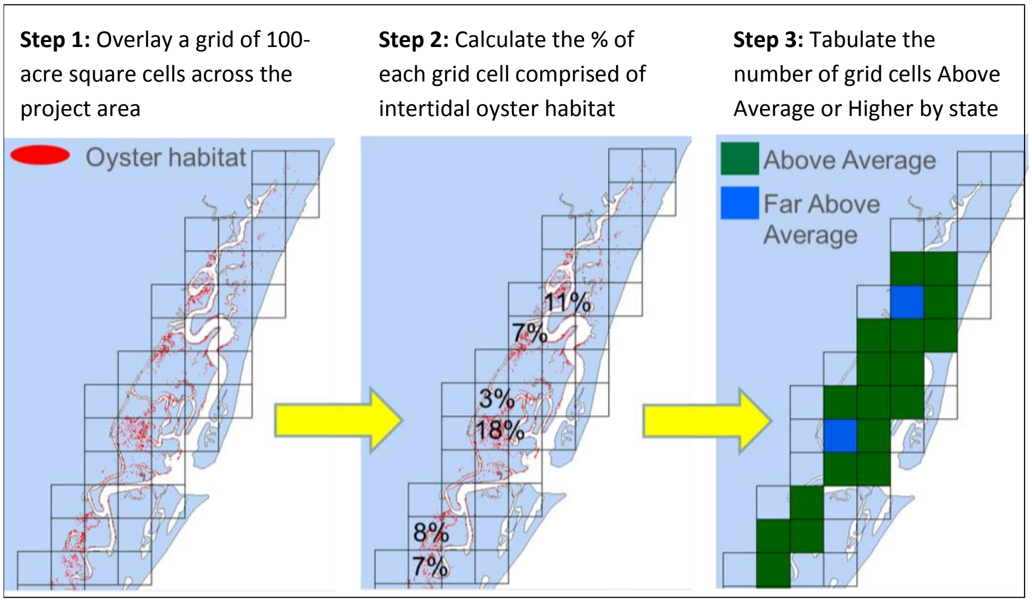

Figure 5.1. Identifying CSUs with a large number of high-density oyster areas relative to other CSUs, taking into account differences in data collection by state

Species

<u>DIADROMOUS FISH (AVERAGE NUMBER OF SPECIES PER STREAM/RIVER KILOMETER)</u>

Because of their migration patterns, diadromous fish provide unique connections among marine, estuarine, and riverine habitats. To assess the importance of CSU streams and rivers for diadromous fish, we used baseline data on the presence of six diadromous fish species: blueback herring, American shad, hickory shad, alewife, shortnose sturgeon, and Atlantic sturgeon. Using the Southeast Aquatic Connectivity Assessment Project (SEACAP) fish data (Martin et al. 2014), we calculated the average number of diadromous fish species per kilometer of streams and rivers in each CSU. For CSUs with the same average number of species, we used the CSU's average length of connected stream networks (i.e., stream reaches that are not fragmented by a dam or other barriers) as a tie-breaker. This value reflects, on average, how accessible the streams and rivers are to a hypothetical fish moving within a CSU.

<u>ESTUARY-DEPENDENT FISH</u>

Many fish depend on estuaries for all or some part of their life cycle (Table 5.2). To understand the relative value of a particular CSU to estuary-dependent fish species, we associated nearshore fishery-independent trawl survey data with the nearest CSU and then evaluated the abundance and diversity of selected species related to habitat characteristics.

Table 5.2. Fish species selected from the SEAMAP-SA independent survey dataset that depend on estuarine habitats for at least one life stage

• Atlantic croaker	• Northern pipefish	• Spot
• Atlantic menhaden	• Northern sea robin	• Spotted hake
• Bay anchovy	• Pinfish	• Spotted seatrout
• Blueback herring	• Pink shrimp	• Summer flounder
• Butterfish	• Silver perch	• Weakfish
• Clearnose skate	• Southern flounder	• White shrimp
• Northern brown shrimp	• Southern kingfish	• Windowpane flounder

Twenty-three years (1989-2012) of independent trawl survey data from the Southeast Area Monitoring and Assessment Program-South Atlantic (SEAMAP-SA 2014) were used to estimate abundance and diversity of estuary-dependent fish on the inner Continental Shelf. The 6,481 samples, covering 220 species, were evaluated by season with spring defined as April through July and fall from September through November. The dataset covered the Carolinian and Mid-Atlantic subregions (Figure 5.2). To account for the data gap in the Floridian subregion, we considered using data from the Florida Fish and Wildlife Conservation Commission's (FWC) Inshore Fisheries-Independent Monitoring (FIM) Program (FWC, FWRI 2010; Figure 5.2). However, the FWC data used different sampling techniques that were not compatible with the analysis, and were therefore not incorporated. The impact and limitation of this data gap on the Floridian CSU analyses is noted below.

Each trawl sample was assigned to the closest CSU using a proximity analysis with a maximum search distance of 25 km. This resulted in 25 of the 39 CSUs having information on at least one of the 21 possible estuary-dependent fish (Table 5.2). To evaluate the strength of each species-estuary association and correct for sampling effort, we ran an ordinary least squares regression with the number of times a species was detected in a CSU as the dependent variable and the number of times the CSU was sampled as the independent variable. This allowed us to determine if estuary-dependent fish species were found more often than expected given the number of times sampled.

In the spring season, 18 of the 21species had significant regression models while 17 species had significant models in the fall (significance = $p<0.05$, Table 5.3). From these we extracted the standardized regression residuals as a measure of how much more, or less than expected the species was detected. For each CSU, we summed the number of species with a standardized residual greater than zero. This value indicates the number of species that were found more times than expected in each season (henceforth: the baseline score).

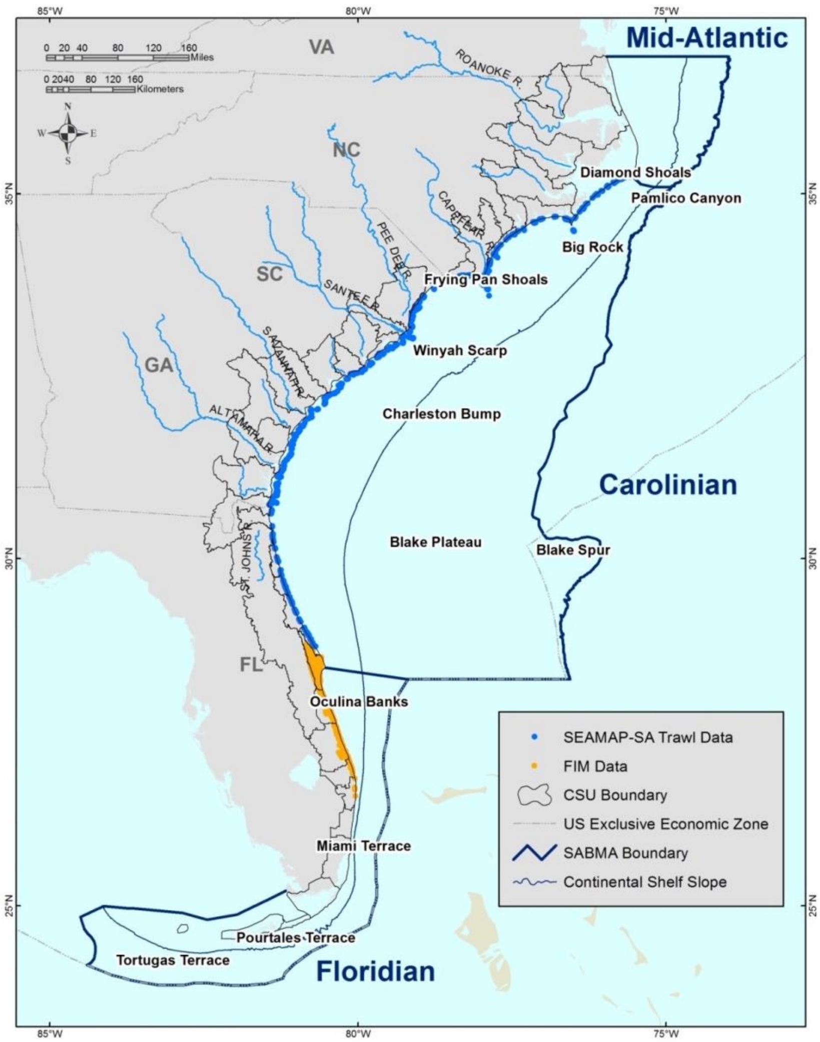

Figure 5.2. Spatial distribution of the SEAMAP-SA trawl data and Florida's FWRI FIM monitoring data. The SEAMAP-SA data occur within the Carolinian and Mid-Atlantic subregions of the project area while the FIM data primarily occur within the Floridian subregion.

Table 5.3. Regression results for the 21 selected estuarine fish species by season. Results show the strength of the relationship between detection and sampling effort in the SEAMAP-SA trawl data.

	Spring		Fall	
Species	**Adj. R2**	**p-value**	**Adj. R2**	**p-value**
Atlantic croaker	0.723	0.000	0.873	0.000
Atlantic menhaden	0.162	0.036	0.195	0.018
Bay anchovy	0.629	0.000	0.592	0.000
Blueback herring	----	NS	----	NS
Butterfish	0.865	0.000	0.785	0.000
Clearnose skate	0.455	0.000	0.644	0.000
Northern brown shrimp	0.684	0.000	0.743	0.000
Northern pipefish	----	NS	----	NS
Northern searobin	0.819	0.000	0.555	0.000
Pinfish	0.665	0.000	0.690	0.000
Pink shrimp	0.520	0.000	0.507	0.000
Silver perch	0.185	0.021	----	NS
Southern flounder	0.464	0.000	0.421	0.000
Southern kingfish	0.896	0.000	0.913	0.000
Spot	0.843	0.000	0.934	0.000
Spotted hake	0.689	0.000	----	NS
Spotted seatrout	----	NS	0.475	0.016
Summer flounder	0.692	0.000	0.652	0.000
Weakfish	0.728	0.000	0.833	0.000
White shrimp	0.425	0.000	0.758	0.000
Windowpane	0.606	0.000	0.571	0.000

In addition, we calculated a boosted score to indicate how many species were present far more than expected (i.e., had a standardized residual greater than 1), revealing the estuaries where these species are persistently found in high abundance (Figure 5.3 provides an example for one species). We combined the two scores using a weighted sum giving the baseline score twice as much weight as the boosted score (baseline + (½ boosted)). This approach ensured that a CSU with only four species that were all detected far more than expected would not get a higher score than a CSU with six species that were all detected slightly more than expected. The weighted sum served as the final fish detection score and was joined to the 25 CSUs.

Finally, we estimated scores for the unsampled estuaries by calculating 19 spatially-explicit habitat and biophysical variables (Table 5.4) that were hypothesized to be important for estuarine fish and for which data were available. We then used a general additive regression model (GAM) to assess the relationship between the confirmed estuarine fish detection scores and CSU habitat characteristics. For all regressions, we assigned each CSU the highest of its two scores from fall or spring to serve as the dependent variable while the metrics described in Table 5.4 served as the predictor variables.

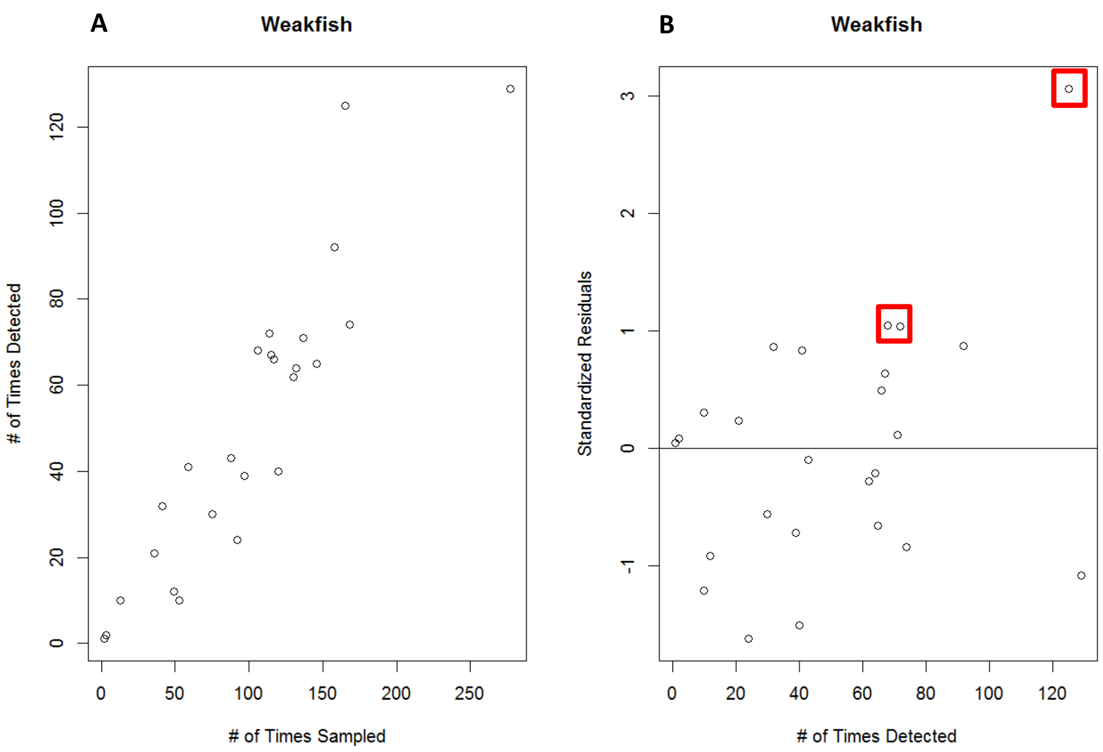

Figure 5.3. Weakfish in the SEAMAP-SA trawl dataset in the fall season. A) the relationship between the number of times CSUs were sampled and the number of times that weakfish was found, and B) the standardized residuals from the regression analysis of detection on number of times sampled. In B, all the points with a standardized residual greater than 0 (points above the horizontal line) represent CSUs where weakfish was found more than expected given the number of times the CSU was sampled. The three points enclosed in a red box indicate CSUs where weakfish was found far more than expected given the number of sampling events. These three CSUs would receive a boosted score of 1 for weakfish. This type of analysis was conducted for each estuarine species.

Table 5.4. Habitat and variables calculated to characterize the Coastal Shoreline Units

Variable	Units	Description	Source
seagrass area	m^2	amount of seagrass	Seagrass data compiled for the region by TNC
seagrass percentage	%	percentage of CSU comprised of salt marsh	Seagrass data compiled for the region by TNC
salt marsh area	m^2	amount of salt marsh	Tidal wetlands data compiled for the region by TNC
salt marsh percentage	%	percentage of CSU comprised of seagrass	Tidal wetlands data compiled for the region by TNC
mangrove forest area	m^2	amount of mangrove forest	Tidal wetlands data compiled for the region by TNC
mangrove forest percentage	%	percentage of CSU comprised of mangrove forest	Tidal wetlands data compiled for the region by TNC
freshwater marsh area	m^2	amount of freshwater marsh	Tidal wetlands data compiled for the region by TNC
freshwater marsh percentage	%	percentage of CSU comprised of freshwater marsh	Tidal wetlands data compiled for the region by TNC
tidal flats area	m^2	amount of tidal flats	Tidal wetlands data compiled for the region by TNC
tidal flats percentage	%	percentage of CSU comprised of tidal flats	Tidal wetlands data compiled for the region by TNC
mean bathymetry	M	mean depth	TNC 90-m bathymetry raster
standard deviation of bathymetry	M	standard deviation of depth	TNC 90-m bathymetry raster
range of bathymetry	M	range of depth values	TNC 90-m bathymetry raster
mean height	M	mean height	TNC 90-m height raster
standard deviation of height	M	standard deviation of height values	TNC 90-m height raster
Range of height	M	range of height values	TNC 90-m height raster
open water area	m^2	amount of open water	TNC 90-m bathymetry raster
open water percentage	%	percentage of CSU comprised of open water	TNC 90-m bathymetry raster
Shoreline complexity (sinuosity)	Unit-less	lower values indicate greater complexity	ESI medium resolution shoreline

Stepwise regression, forward and backward, was used to identify the most important predictor variables for the analyses. The best performing GAM model was selected as the final model to represent the relationship between CSU habitat characteristics and the fish detection score. The model had an adjusted R^2 of .822 and explained 93.1% of the variation in the fish detection scores. The most important variables in the model were percentage of salt marsh, percentage of tidal flats, and percentage of open water. Additional variables used in the model included sinuosity of the shoreline, mean height, range of height, and range of depth values.

We used the final model to predict fish detection scores for all 39 CSUs. The average fish detection score for the CSUs was 12 with a standard deviation of 6, and maximum and minimum scores of 29 and 0, respectively. The fish detection scores for all 39 CSUs were then converted to standardized normal scores (z-scores) for the entire project area (Figure 5.4). As we did not have fish survey data for the Floridian subregion, the results of the analysis using the SEAMAP-SA trawl data for this subregion should be interpreted with caution as there are ecological communities, such as mangrove forests, that are largely unique to the Floridian subregion and were not included in the habitat characterization model.

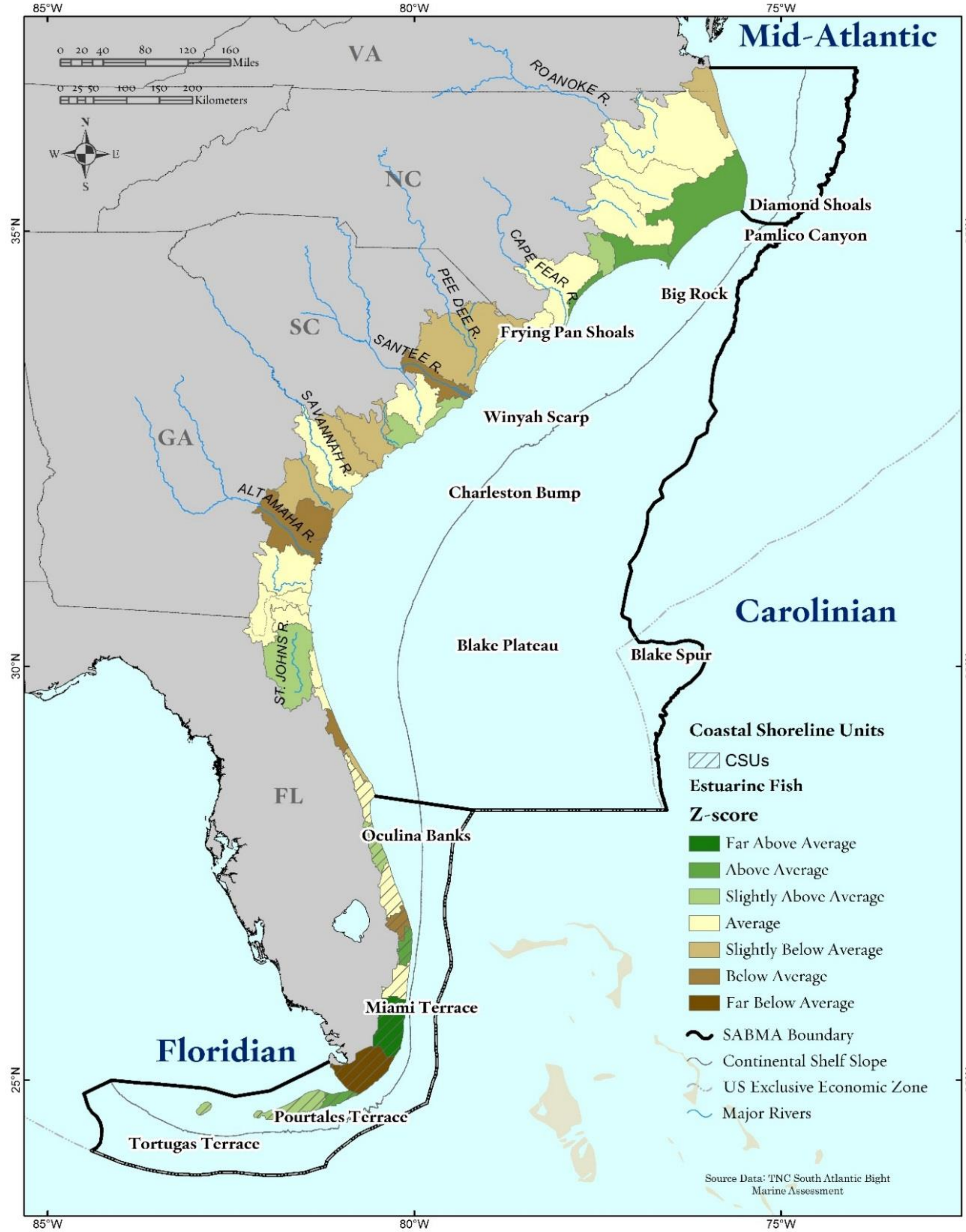

Figure 5.4. Predicted estuarine fish detection scores for CSUs converted to standard normal scores (z-scores) for the SABMA project area. Note that in the Floridian subregion all scores were estimated based on the northern data, and should be interpreted with caution as they do not reflect the many fish species and habitats unique to this region.

LOGGERHEAD SEA TURTLES (HIGH DENSITY NESTING BEACHES)
As discussed in the Marine Mammal and Sea Turtle chapter (Geselbracht et al. 2015), loggerhead sea turtles nest on sandy beaches throughout the South Atlantic. Five subpopulations of loggerhead sea turtles have been identified in the region. To highlight the most critical beaches, surveyed shorelines ranked in the top 25% for loggerhead nesting density for each subpopulation were selected and associated with their respective CSU. For each CSU, total shoreline distance (km) of high density nesting beaches was calculated.

MANATEES (AVERAGE WEIGHTED PERSISTENCE FOR WINTERING AREAS)
The Marine Mammal and Sea Turtle chapter describes the important role of coastal springs and warm water areas in providing warm water refugia for Florida manatees during the winter months. We used data collected during winter aerial surveys of manatees from 1991-2011 by the Florida Fish and Wildlife Conservation Commission (FL FWCC). The Florida winter synoptic survey weighted persistence analysis, described in the Marine Mammal and Sea Turtle chapter, was used to assess the importance of CSUs for manatee wintering habitat. The average of the weighted persistence scores for all the one-minute squares within a CSU was calculated as the final metric of manatee wintering habitat importance.

COASTAL CONDITION (LAND USE AND SHORELINE METRIC)
Upland land use and shoreline structures can have a significant impact on the condition of estuarine systems, affecting nutrient loads, water quality, and the ability of intertidal habitats to migrate under pressure from sea level rise. Previous research suggests that watersheds with relatively high percentages of urban and agricultural land are associated with lower estuarine benthic indicators of condition and biodiversity (Hale et al. 2004) and reduced submerged aquatic vegetation (Li et al. 2007). To make the connection between terrestrial and estuarine systems, we calculated a current condition metric to identify CSUs with intact and natural shorelines as well as those expected to have good estuarine water quality based on current land use.

Current condition was calculated by tabulating the area of NLCD 2011 development and agriculture (Jin et al. 2013) as well as roads (US Census 2014) at three geographic scales: a 2-m vertical elevation zone along the shoreline, a 300m horizontal buffer zone along the shoreline, and the entire upstream watershed of each CSU. Because the summed scores were highly correlated across the three scales, a principal component analysis was used to reduce the correlated values to a single axis. This single axis score was normalized to a scale of 0-100, with 100 representing the least developed and therefore, presumably, the best water quality condition. The final condition score incorporated information on hardened shorelines through subtraction of the percent of manmade shoreline in the CSU from the normalized condition score. For example, Pamlico Sound in North Carolina had a current condition score of 97 based on a normalized condition score of 100 and 3% hardened shoreline.

Rare and Exemplary Features

We also assessed the CSUs for outstanding features that we thought were important for marine biodiversity, but for which we did not have comprehensive data throughout the project area. These “rare and exemplary features” may indicate high priority biodiversity conservation opportunities and are provided as supplementary information to inform the characterization and assessment of sites for conservation or management actions. Examples of rare or outstanding features include CSUs with moderate-low eutrophication, low density of point source pollutant sites, internationally significant bird areas, and important small lagoonal systems in Florida.

LOW EUTROPHICATION

Eutrophication due to excess nutrients from anthropogenic activities is an increasing problem for estuaries as coastal populations continue to grow. In addition, the warmer water temperatures that are predicted to accompany climate change are expected to exacerbate eutrophication. Excess nutrients increase waterbody productivity resulting in increased concentrations of chlorophyll *a*, algal blooms, decreased levels of dissolved oxygen, and the loss of submerged aquatic vegetation and benthic species. These impacts degrade water quality, ecosystem services, and the overall health of estuaries.

To identify CSUs with low eutrophication, we used the Overall Eutrophic Condition (OEC) index from the National Estuarine Eutrophication Assessment (NEEA; Bricker et al. 2007). The OEC overall rating is based on the assessment of quantitative and qualitative data for three categories: 1) influencing factors; 2) overall eutrophic condition; and 3) future outlook. Influencing factors include nitrogen loads and the ability of an estuary to respond to nitrogen (i.e., via dilution and flushing). Overall eutrophic condition incorporates the occurrence, spatial coverage and frequency of five symptoms: chlorophyll *a*, macroalgae, dissolved oxygen, nuisance/toxic blooms, and submerged aquatic vegetation (SAV) impacts. Future outlook is based on both the sensitivity of an estuarine system to nutrients and future nutrient load levels expected in 2020. Information from the above three categories was synthesized to arrive at an overall qualitative rating for estuaries. Refer to Bricker et al. (2007) for more information on the OEC index. The OEC rating was available and applicable for 18 of the 39 CSUs. For the other 21 CSUs, an OEC rating was either unavailable due to lack of information or the spatial extent of the OEC estuaries and the CSUs did not align (e.g., an OEC rating was only available for the Ossabaw portion of the Ossabaw Wassaw Sounds CSU).

LOW POINT SOURCE POLLUTION

We used data developed for the National Fish Habitat Action Plan (NFHAP) Assessment of Stressors to Estuarine Fish Habitats (Greene et al. 2015) to characterize the impact of point source pollution on CSUs. Greene et al. (2015) compiled publicly-available point source locations from the Toxic Release Inventory (TRI), National Pollution Discharge Elimination System (NPDES), Superfund, and mine sites. For each estuary, the total number of point source sites within 500 m of an estuary was tabulated and then normalized by total watershed area (km^2). We used the NFHAP pollutant densities to calculate rank-based z-scores for each CSU type by subregion which led to the identification of CSUs with a low density of point source sites relative to other CSUs of the same type and within the same subregion.

COASTAL AND MARINE BIRDS

As described in the Coastal chapter, data sources that focused on population counts and could be evaluated at a regional level were not available for marine and coastal birds. This data challenge led us to focus on the Western Hemisphere Shorebird Reserve Network (WHSRN 2010). Two WHSRN sites are in the SABMA project area: Cape Romain National Wildlife Refuge and Altamaha River Delta. The three CSUs which overlap with the two WHSRN sites, Cape Romain, Altamaha River, and St. Catherines/Sapelo Sounds, are recognized for their unique bird status.

Climate Change

While there are numerous ways in which climate change is expected to impact coastal systems, one of the threats that could be more directly quantified at the CSU scale was sea level rise vulnerability. As with the rare and exemplary features described above, we do not consider relative vulnerability to sea level rise in the portfolio scoring process. Rather, we included this variable to remind or alert users to consider this threat as they are evaluating the other key characteristics of a CSU.

SEA LEVEL RISE VULNERABILITY

To provide a relative and coarse estimate of CSU vulnerability to sea level rise (SLR) by 2100, we assessed the amount of land in each CSU with an elevation value less than 0.5 m. The elevation threshold was based on a recent report by NOAA (Parris et al. 2012) that synthesizes the wide range of mean global SLR estimates in the scientific literature and provides four different SLR scenarios for coastal planning, policy, and management efforts (Table 5.5). We selected the conservative "intermediate-low scenario" which projects an increase in sea level of 0.5 m by 2100. We used a 30 m Digital Elevation Model (DEM) from the National Elevation Dataset (NED; Gesch et al. 2002, Gesch 2007) to calculate the percentage of the CSU comprised of 30 m grid cells with an elevation value less than 0.5 m. This approach is simplistic and has several caveats that should be considered. First, much finer scale elevation data such as LiDAR is preferred for SLR inundation analyses but was not readily available for the entire project area. In addition, this approach does not consider connectivity of the land areas, coastal flooding, tidal variability information, marsh migration, and erosion/deposition processes. Despite these limitations, the approach does provide a quick snapshot of the relative vulnerability of each CSU to SLR for consideration by end users of this coastal assessment.

Table 5.5. Global sea level rise (SLR) scenarios from Parris et al. (2012)

Scenario	SLR by 2100 (m)*	SLR by 2100 (ft)*
Highest	2.0	6.6
Intermediate-High	1.2	3.9
Intermediate-Low	0.5	1.6
Lowest	0.2	0.7

*Using mean sea level in 1992 as a starting point.

Coastal Portfolio Scoring Process

We determined the relative importance of individual CSUs for each of the thirteen attributes (e.g., habitats, species, and condition) described above. Most metrics were calculated for each of the 39 CSUs. In some cases (e.g., seagrass beds and manatees), the natural extent of the conservation target limited the association to CSUs where the resource is present. In addition, we calculated the cumulative value of attributes associated with each CSU. This provides users with a broad picture of the relative value of CSUs across the suite of habitat, species and condition attributes. However, it is not meant to be interpreted as a CSU prioritization. Depending on the management question or conservation goal, the CSU's importance for a singular attribute may outweigh the cumulative total.

We aimed to institute a transparent evaluation process that quantitatively accounted for each regionally-available attribute metric without establishing arbitrary numeric conservation target goals (i.e., conserve 10,000 acres of seagrass). Both subregion and estuarine type (i.e., lagoonal, riverine) were incorporated into the scoring system to ensure geographic representation. In addition, we accounted for CSUs that were regionally important regardless of type or location. For example, the greater freshwater flow and tidal extent of piedmont rivers in the Carolinian region support large areas of tidal freshwater wetlands which are important habitats for some fish species. In coastal riverine estuaries and lagoons, the extent of freshwater wetland habitats is smaller, but can still be geographically important.

These considerations resulted in the following scoring process which was applied to each of the regionally-available attribute metrics, resulting in individual attribute scores by CSU:

- Top Ranked (3 points): The CSU with the highest value by subregion and type received a score of three, if it met an 'average' ranking requirement.
- Regionally Important: CSUs that were not the top ranked were evaluated based on their ranked based z-score d as follows:
    - Above average regional rank-based z-score (2 points)
    - Slightly above average regional rank-based z-score (1 point)

Small Florida Lagoonal Systems

The lagoonal CSUs in Florida are small relative to other lagoonal systems in the project area. We recognized that their smaller size limited classification as regionally important. To highlight those small systems that had relatively high attribute metric scores, we completed an additional ranking of the small lagoonal CSUs within the state of Florida based on their total portfolio score.

Salt Marsh Example

The following example uses the salt marsh attribute to describe the progression from an initial characterization of the coastal attributes described in the Coastal chapter to a quantitative assessment of each attribute for the portfolio.

<u>Step 1</u>: The Coastal chapter showed the distribution of salt marsh area by CSUs, displayed as quintiles (i.e., Figure 5.5). Quintiles were used to illustrate patterns of salt marsh distribution across the project area and to facilitate visual comparison of salt marsh area among CSUs. In Figure 5.5, each class or quintile contains 20% of the CSUs with the top quintile containing the 20% of CSUs with the greatest total area of salt marsh habitat across the South Atlantic Bight.

<u>Step 2</u>: The area of salt marsh habitat was ranked by CSU type and subregion. For example, among Coastal Plain Basin Riverine CSUs in the Carolinian subregion, the Satilla River had the greatest area of salt marsh with 41,192 ha followed by St. Catherine's/Sapelo Sound (38,855 ha) and St. Helena Sound (38,363 ha) (Table 5.6). This step ensured geographic representation and enabled us to highlight the different types of CSUs important for salt marsh at the subregional scale. For example, Cape Canaveral has an average area of salt marsh at the regional scale but is an important salt marsh location among lagoonal CSUs in the Floridian subregion.

<u>Step 3</u>: Rank-based z-scores were calculated for the area of salt marsh habitat in each CSU across the full project area (Figure 5.6). While the quintile map and the rank-based

z-score map show similar patterns with CSUs in the top quintile falling into the Far Above Average and Above Average z-score categories, the z-score map expresses the area of salt marsh habitat in terms of the mean salt marsh habitat across all CSUs in the project area and highlights above average and below average CSUs. With 41,192 hectares of salt marsh, the Satilla River CSU had an area of salt marsh that is Far Above Average (i.e., greater than two standard deviations above the mean) compared to all other CSUs across the project area.

Table 5.6. Illustration of the portfolio scoring process for salt marsh habitat. Salt marsh is one of the thirteen attributes scored in the portfolio assessment. As highlighted by the red box, the Satilla River CSU received a score of 3 because it had the largest area of salt marsh for Coastal Plain Riverine CSUs in the Carolinian subregion. The four CSUs boxed in green received 2 points due to their regionally significant salt marsh amounts (i.e., regional z-score = Above Average) while CSUs boxed in dark blue received 1 point for their Slightly Above Average salt marsh amounts.

CSU_Code	CSU_Name	CSU_Type	Subregion	TotArea	Salt Marsh Area (ha)	Salt Marsh Rank	Salt Marsh Regional Score	Salt Marsh Portfolio Score
201	Bogue Sound	Lagoonal	Carolinian	181,947	8,307	2	A	0
203	SE NC Estuaries	Lagoonal	Carolinian	44,359	5,470	4	A	0
205	Long Bay	Lagoonal	Carolinian	98,038	4,658	5	A	0
208	Cape Romain	Lagoonal	Carolinian	68,082	20,205	1	SAA	3
221	St Augustine Inlet	Lagoonal	Carolinian	52,652	5,735	3	A	0
222	Mantanzas Inlet	Lagoonal	Carolinian	34,824	2,049	8	SBA	0
223	Ponce Inlet	Lagoonal	Carolinian	68,824	2,765	6	SBA	0
224	Mosquito Lagoon	Lagoonal	Carolinian	31,638	2,359	7	SBA	0
202	New River	Riverine (Coastal Plain Basin)	Carolinian	120,459	1,095	10	SBA	0
210	Stono North Edisto Rivers	Riverine (Coastal Plain Basin)	Carolinian	122,561	20,242	6	SAA	1
211	St Helena Sound	Riverine (Coastal Plain Basin)	Carolinian	292,346	38,364	3	AA	2
212	Port Royal Sound	Riverine (Coastal Plain Basin)	Carolinian	232,291	28,647	5	AA	2
214	Ossabaw Wassaw Sounds	Riverine (Coastal Plain Basin)	Carolinian	373,044	32,369	4	AA	2
215	St Catherines Sapelo Sounds	Riverine (Coastal Plain Basin)	Carolinian	197,976	38,855	2	AA	2
217	Satilla River	Riverine (Coastal Plain Basin)	Carolinian	372,614	41,192	1	FAA	3
218	St Marys River	Riverine (Coastal Plain Basin)	Carolinian	303,541	14,447	7	SAA	1
219	Nassau River	Riverine (Coastal Plain Basin)	Carolinian	112,296	11,944	8	SAA	1
220	St Johns River	Riverine (Coastal Plain Basin)	Carolinian	527,132	7,711	9	A	0
204	Cape Fear River	Riverine (Piedmont Basin)	Carolinian	466,586	3,886	6	A	0
206	Winyah Bay	Riverine (Piedmont Basin)	Carolinian	842,705	5,777	5	A	0
207	Santee Rivers	Riverine (Piedmont Basin)	Carolinian	182,398	5,829	4	A	0
209	Charleston Harbor	Riverine (Piedmont Basin)	Carolinian	293,728	11,759	3	A	0
213	Savannah River	Riverine (Piedmont Basin)	Carolinian	383,871	18,359	2	SAA	1
216	Altamaha River	Riverine (Piedmont Basin)	Carolinian	322,990	20,684	1	SAA	3

Step 4: In assigning portfolio scores, the Satilla River received a score of 3 because it had the largest area of salt marsh habitat among Coastal Plain Basin Riverine CSUs in the Carolinian subregion. Four CSUs received a score of 2 due to their regionally significant salt marsh area which was Above Average (Table 5.6). Three additional CSUs received a score of 1 with salt marsh area that was Slightly Above Average. Figure 5.7 shows the final salt marsh portfolio scores for CSUs.

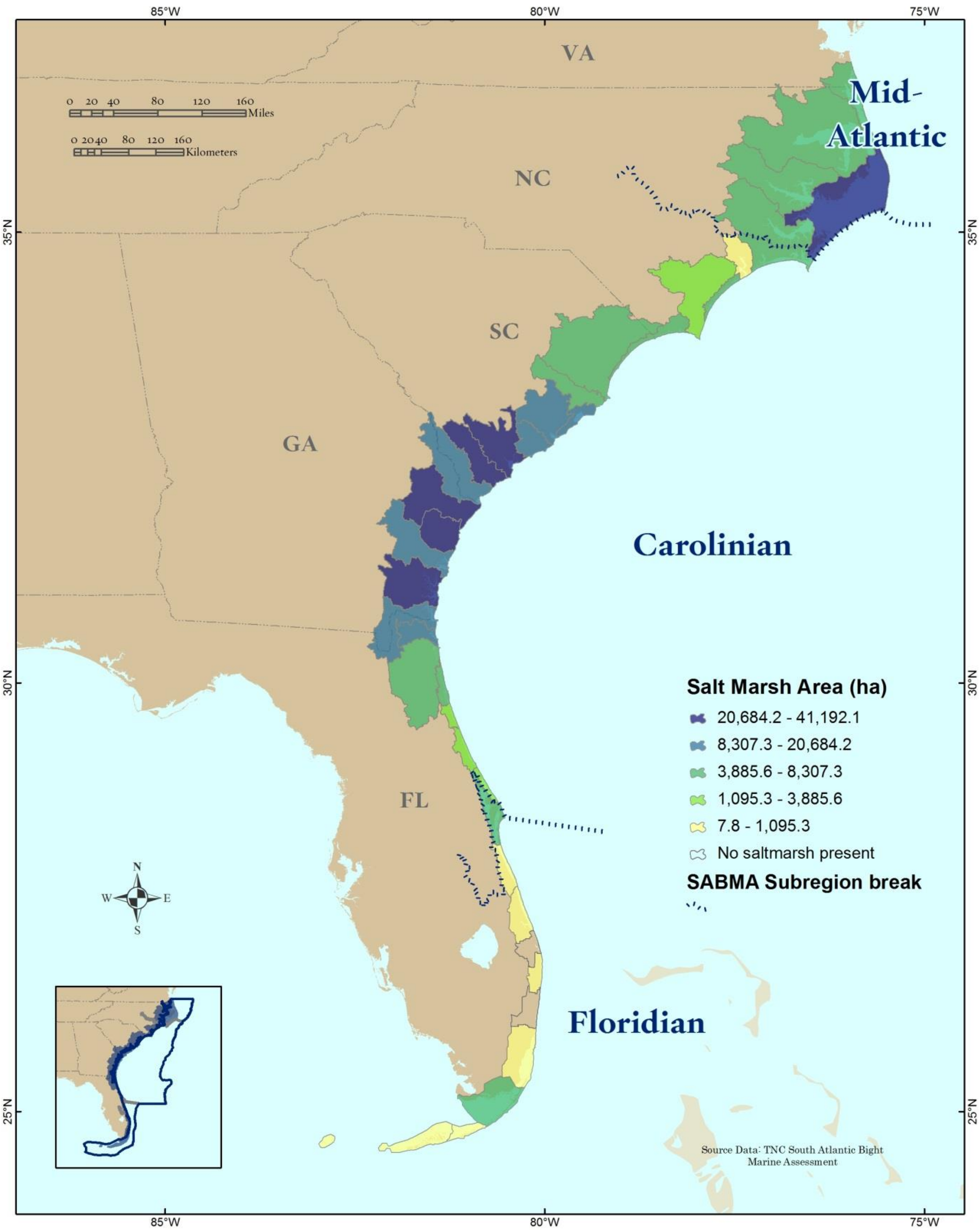

Figure 5.5. Coastal Shoreline Units ranked by salt marsh area, using quintiles

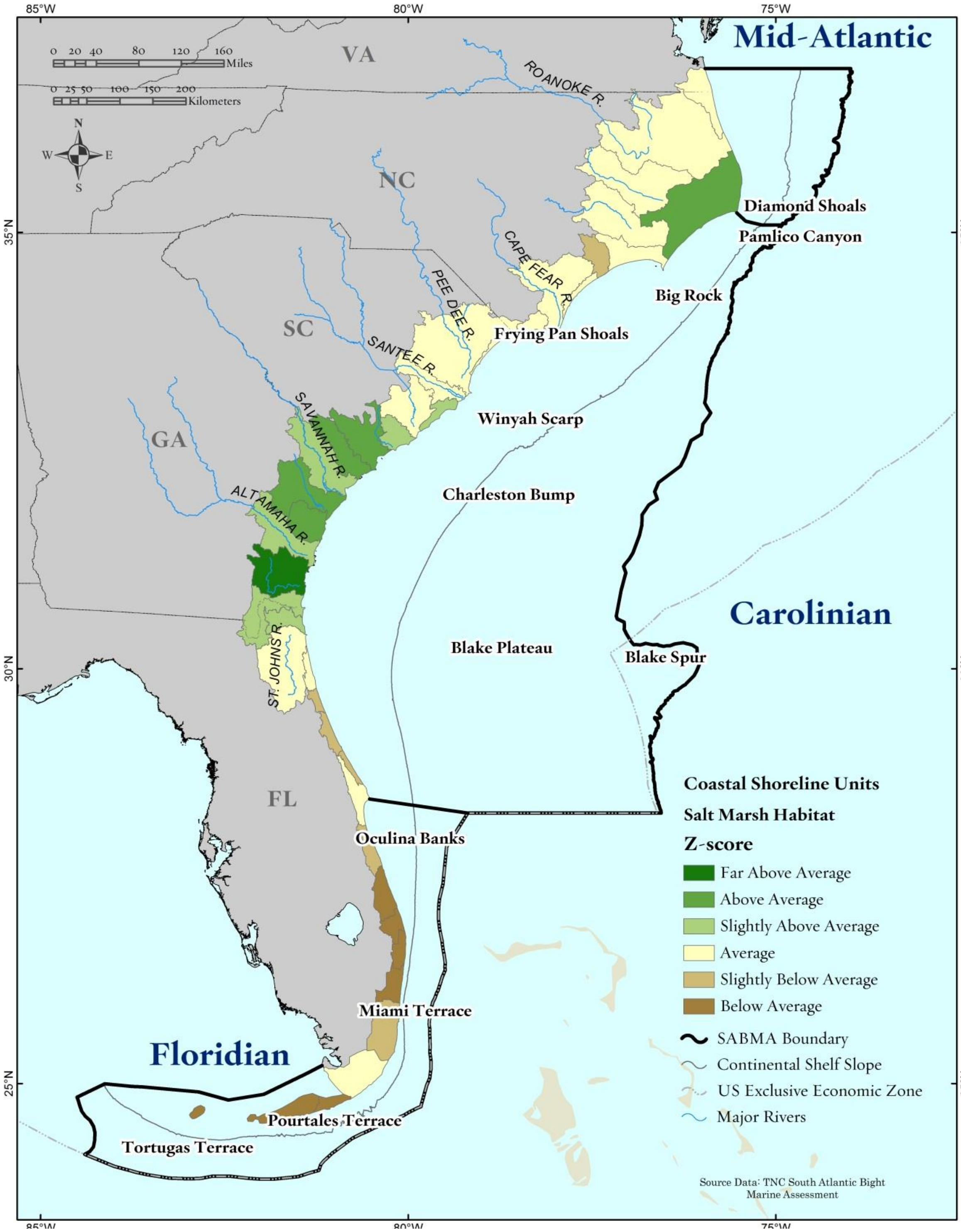

Figure 5.6. Coastal Shoreline Units shown by rank-based z-score, highlighting CSUs with regionally significant amounts of salt marsh habitat

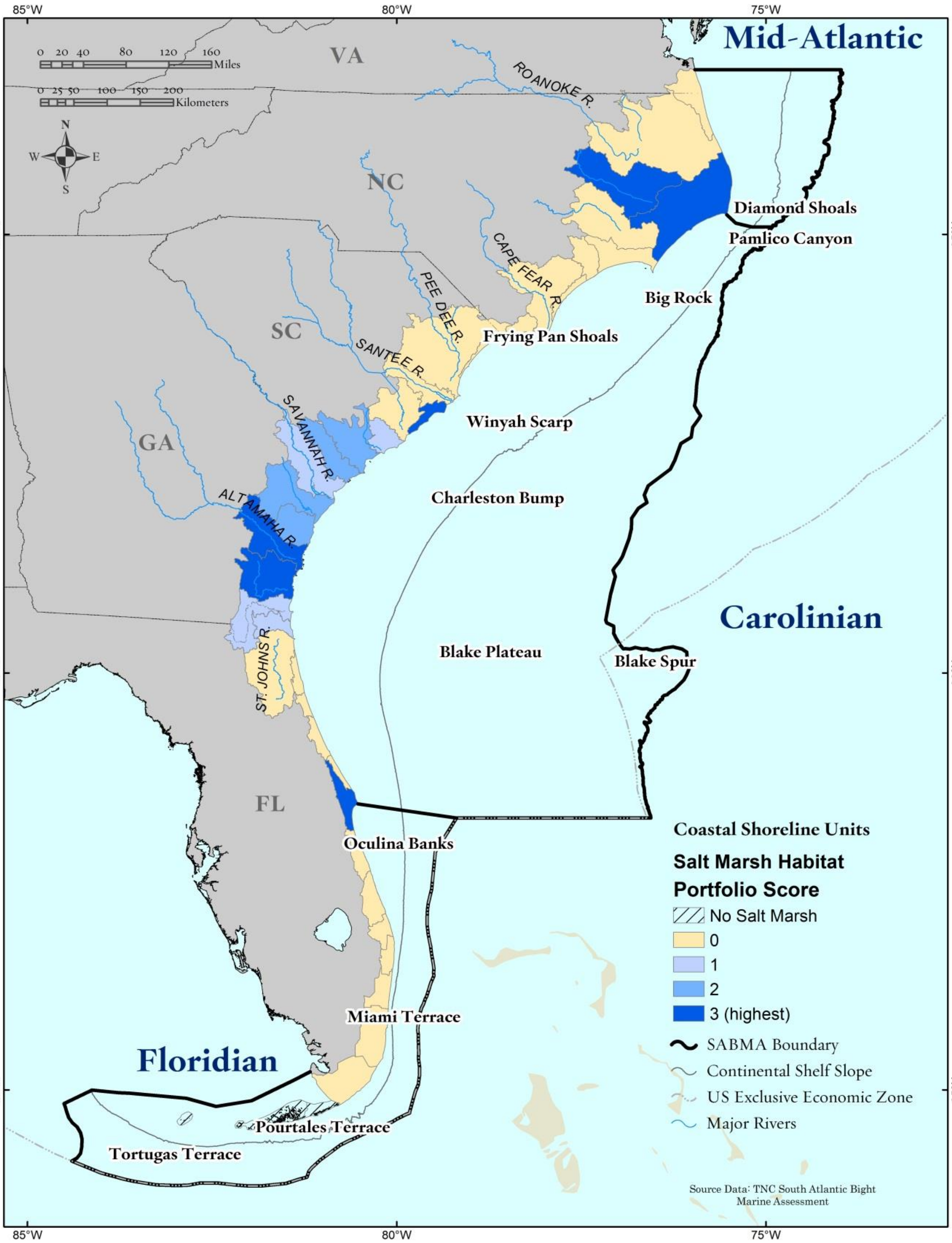

Figure 5.7. Portfolio score for salt marsh habitat assigned to Coastal Shoreline Units

Coastal Portfolio Results

The results of the coastal portfolio analyses are briefly described below. We highlight results by individual attribute metrics (e.g., habitat, species, and condition). A brief overview of the CSUs that qualified as regionally important based on the scoring system is provided along with a list of the highest ranked CSU for each estuary type by subregion. Finally, we discuss the cumulative portfolio score results. Tables summarizing the results by CSU are included in Appendix 7. These tables provide information on how the CSU ranked for the individual attributes and the summed score looking across conservation metrics in an integrated coastal portfolio (Appendix 7).

Salt Marsh (total extent)

Fourteen CSUs were identified as most critical for salt marsh preservation (or as priority areas for conservation and management). Totaling CSUs of local (e.g., type and subregion) and regional importance, this represents 78% of the total salt marsh in the South Atlantic Bight. A majority of regionally important CSUs were found in the coastal riverine systems in the Carolinian subregion. Island archipelago CSUs in the Floridian subregion were not included because the total extent of salt marsh did not meet the average standard. The following CSUs were top-ranked for each type and subregion:

- Mid-Atlantic Lagoonal: Pamlico Sound (36,536 ha)
- Mid-Atlantic Piedmont Riverine: Tar River (7,478 ha)
- Carolinian Lagoonal: Cape Romain (20,205 ha)
- Carolinian Coastal Riverine: Satilla River (41,192 ha)
- Carolinian Piedmont Riverine: Altamaha River (20,684 ha)
- Floridian Lagoonal: Cape Canaveral (4,672 ha)

Tidal Freshwater Marsh (total extent)

Thirteen CSUs representing 92% of tidal freshwater marsh habitat were identified. Island archipelago CSUs in the Floridian subregion were not included because the total extent of tidal freshwater marsh did not meet the average standard. Carolinian CSUs classified as piedmont riverine supported the majority of the regionally important habitat beyond the top-ranked CSUs by type and subregion which were:

- Mid-Atlantic Lagoonal: Currituck Sound (6904 ha)
- Mid-Atlantic Piedmont Riverine: Tar River (936 ha)
- Carolinian Lagoonal: Cape Romain (14,33 ha)
- Carolinian Coastal Riverine: St. Helena Sound (10,194 ha)
- Carolinian Piedmont Riverine: Winyah Bay (8,841 ha)
- Floridian Lagoonal: Florida Bay (179 ha)

Tidal Forest (total extent)
Ninety percent of the total tidal forest area was included within the 15 CSUs identified. Piedmont riverine CSUs (e.g., Altamaha River, Santee River) in the Carolinian subregion and lagoonal CSUs (e.g., Pamlico Sound) represented the majority of regionally important tidal marsh habitat beyond CSUs ranked highest by subregion and type:

- Mid-Atlantic Lagoonal: Currituck Sound (10,821 ha)
- Mid-Atlantic Piedmont Riverine: Tar River (4,215 ha)
- Carolinian Lagoonal: Bogue Sound (1,618 ha)
- Carolinian Coastal Riverine: Satilla River (7,140 ha)
- Carolinian Piedmont Riverine: Winyah Bay (28,095 ha)
- Floridian Lagoonal: St. Lucie River (535 ha)
- Floridian Island Archipelago: Lower Keys (2,604 ha)

Mangrove Forest (total extent)
The natural extent of mangrove forests is limited to the southern portion of the Carolinian subregion and the Floridian subregion. Eleven CSUs were identified representing 98% of the total habitat. The top-ranked CSU by type and subregion were:

- Carolinian Lagoonal: Mosquito Lagoon (2,040 ha)
- Floridian Lagoonal: Florida Bay (37,504 ha)
- Floridian Island Archipelago: Lower Keys (8,959 ha)

Tidal Flat (total extent)
Thirteen CSUs were identified based on their local and regional importance for tidal flat habitat. This represented 91% of the total habitat. Lagoonal CSUs in the Floridian subregion supported the majority of regionally important CSUs. Piedmont Riverine CSUs in the Mid-Atlantic subregion were not included because the total extent of tidal flat did not meet the average standard. Highest ranked CSUs were:

- Mid-Atlantic Lagoonal: Pamlico Sound (9,828 ha)
- Carolinian Lagoonal: Cape Romain (1,893 ha)
- Carolinian Coastal Riverine: Stono and North Edisto Rivers (2,109 ha)
- Carolinian Piedmont Riverine: Charleston Harbor (402 ha)
- Floridian Lagoonal: Florida Bay (46,418 ha)
- Floridian Island Archipelago: Lower Keys (20,635 ha)

Ocean Beach (total extent)
Fifty-eight percent of the South Atlantic Bight's ocean beach area was identified with the 12 priority CSUs. Neither the Floridian island archipelago nor the Mid-Atlantic piedmont riverine are represented because they did not meet the average criterion. Lagoonal CSUs across the South Atlantic represented the majority of the regionally important CSUs. The top-ranked CSUs by subregion and type were:

- Mid-Atlantic Lagoonal: Pamlico Sound (1,513 ha)
- Carolinian Lagoonal: Long Bay (694 ha)
- Carolinian Coastal Riverine: Ossabaw and Wassaw Sounds (408 ha)
- Carolinian Piedmont Riverine: Altamaha River (375 ha)
- Floridian Lagoonal: Cape Canaveral (468 ha)

Seagrass Beds (total extent)
In the South Atlantic Bight, natural conditions limit seagrass beds to the coasts of North Carolina and Florida. Fourteen CSUs were identified representing 89% of the total seagrass habitat area in the region. The following CSUs were the top-ranked by subregion and type:

- Mid-Atlantic Lagoonal: Pamlico Sound (42,358 ha)
- Mid-Atlantic Piedmont Riverine: Tar River (770 ha)
- Carolinian Lagoonal: Mosquito Lagoon (6,686 ha)
- Carolinian Coastal Riverine: New River (84 ha)
- Carolinian Piedmont Riverine: Cape Fear (124 ha)
- Floridian Lagoonal: Florida Bay (186,667 ha)
- Floridian Island Archipelago: Lower Keys (14,4996 ha)

Oyster Reefs (number of high density oyster reef areas)
As discussed in the methods section, gaps in available oyster data and variation in monitoring methods across states required us to look beyond total extent of oyster habitat. An analysis of the number of high density intertidal oyster reef areas within CSUs enabled comparison across the region. CSUs in the Mid-Atlantic region (where subtidal reefs are more prominent) and Floridian island archipelago did not have high density areas and therefore are not included. Thirteen CSUs were identified and the highest ranked CSUs by subregion and type were:

- Carolinian Lagoonal: Southeast North Carolina Estuaries (134 ha)
- Carolinian Coastal Riverine: Port Royal Sound (168 ha)
- Carolinian Piedmont Riverine: Savannah River (97 ha)
- Floridian Lagoonal: St. Lucie River (16 ha)

Coastal Condition (metric of land use and shoreline)
As described in the methods section, the coastal condition metric combines land use attributes (e.g., developed and agricultural lands) with hardened shorelines. Fourteen CSUs were ranked for this attribute. The highest ranked CSUs by subregion and type were:

- Mid-Atlantic Lagoonal: Pamlico Sound
- Mid-Atlantic Piedmont Riverine: Neuse River
- Carolinian Lagoonal: Long Bay
- Carolinian Coastal Riverine: St. Helena Sound
- Carolinian Piedmont Riverine: Altamaha River
- Floridian Lagoonal: Florida Bay
- Floridian Island Archipelago: Lower Keys

Diadromous Fish (Average number of species per stream/river kilometer)
Sixteen CSUs were identified for their value to diadromous fish based on the number of targeted species present per stream or river kilometer. In cases where there were ties, we considered the connectivity of the stream kilometers. The Floridian subregion is at the southern extent of many of the targeted species' natural range, and data limitations did not allow inclusion of some southern CSUs. The top-ranked CSUs by subregion and type were:

- Mid-Atlantic Lagoonal: Albemarle Sound
- Mid-Atlantic Piedmont Riverine: Neuse River
- Carolinian Lagoonal: Bogue Sound
- Carolinian Coastal Riverine: St. Mary's River
- Carolinian Piedmont Riverine: Santee River
- Floridian Lagoonal: Biscayne Bay

Estuary-Dependent Fish (predicted fish score)
As described in the methods section, the estuary-dependent predicted fish score metric describes the relationship between fish species presence on the nearshore Continental Shelf and estuarine habitats (e.g., seagrass beds and salt marsh). Thirteen CSUs were identified as important at the local or regional level. The highest ranked CSUs by subregion and type were:

- Mid-Atlantic Lagoonal: Pamlico Sound
- Mid-Atlantic Piedmont Riverine: Neuse River
- Carolinian Lagoonal: Bogue Sound
- Carolinian Coastal Riverine: Stono and North Edisto Rivers
- Carolinian Piedmont Riverine: Cape Fear River
- Floridian Lagoonal: Biscayne Bay
- Floridian Island Archipelago: Middle Keys

Loggerhead Sea Turtles (High density nesting beaches)

Thirteen CSUs were identified for their importance for loggerhead sea turtle nesting based on the total beach distance within the CSU that scored in the top 25% for nest density for each subpopulation (see Marine Mammal and Sea Turtle chapter, Geselbracht et al. 2015). No Mid-Atlantic CSU had z-scores that rated above average. The top CSUs by subregion and type were:

- Carolinian Lagoonal: Cape Romain (26.7 km)
- Carolinian Coastal Riverine: St. Helena Sound (18.6 km)
- Carolinian Piedmont Riverine: Winyah Bay (22.8 km)
- Floridian Lagoonal: Sebastian Inlet (45.9 km)
- Floridian Island Archipelago: Lower Keys (3.7 km)

Manatees (Average weighted persistence for wintering areas)

Manatee overwintering areas are only found in southern Georgia and Florida. CSUs were ranked based on average weighted persistence as described in the methods section. Thirteen CSUs had z-scores of slightly above average or higher. The top-ranked CSUs by subregion and type were:

- Carolinian Lagoonal: St. Augustine
- Carolinian Coastal Riverine: St. Mary's River
- Floridian Lagoonal: Lake Worth Lagoon
- Floridian Island Archipelago: Middle Keys

Cumulative Coastal Portfolio

While we recognize many users will prefer to look at individual attributes or to compare CSUs by type and/or subregion, we provide the cumulative results for those interested in the un-stratified distribution of scores across the entire project area. As noted in the methods section, the total portfolio score was calculated by summing scores for each individual metric by CSU (Table 5.7). To facilitate comparison across the project area, we translated the cumulative portfolio scores to rank-based z-scores.

Table 5.7. Cumulative Coastal Portfolio Scores. Overview of attribute scores for individual CSUs (Dark Green = 3; Green = 2; Light Green = 1)

CSU NAME	TYPE	Beach	Salt Marsh	Tidal Fresh Marsh	Tidal Forest	Mangrove	Tidal Flat	Seagrass	High Oyster Density Areas	High Density Nesting Beaches	Diadromous Fish	Manatee Persistence	Estuarine Fish	Condition	TOTAL
Currituck Sound	Lagoonal														9
Albemarle Sound	Lagoonal														7
Pamlico Sound	Lagoonal														20
Tar River	Riverine (Piedmont)														12
Neuse River	Riverine (Piedmont)														6
Bogue Sound	Lagoonal														15
New River	Riverine (Coastal Plain)														4
SE NC Estuaries	Lagoonal														7
Cape Fear River	Riverine (Piedmont)														8
Long Bay	Lagoonal														7
Winyah Bay	Riverine (Piedmont)														13
Santee Rivers	Riverine (Piedmont)														9
Cape Romain	Lagoonal														17
Charleston Harbor	Riverine (Piedmont)														8
Stono North Edisto Rivers	Riverine (Coastal Plain)														12
St Helena Sound	Riverine (Coastal Plain)														15
Port Royal Sound	Riverine (Coastal Plain)														6
Savannah River	Riverine (Piedmont)														9
Ossabaw Wassaw Sounds	Riverine (Coastal Plain)														9
St Catherines Sapelo Sounds	Riverine (Coastal Plain)														4
Altamaha River	Riverine (Piedmont)														14
Satilla River	Riverine (Coastal Plain)														11
St Marys River	Riverine (Coastal Plain)														9
Nassau River	Riverine (Coastal Plain)														1
St Johns River	Riverine (Coastal Plain)														3
St Augustine Inlet	Lagoonal														7
Mantanzas Inlet	Lagoonal														2
Ponce Inlet	Lagoonal														3
Mosquito Lagoon	Lagoonal														7
Cape Canaveral	Lagoonal														13
Sebastian Inlet	Lagoonal														8
St Lucie River	Lagoonal														13
Loxahatchee River	Lagoonal														5
Lake Worth Lagoon	Lagoonal														6
Port Everglades	Lagoonal														3
Biscayne Bay	Lagoonal														15
Florida Bay	Lagoonal														17
Middle Keys	Island Archipelago														6
Lower Keys	Island Archipelago														18

After standardizing the scores, 66% of CSUs fell within the middle categories of 'Slightly Above Average,' 'Average' and 'Slightly Below Average' (Figure 5.8). Sixteen percent of the CSUs ranked at least 'Above Average.' These seven CSUs represented all subregions:

- Pamlico Sound, Mid-Atlantic, Lagoonal
- Bogue Sound, Carolinian, Lagoonal
- Cape Romain, Carolinian Lagoonal
- St. Helena Sound, Carolinian, Riverine (Coastal Plain)
- Biscayne Bay, Floridian, Lagoonal
- Florida Bay, Floridian, Lagoonal
- Lower Keys, Floridian, Island Archipelago

When CSUs scoring 'Slightly Above Average' are added to these seven, each estuary type is also represented (Figure 5.9). Pamlico Sound in North Carolina received the highest cumulative score of 21 while Nassau River in Florida received the lowest score of 1.

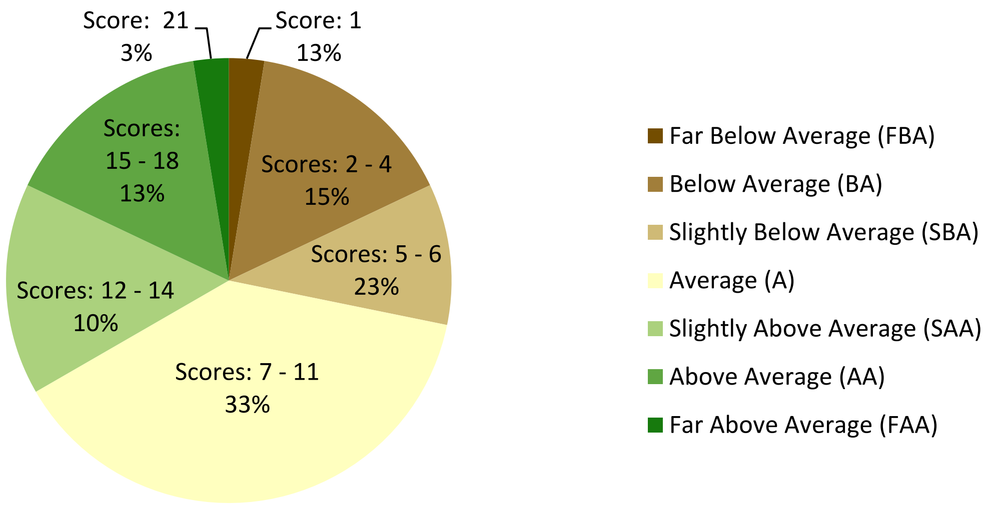

Figure 5.8. Distribution of the cumulative portfolio scores translated to rank-based z-scores for the entire project area

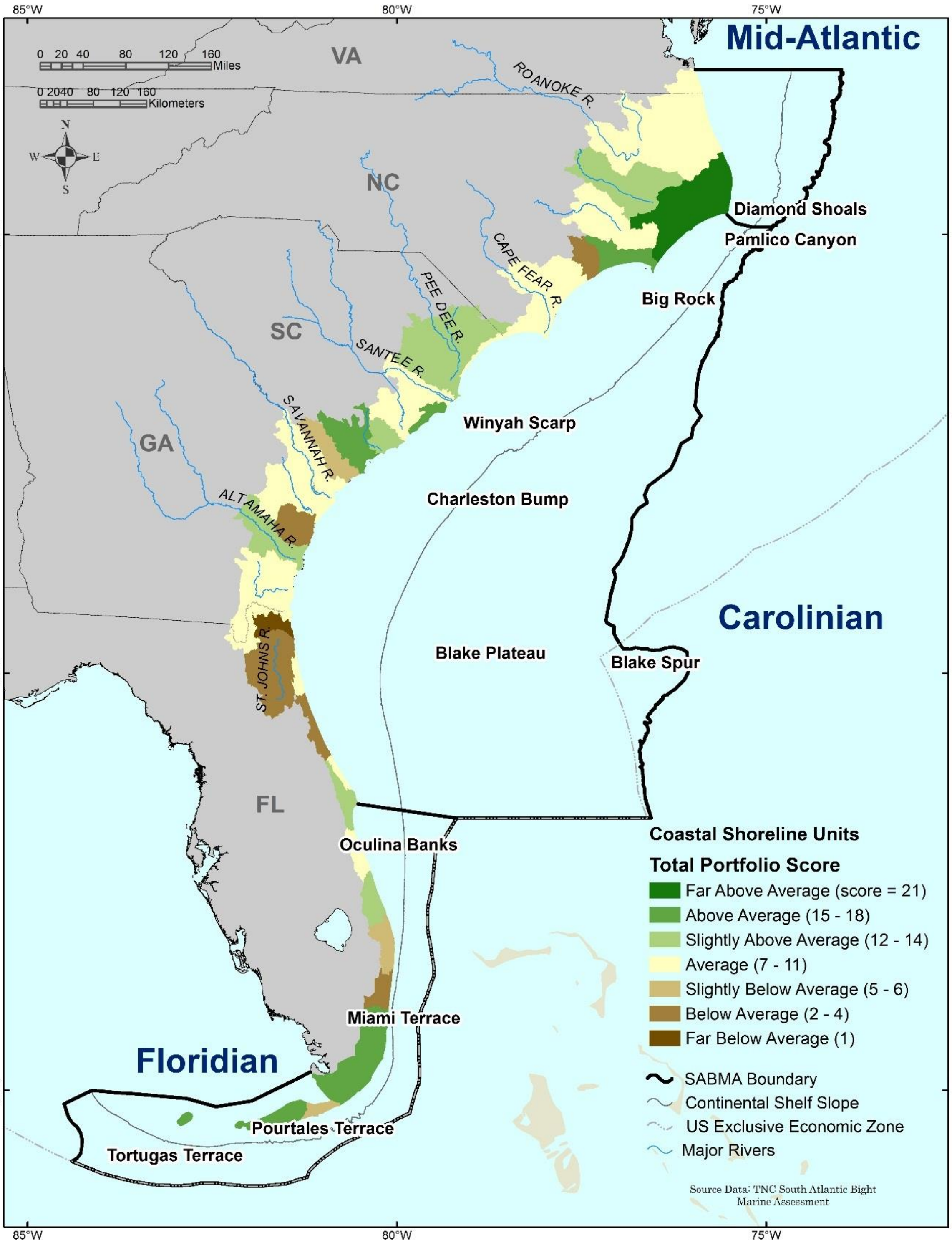

Figure 5.9. Cumulative portfolio scores by CSU. Rank-based z-scores were used to compare each CSU's score to the average for all CSUs

Seafloor Portfolio

The South Atlantic seafloor provides a range of habitats that support important fisheries and other biodiversity. The seafloor itself, consisting almost entirely of unconsolidated sand and mud, sustains important fishery species such as tilefish, flounder, scallops, and shrimp. However, biological diversity is concentrated at the rocky outcrops and coral reefs, which provide substrate for sponges, corals, and algae, particularly on the Continental Shelf. Colonized rocky reefs, or "live bottom," attract a variety of mollusks and crustaceans, and sustain economically valuable fisheries of snapper, grouper, grunt, and porgy that shelter among the nooks and crannies. Seaward from the shelf break, the rock outcrops of the Blake Plateau are colonized by a wide variety of deep-sea sponges and corals, forming significant coral mound systems up to 150 m tall, which similarly support a diversity of invertebrates and fishes. Southward in the Floridian region, rocky reefs are replaced by shallow coral reefs that run parallel to the shoreline of Florida. The Florida reef tract encompasses over 6,000 patch reefs, platform reefs, coral pavements, and a well-developed coral ridge formation. It is the only system of shallow reef-building corals in the continental U.S. Seagrass beds, found in unconsolidated bottom sediment areas, are an important benthic habitat, providing shelter and nursery habitat for many species. A single acre of seagrass can produce over 10 tons of leaves per year and may support as many as 40,000 fish and 50 million small invertebrates (Miththapala 2008)

This section identifies a portfolio of priority conservation areas for species and habitats associated with the seafloor of the South Atlantic Bight. The goal of this analysis was to identify places of high biodiversity or ecological importance that collectively represent the full range of seafloor habitats. Detailed information on seafloor features, data sources, and data processing steps used to map the features may be found in the associated Seafloor chapter.

The importance of rock substrates and coral reefs to the diversity of the region compelled development of an accurate map showing the location of each individual reef and concentrations of rock substrates.

The analysis characterized three target habitats: rock substrates, coral substrates, and unconsolidated substrates, using the attributes outlined below.

Rock Substrates (reefs, outcrops, pavements) with

- High fish diversity
- Cold water corals
- Deepwater coral mounds
- Hardbottom concentrations

Coral Substrates (shallow and mid-depth reefs) with

- Shallow reef concentrations (patch, platform, pavements)
- Oculina banks

Unconsolidated Substrates (mud, silt, sand, and gravel) with

- High estuarine fish diversity
- Seagrass habitat
- Adjacency to hardbottom

Methods for the Seafloor Portfolio

For all analyses, the region was divided into a grid of ten-minute squares (TMS) overlaid on the seafloor datasets, and each TMS was characterized by the types and amounts of seafloor features it contained. The criteria used to identify ecologically important areas or reveal spatial patterns relevant to conservation are described below for each target.

Rock Substrates (Rocky Reefs, Outcrops, Pavements)

HARDBOTTOM WITH HIGH FISH DIVERSITY

Bottom-dwelling (demersal) fish use the seafloor for resting, feeding, and spawning, and many depend on the structure and resources associated with hardbottom. Grouper, for example, shelter under big rocks or use structural features such as ledges, rocks, and coral reefs as habitat. To identify hardbottom areas with high fish diversity we compiled data from the Marine Resources Monitoring Assessment and Prediction program (MARMAP, Reichert 2009) that has been sampling fish diversity on hardbottom for 23 years. The sampling program covers the Continental Shelf from NC to GA and has taken 7,885 chevron trap samples from hardbottom areas 15 m to 100 m in depth. The samples concentrate on 24 species closely associated with hardbottom including various species of grouper, snapper, porgy, sea bass and morays.

We calculated the number of fish species found in each MARMAP sample and the average fish diversity score across all sample locations adjusted for the effort expended. The results were grouped into seven standard deviation classes based on whether the fish diversity of the sample area was above or below the mean diversity. Because a single TMS might contain several sample areas, the score for the TMS was calculated as a weighted sum of the samples based on the area of each standard deviation class within the square. The formula gives more weight to the area of highest fish diversity:

*D = 1*area far below average + 2*area below average+3…etc.…7*area far above average.*

We ranked all the TMS within each depth zone (inner shelf, mid shelf, outer shelf) based on their fish diversity scores, then selected the TMS where the scores were average or above (> -0.5) for each zone, ensuring capture of the full range of species associated with each depth zone.

HARDBOTTOM WITH CONFIRMED COLD WATER CORALS

Coldwater corals thrive in darker, deeper waters than their shallow water counterparts. Most are colonial stony corals whose hard exoskeletons aggregated over time to build calcium-based “mounds” on rock substrates (the deepwater counterpart of coral reefs), but some are solitary. The presence of cold water corals on rocky reefs is an indication that the substrate has been colonized and likely supports associated sponges, mollusks, crustaceans, and fish.

To identify TMS with confirmed coldwater corals and hardbottom, we compiled 1,167 confirmed coral points from seven recently-collected and spatially-explicit coral datasets (Fautin 2011, Freiwald et al. 2005, Partyka et al. 2007, Scanlon et al. 2010, Skidaway Institute of Oceanography 2004, Watling and Auster 2005, Woods Hole Laboratories - NOAA 2012; see Tables A2.2-A2.3 in Appendix 2 for specific details). We used only data points with precise locations overlapping a hardbottom feature and high confidence in coral identification. Next, we identified the TMS in each depth zone that contained both confirmed corals and above-average acreage of hardbottom (note that the majority of coldwater corals occur only in the deeper zones). TMS that met these criteria collectively contained 102 species, the five most common of which were: *Lophelia pertusa* (deepwater white coral), *Balanophyllia floridana* (porous cup coral), *Polymyces fragilis* (twelve-root cup coral), *Astrangia poculata* (Northern star coral) *and Madrepora oculata* (zigzag coral).

CORAL MOUNDS

Corals mounds are formed when favorable deep water conditions and rocky substrates allow cold water corals to form complex reef structures attracting organisms and sediment that accumulate around the framework. Mounds up to 150 m in height have been found in the Charleston Bump region and on the Blake Plateau.

To identify TMS with confirmed coral mounds, we compiled 83 confirmed coral mound points from seven recently-collected and spatially-explicit coral datasets (Fautin 2011, Freiwald et al. 2005, Partyka et al. 2007, Scanlon et al. 2010, Skidaway Institute of Oceanography 2004, Watling and Auster 2005, Woods Hole Laboratories - NOAA 2012; see Tables A2.2-A2.3 in Appendix 2 for specific details). We used only data points with precise locations overlapping a hardbottom feature and high confidence in coral identification. Next, we identified the TMS that contained both above-average acreage of hardbottom and above-average densities of coral mounds (z >0). Coral mounds occur only in the deeper zones.

HARDBOTTOM CONCENTRATION AREAS

Only a portion of the rocky substrates in the South Atlantic region have been sampled for fish diversity or coldwater corals, thus our final criterion was size of hardbottom concentration. For patchy hardbottom that occurred on flat topographic settings we calculated the average area across all TMS within each depth zone, and identified areas where the acreage was greater than one standard deviation above the mean (> 1 z). We repeated the process for hardbottom that occurred on topographic slopes or ledges. We merged the results to show the largest concentrations of hardbottom flats and slopes in each depth zone.

Coral Reef

Shallow water coral reefs exist only within the Floridian subregion where patch reefs, platform reefs, coral pavements, and a long coral ridge formation all harbor a relatively consistent assemblage of hard corals, soft corals, and sponges. These reefs tend to have clear ecological zonation consisting of an inner reef (4 to 8 m), a middle patch reef zone (9 to 15 m), and an outer reef (18 to 30 m, SAFMC 2009). The Oculina Bank region off the Central Florida coast is included in this group although it is arguably a deeper-water ecosystem.

SHALLOW REEF CONCENTRATIONS

Platform Reef Concentration: Platform reefs consist of hardened substrate of unspecified relief formed by the deposition of calcium carbonate by reef-building corals. This group includes shallow water coral reef and colonized rock substrate, linear reef, reef terrace, spur and groove reef, nearshore reef, offshore reef, and associated remnants and reef rubble. To identify concentration areas, we calculated the average amount of platform reef in each TMS then selected areas with greater than the mean amount (>0 z).

Patch Reef Concentration: Patch reefs are irregularly distributed clusters of corals and associated biota along the coast of the Florida Keys. This class includes aggregated patch reef, aggregate reef, and individual patch reef. To identify concentration areas, we calculated the average amount of patch reef in each TMS then selected areas with greater than the mean amount (>0 z).

Pavement Reef Concentration: Pavements are low relief solid carbonate rock, frequently colonized by macroalgae, hard coral, gorgonians, and other sessile invertebrates, often dense enough to obscure the substrate. To identify areas of high concentration, we calculated the average amount of pavement reef in each TMS then selected areas with greater than the mean amount (>0 z).

OCULINA BANK CONCENTRATION

Oculina Banks are a unique cool to cold-water coral reef system dominated by the ivory tree coral, *Oculina varicosa*. Found as deep as 100 m on the shelf edge, the corals form thickets of white branches that are home to hundreds of different kinds of invertebrates and provide essential habitat for many commercial fish species. Oculina occurs elsewhere in the region but not to the extent and abundance that it does in this unique area. To identify concentration areas, we calculated the average amount of Oculina bank in each TMS then selected areas with greater than the mean amount (>0 z).

Soft-bottom (Unconsolidated Sand, Mud and Gravel)

SOFT-BOTTOM WITH HIGH NEARSHORE FISH DIVERSITY

Shallow water nearshore areas provide a unique habitat for marine fish and shellfish because the wave-dominated sun-lit environment supports aquatic plants that provide food and shelter for many species. Many commercially valuable fish species depend on nearshore waters at some point during their development. Our depth analysis recorded 215 fish species in the nearshore zone, with 99 being restricted to the zone. This number includes many soft-bottom species like Atlantic bumper, southern flounder, and blue crab. To identify areas of high fish diversity we used data from the Southeast Area Monitoring and Assessment Program (SEAMAP-SA) shallow water trawl sampling program. The surveys, initiated in 1986 to monitor the status and trends of coastal fish, invertebrates and sea turtles, sample shallow (49-98m; 15-30 ft) coastal waters from Cape Hatteras to Cape Canaveral. A total of 102 stations are sampled each season. We used the same methods described in the coastal section on estuary-dependent fish to evaluate species richness, but we calculated the statistics (mean, range, and variance) for each sampling station rather than each CSU. This approach allowed determination of which fish species were found in each sampling station more often than expected given the number of times the station was sampled. To correct for effort, we first determined whether there was a significant relationship between effort and detection for each species. For each species where this relationship was significant, we extracted the standardized residuals from the regression model as an estimate of how much the detection varied from the expected amount. We counted the number of species with positive values and identified stations where more species were detected than expected from the amount of sampling. Scores based on the total number of species with positive values were calculated for each station; these were normalized across stations to calculate z-scores, and grouped into standard deviation classes.

Because each TMS could contain several sampling stations we calculated a weighted sum of the samples based on the area of each standard deviation class within the square. The formula gives more weight to the area of highest fish diversity:

*D = 1*area far below average + 2*area below average+3…etc.…7*area far above average.*

We ranked all the TMS based on their nearshore fish diversity scores, then selected the TMS where the z-scores were > -0.5. (This threshold is slightly more generous than others in this section because it is applied to a weighted index).

SOFT-BOTTOM WITH SEAGRASS CONCENTRATIONS

We used the regional seagrass dataset described in the Coastal chapter to identify areas of abundant seagrass. We characterized each TMS by the total acres of seagrass habitat present, and calculated the mean abundance of seagrass in all TMS. TMS with seagrass abundance greater than the mean (>0 z) were selected to represent high seagrass concentrations.

SOFT-BOTTOM ADJACENT TO HARDBOTTOM

The coral reefs, rocky reefs, pavements, and outcrops discussed in the hard bottom section are typically embedded in a matrix of soft sediments which can be high in species diversity. Thus, we included the soft-bottom areas found within TMS selected for hard bottom as part of the soft-bottom portfolio, although we did not specifically select any areas for this attribute.

Seafloor Portfolio Results

This section describes the set of priority conservation areas identified for seafloor diversity using the criteria presented above.

Rock Substrates

HARDBOTTOM WITH HIGH FISH DIVERSITY

The MARMAP program sampled 106 of the TMS defined in this analysis. Of these, 74 squares had scores for hardbottom with high fish diversity that were average or better. These sites were all found on the Continental Shelf or shelf-slope break (Figure 5.10). Many of these areas do not have names but they do include some well-known sites such as:

- Cape Lookout shoals and the area just south
- The area northeast of Frying Pan Shoals
- Winyah Scarp and Georgetown Hole
- Gray's Reef and surrounding area
- The sand ridges due east of Charleston Harbor
- Several concentrations on the shelf-slope break

HARDBOTTOM WITH CONFIRMED COLD WATER CORALS

Collectively 259 TMS contained cold water corals (176), coral mounds (53), or both (30). Of these, 102 had both greater than average amounts of rocky reef and confirmed coral points. The distribution of these areas was largely along the shelf-slope break or eastward into the Blake Plateau and the deep terraces of the Floridian region (Figure 5.10). Many of these areas corresponded to well-known sites such as:

- The Point
- Fathom Ledge and Big Rock
- Cape Lookout Lophelia Banks
- Cape Fear Lophelia Banks
- Stetson Reef
- Miami Terrace
- Portales Terrace
- Marathon Hump

CORAL MOUNDS

Coral mounds occur in 83 TMS. Of these, 37 had greater than average densities of deepwater mounds; some of these are significant mound and ridge systems. The distribution of these areas was largely in the Charleston Bump region, corresponding to the Deepwater Coral HAPC (habitat area of particular concern). The sites include (Figure 5.10):

- Stetson Reef
- South Ledge – Jacksonville Slope
- Miami Terrace

HARDBOTTOM: LARGEST CONCENTRATIONS OF FLATS OR SLOPES

This metric identifies the largest concentrations of hardbottom on the Continental Shelf (flats) and shelf slope break (slopes). Many of these areas have not been surveyed for fish or corals so the criterion is based solely on the concentration of hardbottom on flats and slopes. We identified TMS that contained amounts of hardbottom one standard deviation above the mean amount (>SD) for both patchy hardbottom on flats (27 TMS) and hardbottom slopes (69 TMS). The sites largely expand several sites already selected for other criteria (Figure 5.10) especially:

- The area northeast of Frying Pan Shoals
- Gray's Reef and surrounding area
- Shelf-slope break

Coral Reefs

PLATFORM, PATCH, PAVEMENT AND OCULINA BANK
This metric identifies the TMS with greater than average acreage of each type of coral reef. All of these features co-occur within the Floridian Ecoregion between the shoreline and the shelf-slope break. Collectively, the 58 TMS that contain these features cover the Oculina Bank HAPC, the Shallow Reef HAPC, and most of the Florida Keys National Marine Sanctuary (Figure 5.10). The list includes many notable areas:

- Oculina Bank
- Carysfort, The Elbow, Grecian Rocks, French Reef and Molasses Reef (Management area)
- Conch Reef, Davis Reef, Hens and Chickens, Cheeca Rocks, Alligator Reef
- Coffins Patch, Sombrero Reef
- Looe Key, Eastern and Western Sambo
- Eastern Dry Rocks, Rock Key, Sand Key
- Great White Heron and Key West NWR

Soft-bottom

SEAGRASS
Seagrass roots in soft sands and mud, and is only present in the northern and southern ends of the ecoregion. In all, 174 TMS contained seagrass beds ranging from 0.25 acres to 69,313 acres, with a mean of 8,067 acres (Figure 5.11). Abundance at 120 TMS was greater than the mean abundance (> 0 z). These areas included:

- Albemarle-Pamlico Sound
- Cape Canaveral to Loxahatchee River
- Biscayne Bay to Lower Keys

NEARSHORE AREAS OF HIGH FISH DIVERSITY
Areas selected for their nearshore fish diversity included 41 TMS where the total number of species was higher than the mean of all the samples (Figure 5.11). These were all located near the coast in the Carolinian ecoregion, the sole location of the trawling survey used in the analysis. The sites were widespread along the coast including:

- Nearshore region around southern Pamlico Sound and Bogue Sound
- Nearshore region from Cape Fear River to Savannah River
- Nearshore region near the Altamaha River
- Nearshore region from St Johns River to Mananzas Inlet

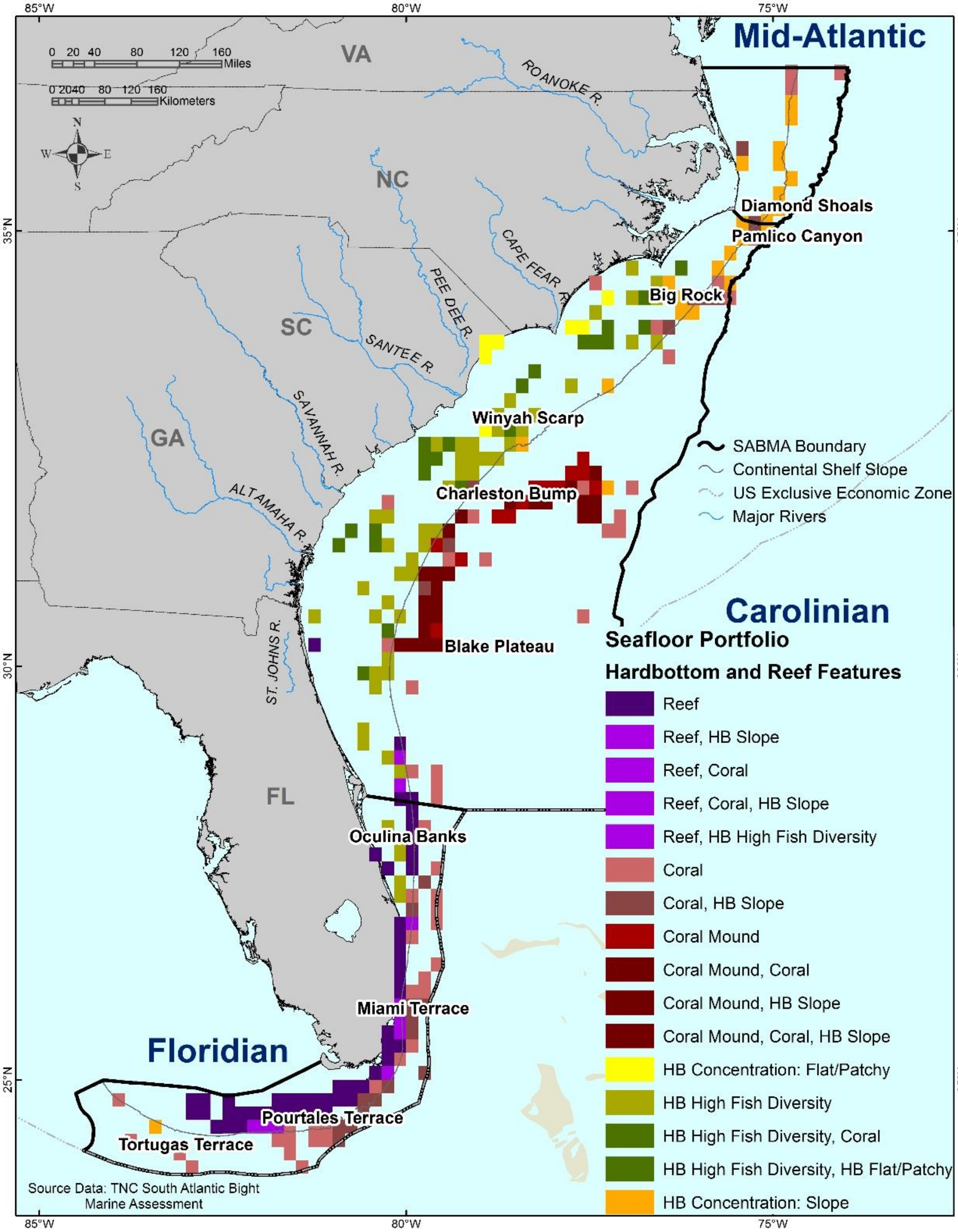

Figure 5.10. Hardbottom and reef portfolio. Ten minute squares containing hardbottom concentrations on flats or slopes, hardbottom with high fish diversity, hardbottom with coldwater corals or coral mounds, shallow water coral reefs, and Oculina banks.

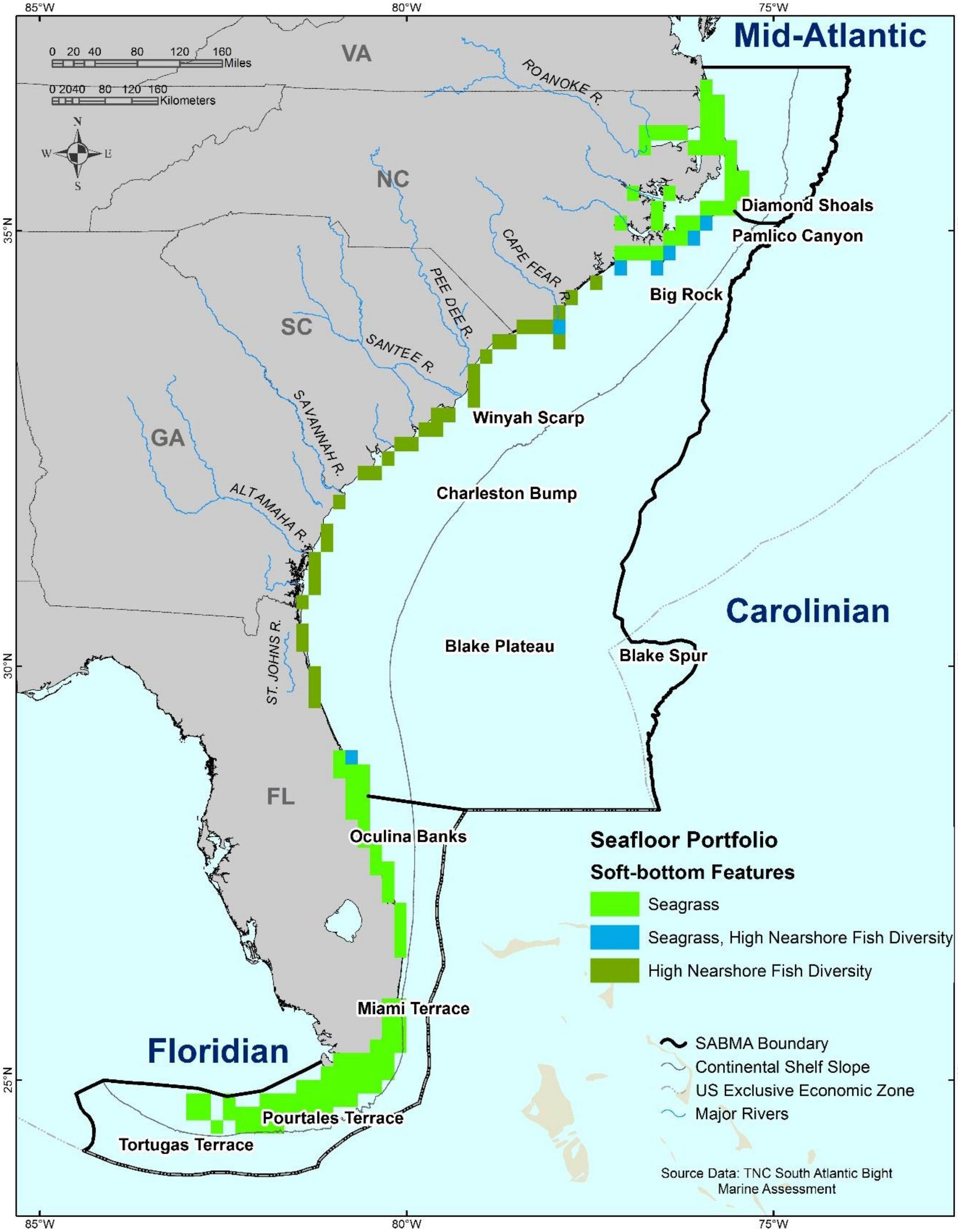

Figure 5.11. Nearshore soft-bottom portfolio. Ten minute squares containing softbottom (sand, silt and mud) areas with seagrass or high fish diversity.

Final Seafloor Portfolio

Based on the individual analyses presented above, we determined which TMS contained a high degree of overlapping targets and designated those TMS as a high priority for conservation. This integrated seafloor portfolio includes 381 TMS of which 33% contain multiple targets. Coldwater coral had the highest degree of co-occurrence with other targets, being found with rocky reefs, coral mounds, hardbottom slope, seagrass, nearshore estuaries and coral reefs (Table 5.8; Figure 5.12).

Table 5.8. Overlap among seafloor targets. The 381 TMS selected as priority areas for conservation usually contain more than one feature.

	Hardbottom Fish Diversity	Coldwater Corals	Coral Mounds	Hardbottom Flat	Hardbottom Slope	Seagrass	Estuary Fish Diversity	Coral Reefs	Multiple Features	Total	Features (#)
Hardbottom Fish Diversity	51			19				1		71	3
Coldwater Corals	3	50	5		23	1	1	1	6	90	8
Coral Mounds			13		7				12	32	3
Hardbottom Flat				5			2			7	2
Hardbottom Slope					23			1	1	25	3
Seagrass						69	7	36		112	3
Estuary Fish Diversity							31			31	1
Coral Reefs								13		13	1
Total										**381**	

The final seafloor portfolio combines the information from all eight individual queries to identify the full array of exemplary areas that support the diversity of the region. It consists of 381 TMS across all three seafloor targets. Important areas include (Figures 5.12-5.15):

- The nearshore regions seaward from the major river mouths
- The shelf-slope break
- Hardbottom concentration associated with Platt Shoal, Cape Lookout Shoal, Cape Fear Shoal and the sand-ridge complexes of Charleston Harbor
- Stetson Ledge and the coral mound region
- The entire Florida shallow coral reef

To understand and visualize the seabed forms, sediment types and depth zones captured by the seafloor portfolio we created a series of overlay maps where the selected TMS were made transparent to allow the underlying features to show through (Figures 5.13-5.15). Continuous maps of each feature can be found in the Seafloor chapter.

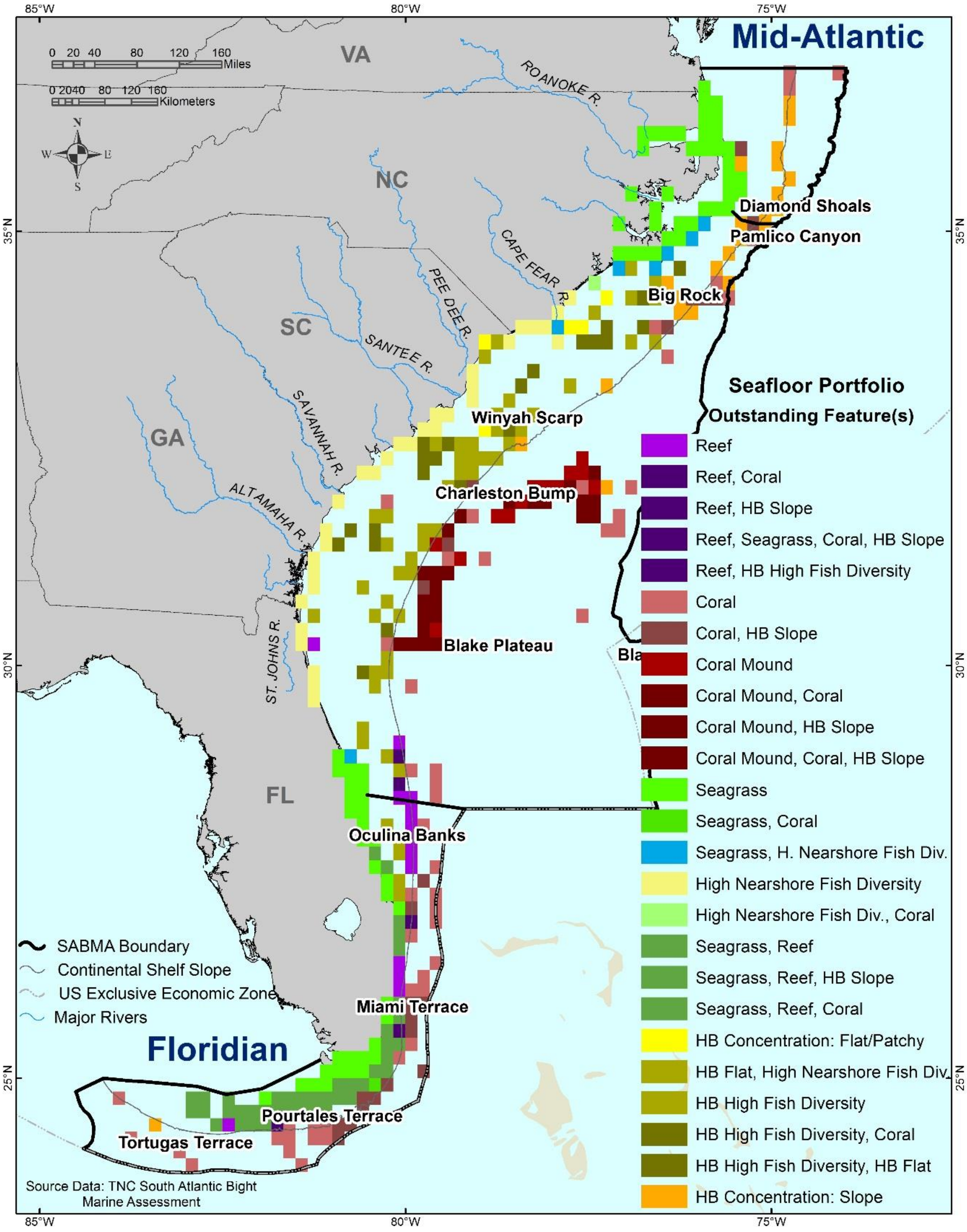

Figure 5.12. Seafloor portfolio. TMS containing any type of seafloor target.

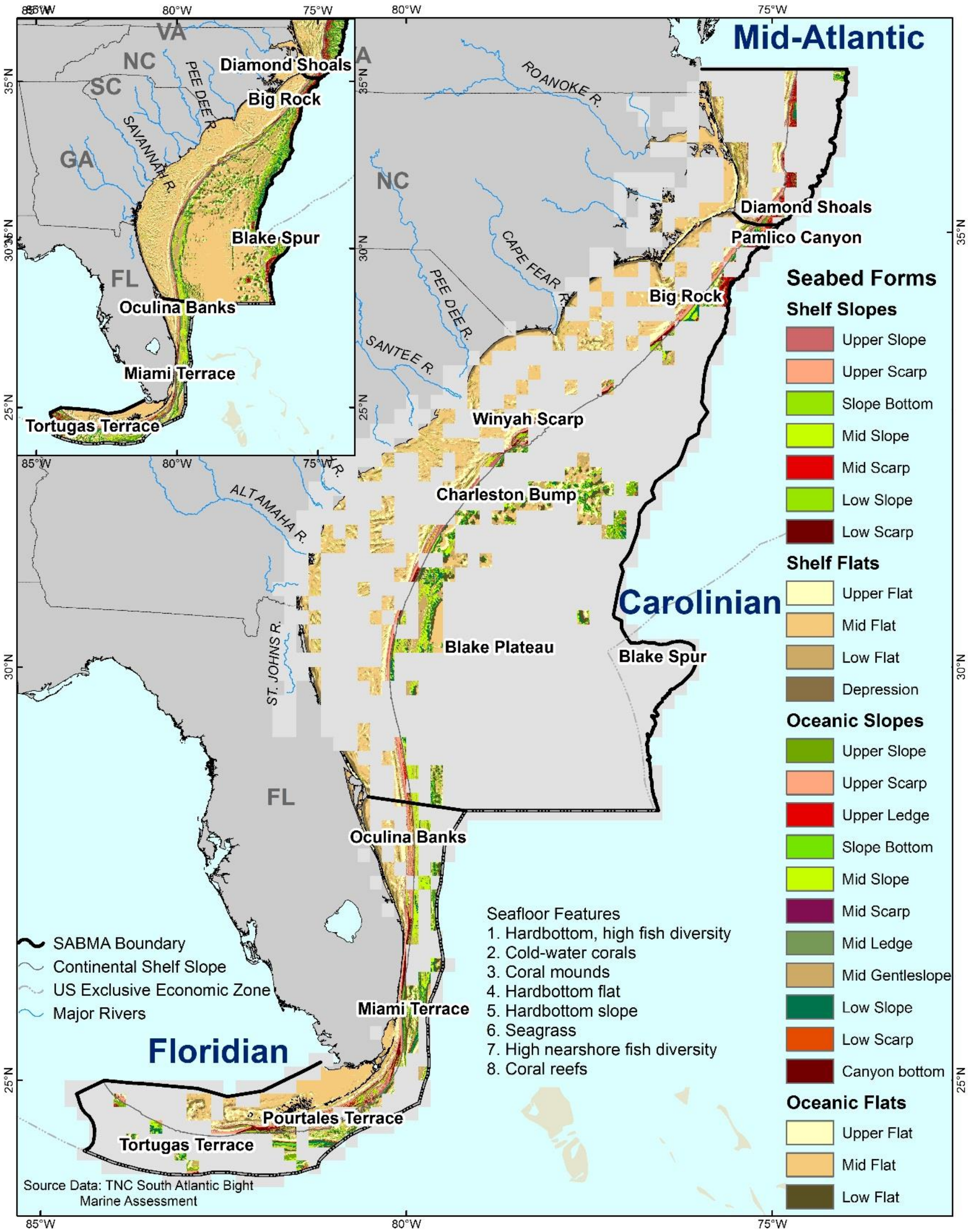

Figure 5.13. Seabed forms "captured" by the selected TMS. Inset shows continuous map.

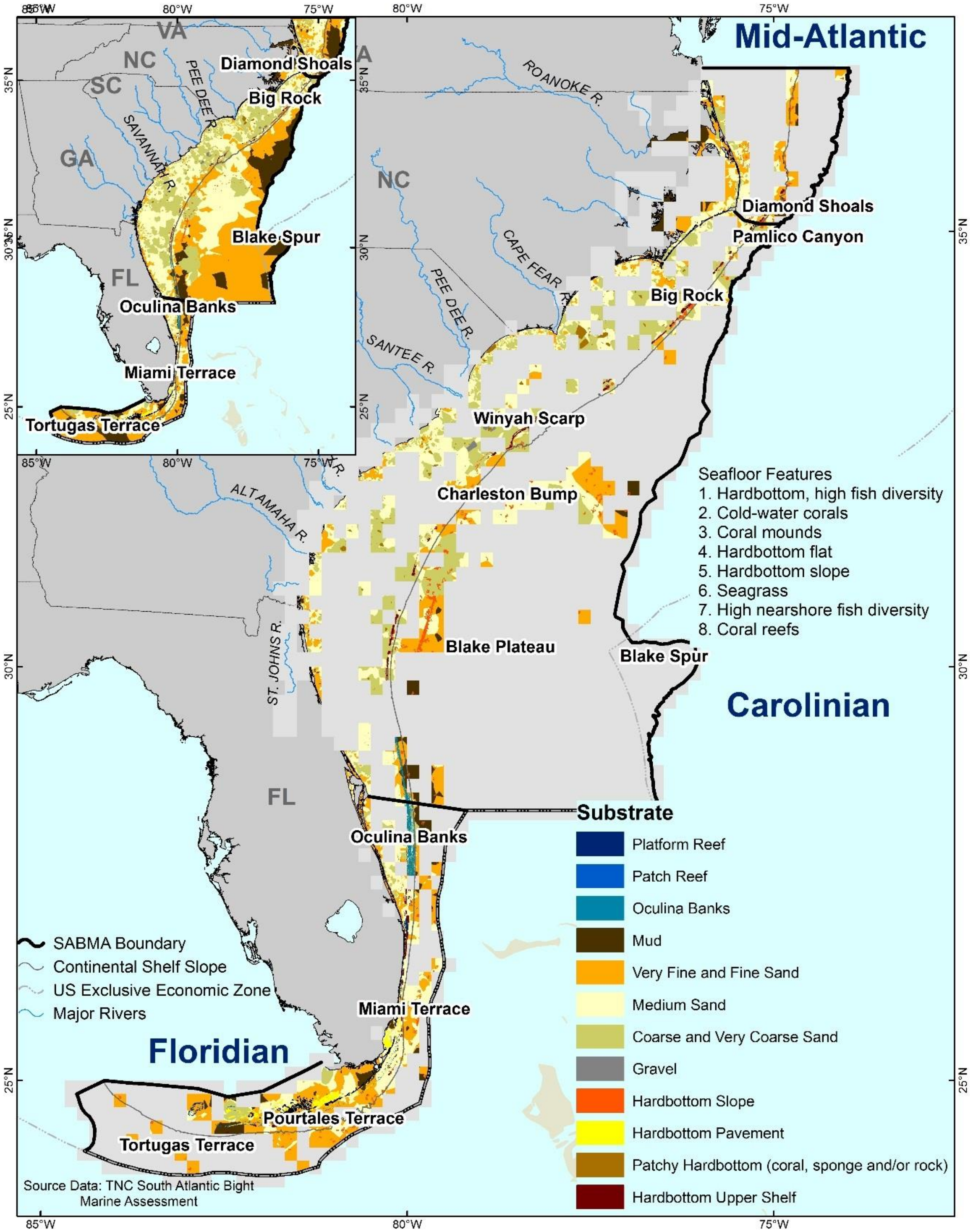

Figure 5.14. Substrate types "captured" by the selected TMS. Inset shows the continuous maps of substrate types (see Seafloor chapter, Anderson et al. 2015).

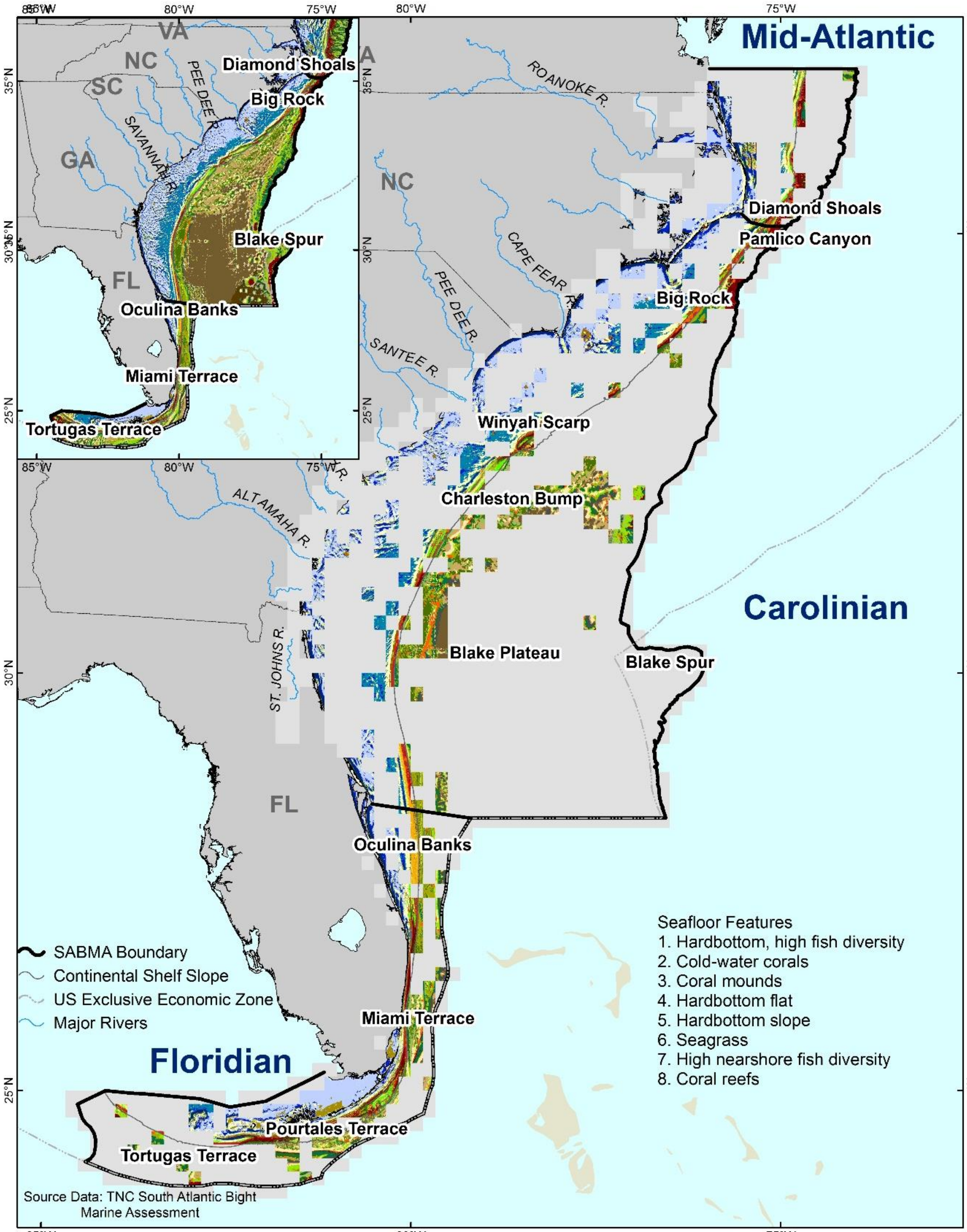

Figure 5.15. Depth zones and seabed forms "captured" by the selected TMS

Migratory Species Portfolio

Migratory species are those that travel seasonally for feeding or breeding; this project considered only marine mammals and sea turtles that migrate seasonally within the region. These species serve a number of important functions in the South Atlantic Bight ecosystem. They serve as vital components of marine food webs as predators, planktivores, or herbivores, and are important conduits for the movement of carbon and nutrients between coastal habitats and the open ocean. These "charismatic megafauna" draw public attention, helping to educate people about the importance of our oceans to life on earth. In many cases, the marine mammal and sea turtle species occurring in this region are endangered, threatened or vulnerable and require a concerted effort by humans to ensure their persistence into the future. A consequence of the large geographic ranges of many of these species is frequent opportunity to interact with humans. These interactions can include exposure to ship and boat traffic, fishing gear (active and derelict) and pollution (including marine debris), underwater noise, and the effects of climate change, all of which may pose serious threats to these sensitive populations. Sea turtles present a unique conservation challenge. While they have been the focus of a multitude of international treaties and conventions, national laws, and regulatory protection strategies, there is still a clear need for greater understanding of their temporal and spatial distribution and migratory patterns, degree and relevance of threat sources on all life stages, and population trend analyses via international monitoring and research efforts.

This section describes the methods used to identify areas of importance to these species. Details on the choice of target species, summaries of their life histories, explanation of data sources, and information on the preparation of the various data sets are found in the Marine Mammal and Sea Turtle chapter of this report.

The dataset used to identify important areas for migratory marine mammals and sea turtles consisted of 30 years of effort-corrected seasonal sightings data (1979-2003) provided by the United States Navy (Department of Navy 2008). The unit of observation was a ten-minute square (TMS) of ocean space. "Sightings" refer to clear observations of a species from a ship or plane, with enough clarity for species identification. Identification can be very difficult for some similar-looking species, so sightings of these species were combined into descriptive groups (e.g., hard-shelled turtles, beaked whales) for this analysis. Details of the analysis differ slightly by target group as discussed below. The results of this analysis include a score and rank for each TMS for each migratory species group and scores across all groups. The target species groups were:

- Baleen whales (humpback, North Atlantic right, fin)
- Toothed whales (sperm, pilot, Risso's dolphin)
- Dolphins (common, bottlenose, spotted [*Stenella* spp.])
- Sea turtles (leatherback, hard-shelled [green, loggerhead, Kemp's ridley])

Methods for the Migratory Portfolio

Migratory species sighting data were only available for the Mid-Atlantic Bight and Carolinian region of the South Atlantic Bight. No data were available for the Floridian region, with the exception of breeding information on loggerhead sea turtles, noted below. Sightings data consisted of 1,050,725 observations during the period 1979-2003. To accommodate for bias introduced by uneven survey coverage or "effort," we used the number of sightings per unit effort (SPUE, an index of relative density) to allow for comparison of data spatially and temporally within the study area. The SPUE calculations were provided by the US Navy along with the sources of data for each species and season.

To summarize the data, we calculated the mean abundance of each species within each TMS by season, and then assigned an overall score equal to the maximum value in any season. For example, if the average North Atlantic right whale sightings were highest in winter, the overall TMS score was based on the winter season. For each species, the set of maximum values was converted to rank-based z-scores using standard methods and including only TMS where the species had been sighted. This approach allowed us to combine the species sighting scores with equal weight within a TMS. For common species, we selected only the most outstanding concentration areas (>1 SD above the mean). For rare species we were less conservative, selecting all areas except those slightly below to far below the average (not < -0.05 SD). The criteria are described by species group below.

Cetaceans (Whales and Dolphins)

The cetaceans studied as part of this assessment use the region for feeding, breeding, calving, or as a migratory pathway. The 30 years of effort-corrected seasonal sightings data contained 987,602 cetacean sightings.

<u>BALEEN WHALES</u>

Three species of baleen whales winter on the Continental Shelf and bear their young in the relatively shallow warm water: humpback whale (129 sightings), North Atlantic right whale (528 sightings) and fin whale (443 sightings). A fourth species, minke whale (50 sightings), is occasionally seen in the region but was not included in the analysis because the sightings were judged to be too sporadic to be meaningful. For each TMS we first calculated individual rank based z-scores for each species as described above, then we counted the number of species that had z-scores greater than one half standard deviation below the mean (>-0.05). This provided an estimate of the number of species found in each TMS while excluding places with very few sightings.

<u>TOOTHED WHALES</u>
Toothed whales are abundant in the region and include three species of squid-eating diving whales typical of the shelf-slope break and the deep canyon and coral mount areas: sperm whale (9,179 sightings), long-finned pilot whale (91,837 sightings), and Risso's dolphin (46,635 sightings). Various species of beaked whales (2,216 sightings) and Kogia (1,323 sighting) have been seen in the deepwater region east of the shelf-slope break but this area has been so little surveyed that we did not include them in the analysis. For each TMS we first calculated individual rank based z-scores for each species as described above and then we counted the number of species that had z-scores greater than one half standard deviation below the mean (>-0.05). This provided an estimate of the number of species found in each TMS while excluding places with very few sightings.

<u>DOLPHINS</u>
Three species of fish-eating dolphins are very abundant on the Continental Shelf: common dolphin (120,731 sightings), bottlenose dolphin (303,094 sightings), and spotted dolphin (*Stenella* spp.; 411,436 sightings). To identify concentration areas for dolphins, which are two to three times more abundant and widespread than the previous groups, we first calculated individual rank based z-scores as described above and then selected TMS with sighting concentrations one standard deviation above the mean (>1SD). This focused the selection on the areas where sightings were consistently very abundant.

Sea Turtles
Sea turtles utilize oceanic waters of the Continental Shelf and nest on sandy beaches (nesting areas are discussed in the coastal section of this analysis). Sea turtle species are hard to distinguish by sightings, so this analysis grouped them into two categories for easy recognition: Leatherback sea turtle (3,036 sightings) and a hard-shelled sea turtle group that included loggerhead, green, and Kemp's ridley (60,088 sightings) turtles. Areas with consistent sightings are presumably utilized for feeding or migration.

To summarize the data, we calculated the mean effort-corrected abundance of each species within each TMS by season and then assigned an overall score equal to the maximum value in any season. To identify concentration areas, we selected TMS where the number of sightings was one standard deviation above the regional mean. Finally, the Floridian region is noted by NOAA as a Habitat Area of Particular Concern (HAPC) for loggerhead breeding. Because we had no sighting data for this region, we added TMS that overlapped with critical loggerhead breeding areas to the portfolio selection.

Integrated Migratory Portfolio
For each migratory species group, the squares meeting the selection criteria were labeled with the target name and combined across all four groups: baleen whales, toothed whales, dolphins, and sea turtles. For example, a cell labeled "Baleen Whale, Dolphin" was selected for both the baleen whale portfolio and the dolphin portfolio.

Migratory Portfolio Results

Baleen Whales
For this group, the 143 TMS that met the selection criteria were located primarily on the Continental Shelf in winter. The areas defined by the selected TMS captured the majority of sightings for humpback whale, fin whale, and North Atlantic right whale. Areas that were important for most of these species included (Figure 5.16):

- The inner shelf southward from the Savannah River to the St Augustine Inlet then narrowly extending to Cape Canaveral. The shallow area under 30 m (infralittoral zone) is a winter calving ground for the Northern right whale and is also used in the winter by humpback and fin whales
- The inner shelf near Pamlico/Albemarle Sound and Currituck Sound is used by humpback and fin whales
- The shelf slope break in the Mid-Atlantic Cashes Ledge region is used by all three species.

Toothed Whales
Important areas for these species included 90 TMS along the shelf-slope break and in deeper waters where sightings of the deep diving toothed whales are concentrated in spring and summer (Figure 5.17). Important concentration areas include:

- The deep canyon region in the Mid-Atlantic Bight.
- The shelf-slope break and shallow mesobenthic zone (200-600 m deep) seaward from the break
- The Blake Escarpment deep water areas.

Dolphins
Dolphins are common, widespread, and found in the study area year-round. Above average sighting concentrations (> 1 SD) were observed at 156 TMS. Primary areas included (Figure 5.18):

- The shelf-slope break and deep canyon region of the Mid-Atlantic especially in spring and summer
- The shelf and shelf-slope break from Diamond Shoal to Cape Fear Shoal
- The midshelf region across the entire Carolinian Continental Shelf.

Sea Turtles

A total of 144 TMS were identified for concentrations of hard shelled and leatherback sea turtle sightings. We did not have data for the Floridian region so we used a previously-identified HAPC for loggerhead as a substitute for sightings data in this region. Primary areas included (Figure 5.19):

- The entire Continental Shelf in the Mid-Atlantic including the narrowest point at Diamond Shoal. This area is concentrated and constricted migratory habitat in spring and fall
- The mid-shelf circalittoral zone from Frying Pan Shoal to Diamond Shoal in winter
- The infralittoral Continental Shelf especially from the Savanah River to Cape Canaveral in all seasons
- The entire shelf from Cape Canaveral south to the Florida Keys is critical breeding habitat for loggerhead from spring to fall.

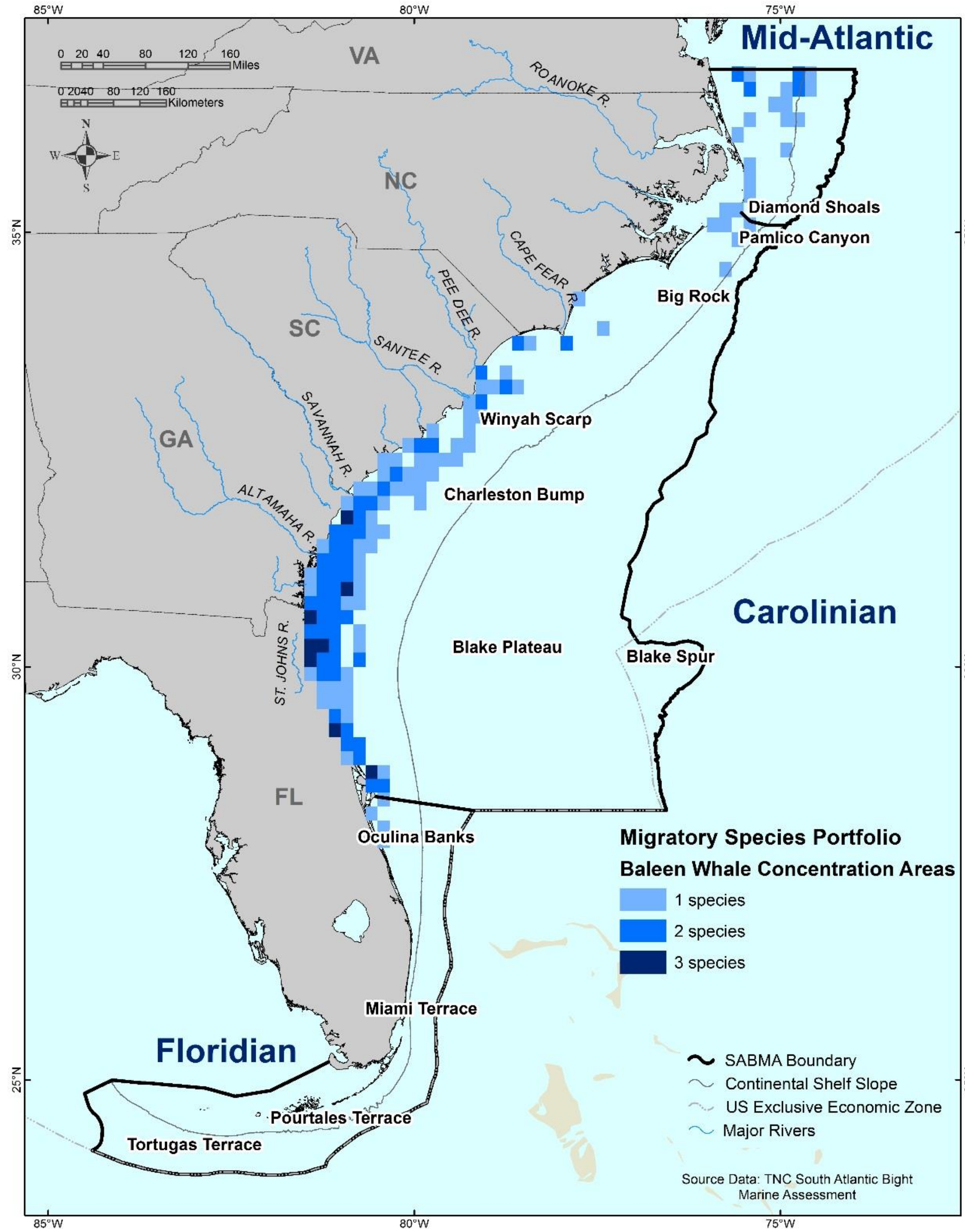

Figure 5.16. Baleen whale concentration areas. Ten Minute Squares with effort-corrected sighting numbers that were average or better (> -0.05 z score) for humpback whale, North Atlantic right whale, and fin whale.

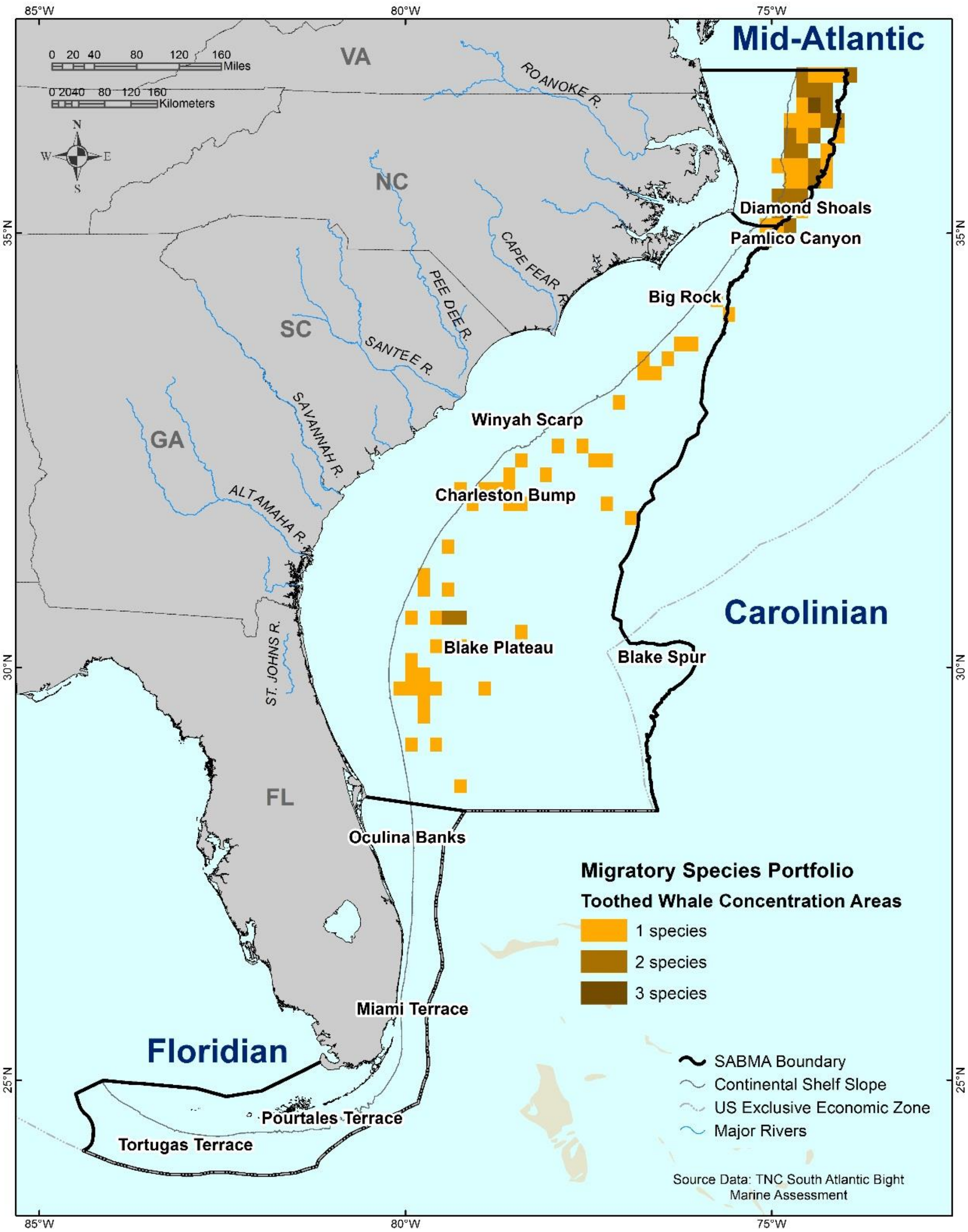

Figure 5.17. Toothed whale concentration areas. Ten Minute Squares with effort-corrected sighting numbers that were average or better (> -0.05 z score) for sperm whale, pilot whale and Risso's dolphin.

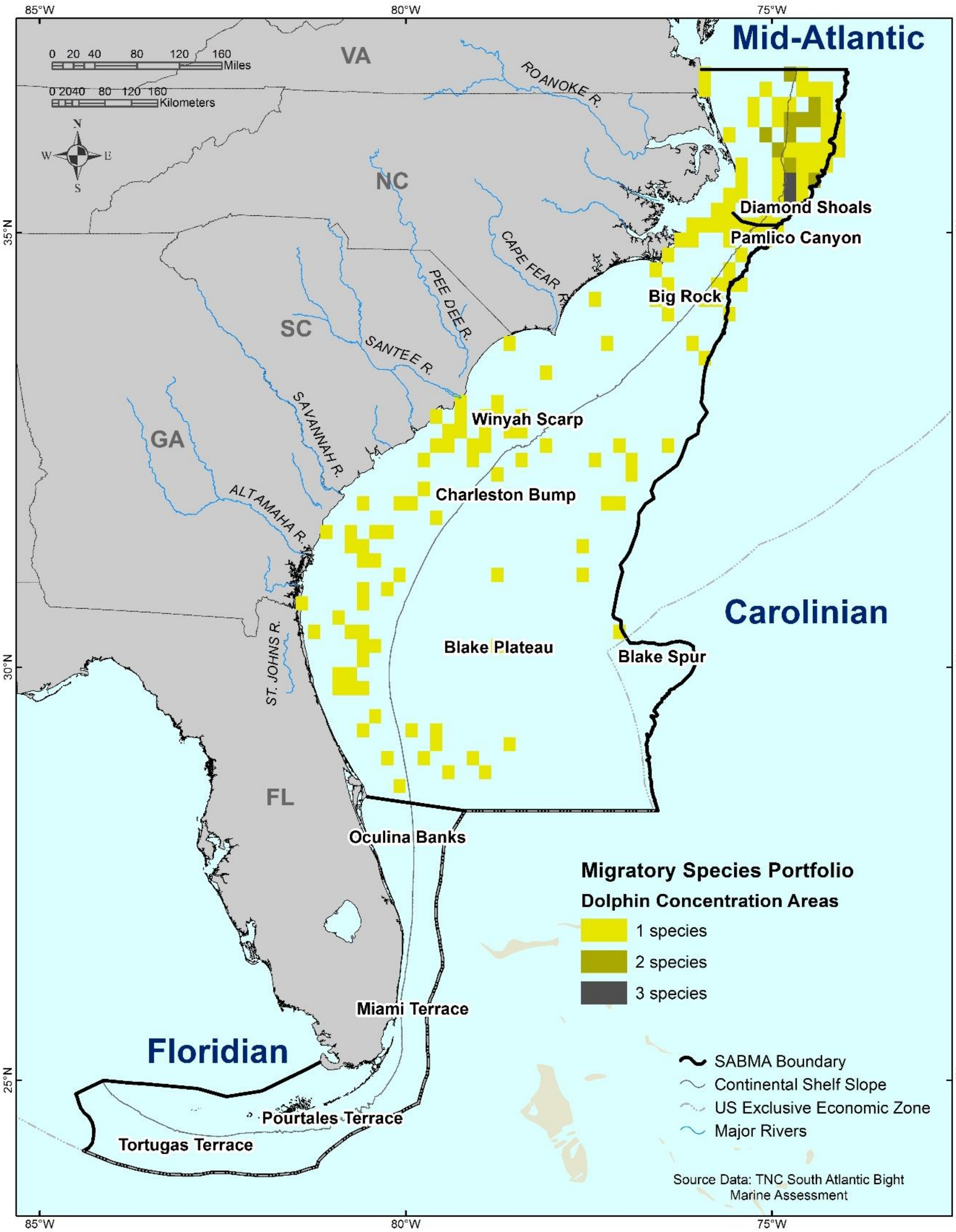

Figure 5.18. Dolphin concentration areas. Ten Minute Squares with with effort-corrected sighting numbers greater than one standard deviation above the mean (> 1 SD z score) for common dolphin, bottlenose dolphin and spotted dolphins (*Stenella* sp.)

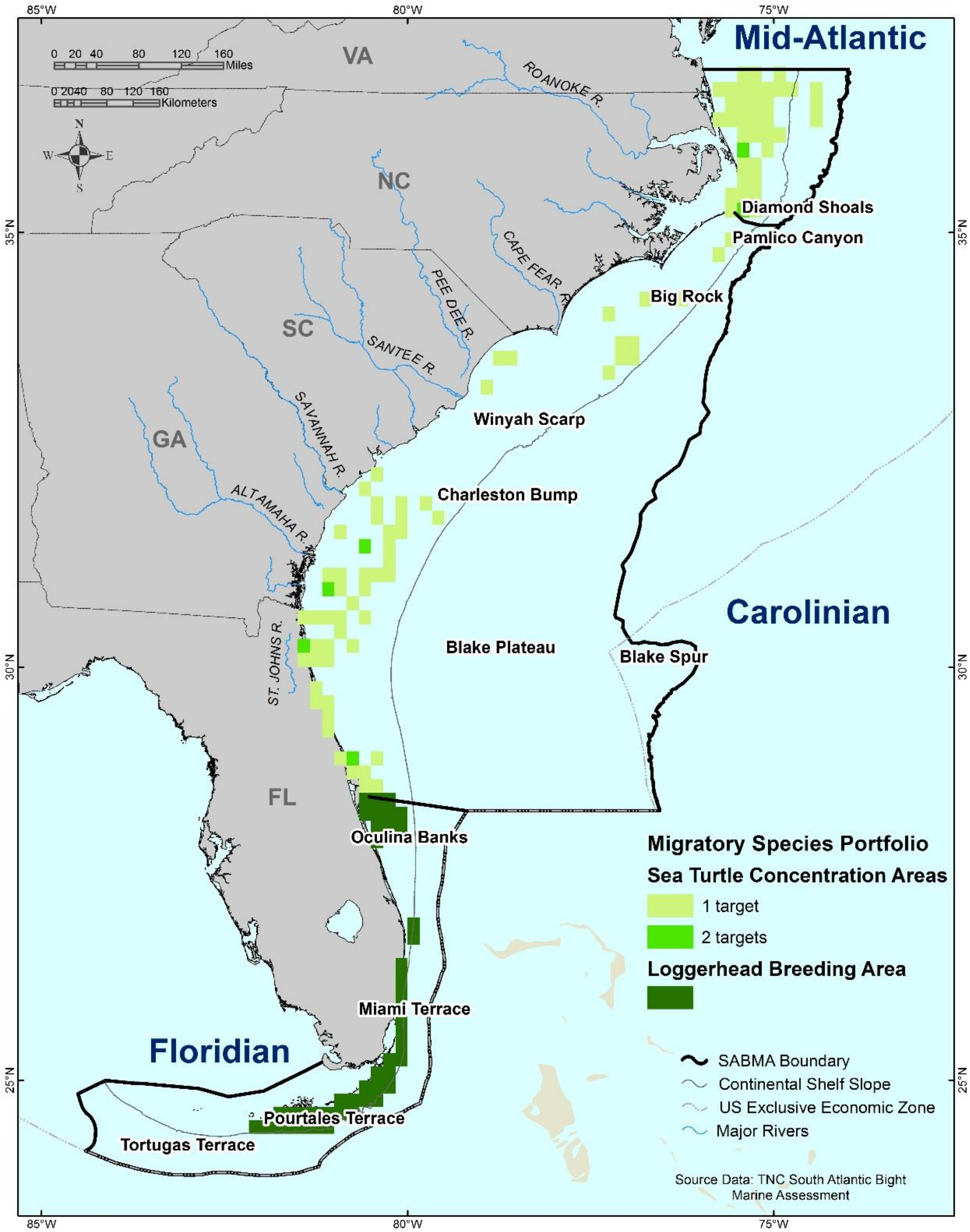

Figure 5.19. Sea turtle concentration and loggerhead breeding areas. Ten Minute Squares with effort-corrected sighting numbers greater than one standard deviation above the mean (> 1 SD z score) for leatherback sea turtle and hard-shelled sea turtles (green, loggerhead, Kemp's ridley). The map also shows critical loggerhead breeding area as mapped by NOAA.

Integrated Migratory Porfolio

Results of the combined analysis across all target groups identified 401 TMS and suggest only modest overlap in important areas for migratory species. Percent overlap was highest for toothed whales (64%), baleen whales (53%), dolphins (43%), and sea turtles (28% excluding loggerhead breeding areas, Table 5.9). Use of the ecoregion also differed seasonally, with baleen whales occurring primarily in winter and toothed whales primarily in spring and summer (Figure 5.20). Areas of highest overlap were the shelf break and canyon region of the Mid-Atlantic Bight and the nearshore shelf region of the Carolinian (Figure 5.21).

Table 5.9. Summary of target representation for the 401 TMS in the Migratory Portfolio. Numbers indicate the number of TMS identified as critical for the species.

Group	Baleen Whale	Baleen Whales (calving)	Toothed Whale	Dolphin	Sea Turtle (incl. loggerhead)	Multiple Migratory Targets	Total	Targets
Baleen Whale	13			10	6	5	34	4
Baleen Whale (calving)		55		15	35		105	3
Toothed Whale			53	31		3	87	3
Dolphin				78	9		87	2
Sea Turtles*					85	3	88	2
Total	**13**	**55**	**53**	**134**	**135**	**11**	**401**	

*Includes loggerhead breeding areas

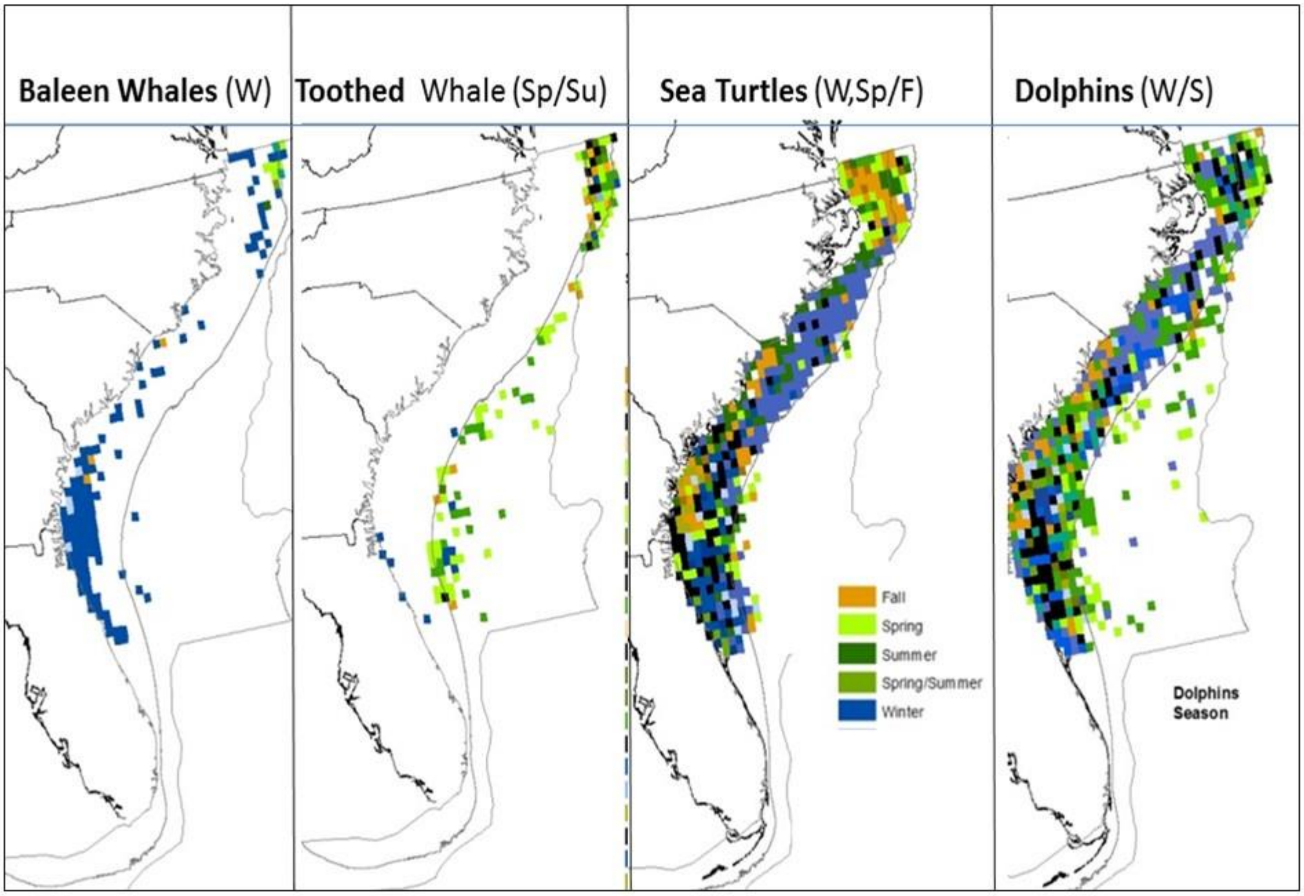

Figure 5.20. Comparison of seasonal use by the four target groups

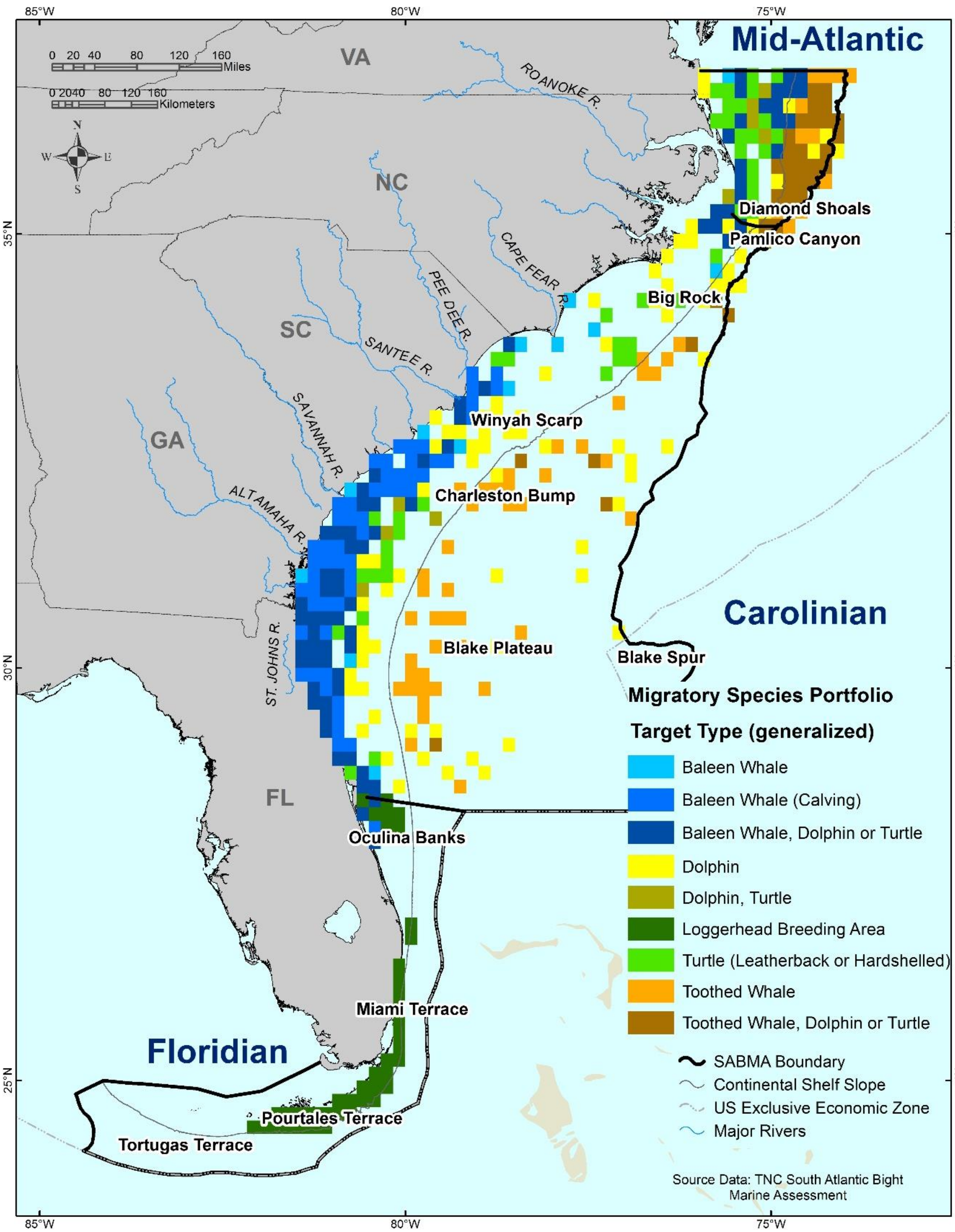

Figure 5.21. Migratory portfolio. Ten Minute Squares with with above-average sighting numbers for baleen whales, toothed whales, dolphins and sea turtles (corrected for effort). This map is a combination of Figures 5.16-5.19.

Integrated Offshore Portfolio

Methods and Results

The objective of this final analysis was to identify a portfolio of offshore areas representing the most important locations for both seafloor habitats and migratory species. In practice, this set of areas was defined as the combination of areas important to any migratory or seafloor targets as defined in the previous sections. The areas selected for each target group were summed across each TMS, as was the number of sub-targets within each group (for instance, hard bottom habitats and corals in the seafloor portfolio). Thus, the combined portfolio includes areas identified as important for one set of targets only, as well as those areas identified for both sets of targets. Coastal shoreline units did not overlap spatially with the offshore portfolio; however, the coastal and seafloor habitats are linked by areas of large seagrass abundance and high estuarine fish diversity.

The analysis identified 643 TMS (42% of all TMS assessed) as important areas for the conservation of marine biodiversity (Figure 5.22). Of the TMS that met the selection criteria, 41% were for migratory species, 38% for seafloor, and 22% for both, reinforcing the idea that these two target groups are spatially distinct in the ecoregion (Table 5.10). The greatest overlap was between the hardbottom areas with high fish diversity and baleen whales and dolphins. Cold water corals and toothed whales also overlapped, as did coral reefs, coldwater corals, and loggerhead breeding areas.

Table 5.10. The number of ten minute squares (TMS) selected for each target group and combination of groups

	Seafloor	Baleen Whales	Dolphins	Sea Turtles	Toothed Whales	Multiple Migratory Targets	Total
Migratory		46	51	44	41	80	262
Hardbottom Flat	4		1			0	5
Hardbottom Slope	8	1	4	1	1	8	23
Hardbottom Fish Diversity	35	1	9	4		2	51
Coral Mound	12				1	0	13
Cold Water Coral	39		1	5	3	2	50
Coral Reef	9			3		1	13
Seagrass	53		3	3		10	69
Estuary Fish Diversity	7	16	1			7	31
Multiple Seafloor Targets	75	4	8	25	7	7	126
Total	**242**	**68**	**78**	**85**	**53**	**117**	**643**

The places where the two overlap highlight a number of well-known areas that correspond with broad-scale physical features. These include (Figures 5.22-5.25):

- The coral reef area of the Florida Keys
- Nearshore shelf regions of the coasts of Georgia and South Carolina
- Nearshore areas near Albemarle-Pamlico sound
- The northern shelf-slope break off the coast of North Carolina.

Additionally, three to six targets of any type co-occur in several places (Figure 5.24)

- The central Florida Keys region
- The nearshore region from Cape Canaveral north along the Georgia coast
- South Ledge and the Charleston Bump
- The pinch point and shelf break off of Diamond Shoals
- The deepwater canyon region of the Mid-Atlantic.

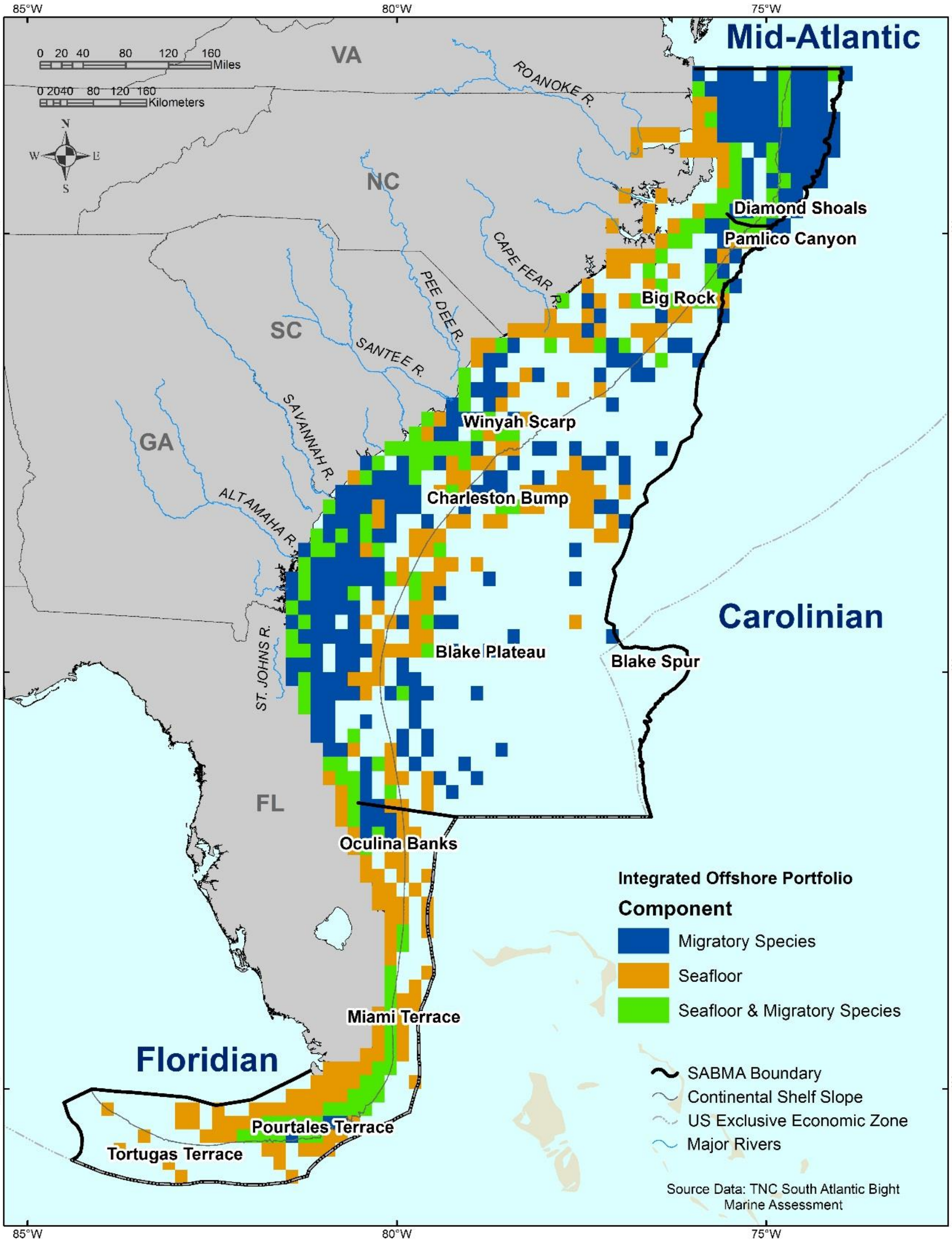

Figure 5.22. Combined portfolio of seafloor and migratory conservation targets. TMS chosen specifically for a single or multiple targets.

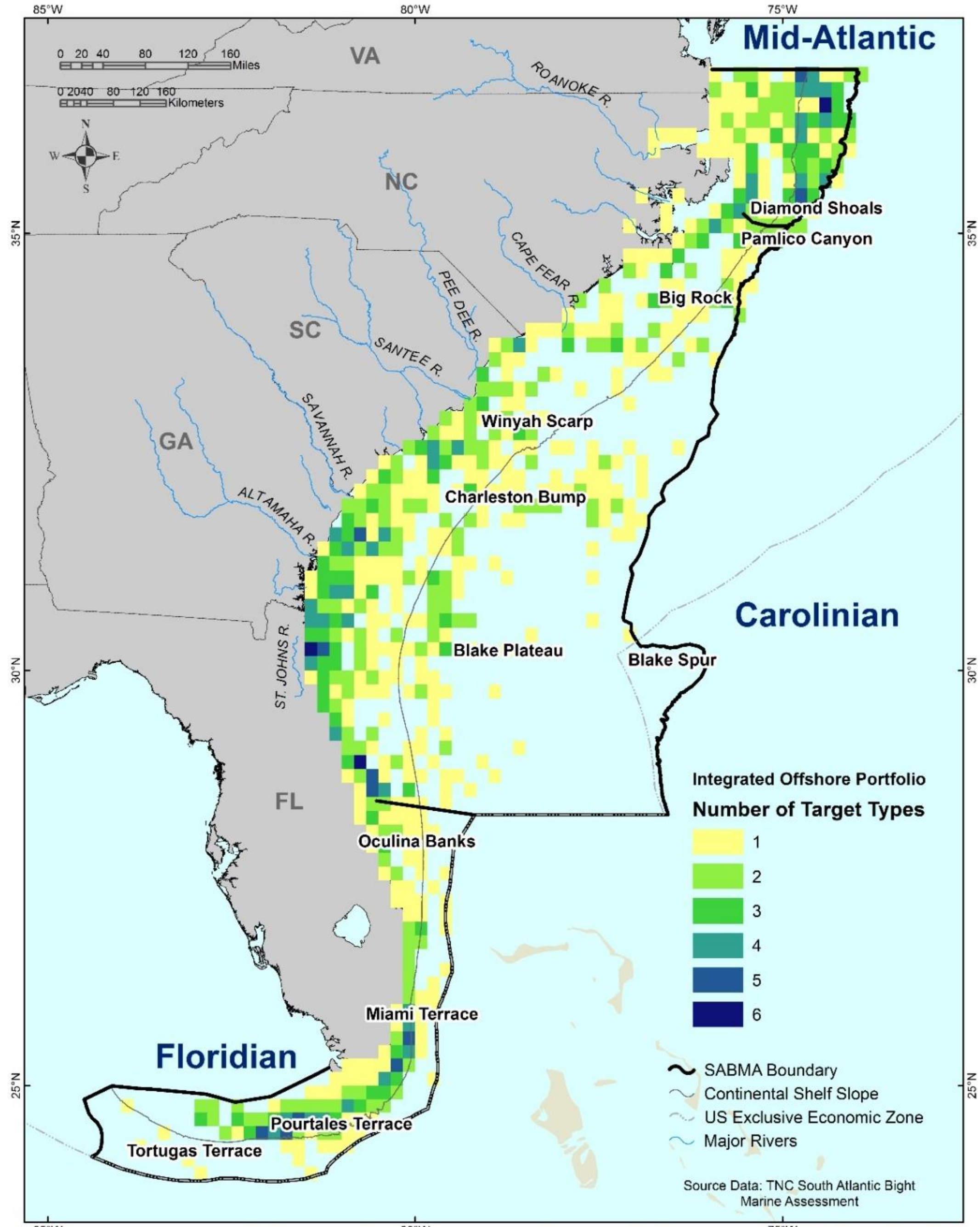

Figure 5.23. Number of target types within each TMS. Seafloor targets include hardbottom concentrations on flats or slopes, hardbottom with high fish diversity, hardbottom with coldwater corals or coral mounds, coral reefs, softbottom with high fish diversity, and softbottom with seagrass. Migratory targets include siting concentrations for baleen whales, toothed whales, dolphins, sea turtles, and loggerhead breeding areas.

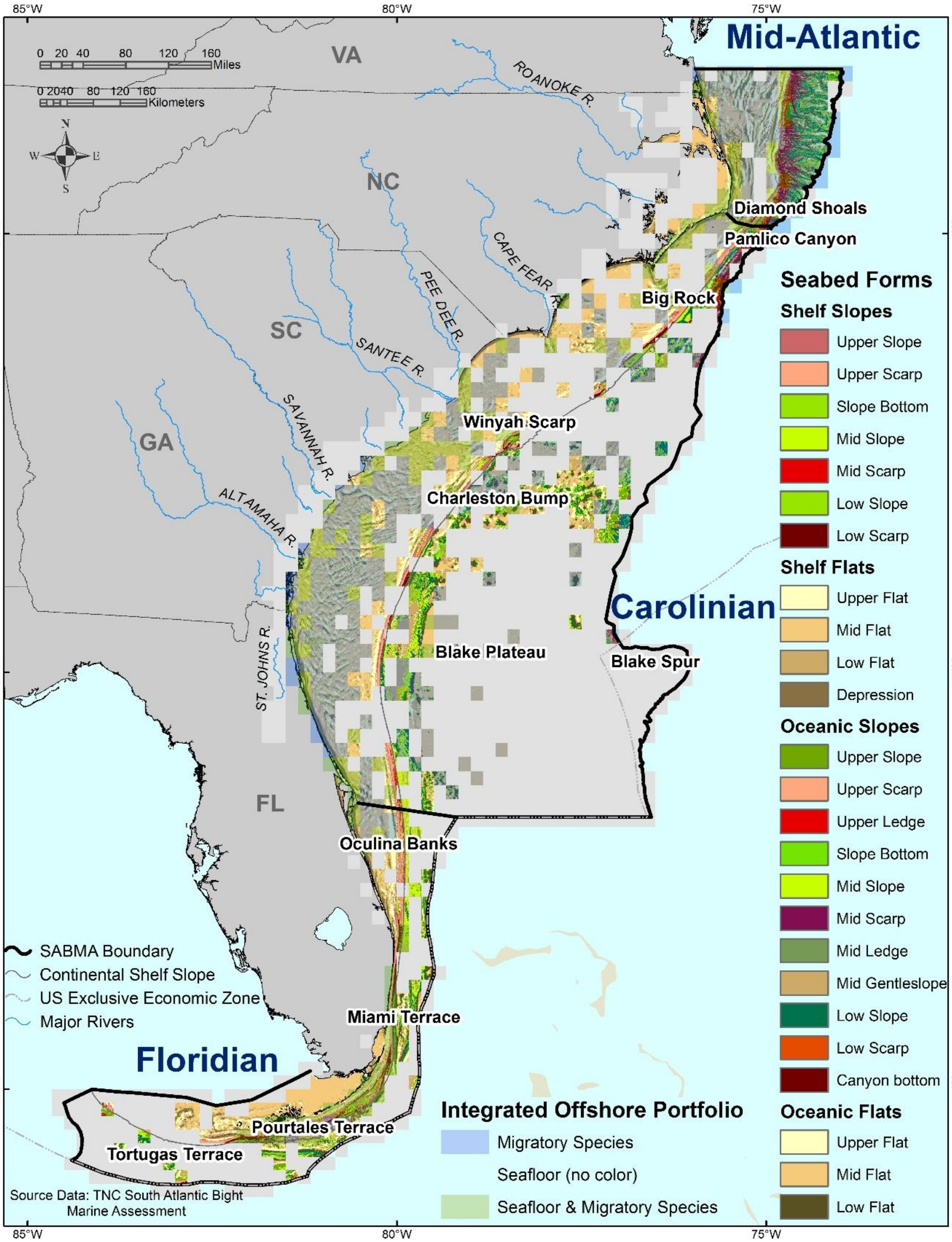

Figure 5.24. Combined portfolio. This map displays the seabed forms that underlie the seafloor portfolio overlaid with the light blue TMS that were selected for migratory species, or seafloor and migratory species to highlight the places where they correspond.

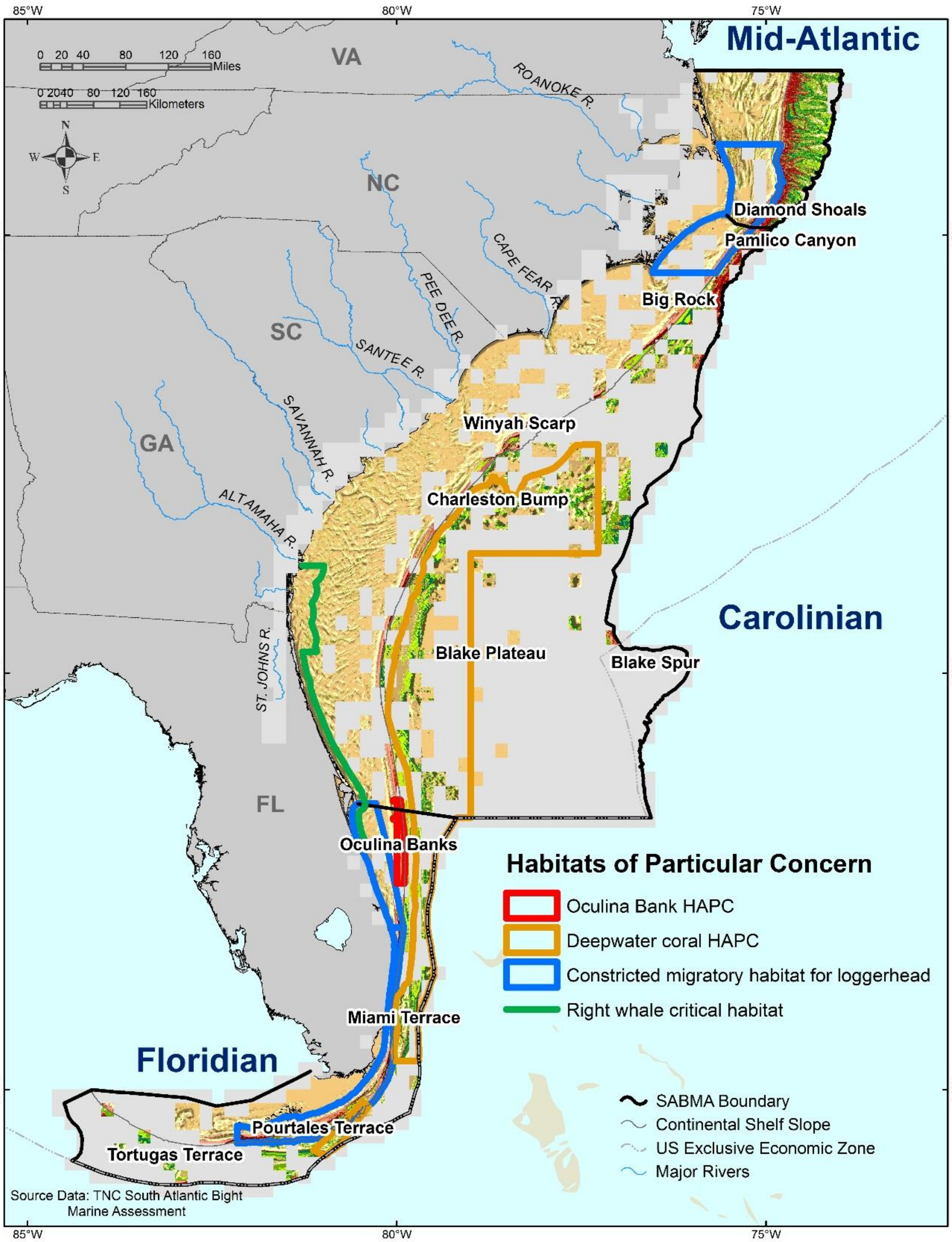

Figure 5.25. Habitat Areas of Particular Concern (HAPCs) and the combined integrated offshore portfolio. Four HAPCs are shown overlaid on the integrated offshore portfolio (transparent) and seabed forms. In general, the portfolio sites chosen for specific targets are finer scale than the HAPCs.

Discussion and Next Steps

This analysis identified 33% (13/39) of the coastal shoreline units and 42% of the offshore region as having high importance to biological diversity (Figure 5.26). The co-occurrence of individual biological signals reveals many ecologically important areas that are tightly linked to topographic features and to the geography of the region. For instance, priority areas for both seafloor and migratory conservation targets correspond to macro-scale features such as shallow coral reefs, submarine canyons, the shelf-slope break, several well-known shoals, and the narrow pinch point where sea turtle migrations concentrate. The calving region for right whales may be the wide shallow shelf and relatively warm water found off the coast of South Carolina and Georgia. Some areas, such as the hardbottom rock substrates, are connected to micro-topography at a much finer scale.

We sought to identify a portfolio of high-priority, high-biodiversity conservation areas based on the best available data and using selection criteria based almost entirely on the quantity and quality of diverse biological signals. This approach was only possible due to the relatively high quality and quantity of data generously made available to The Conservancy by many partners. Although *a priori* representation goals were deliberately not set, the methodology led to an apparently comprehensive portfolio, as measured by substantial representation of every conservation target, particularly the spatially extensive benthic habitats, in the ecoregional area. Many of our results verify or amplify the importance of areas already identified by NOAA as habitats of particular concern (Figure 5.25), or by other ocean users as coral hot spots or productive fishing holes. This correspondence reinforces our confidence in these areas as we made every effort to let the patterns in each dataset reveal themselves and to avoid any preconceived notion of important areas.

We favored ecological coherence over efficiency in order to retain larger processes such as migratory pathways. For example, more geographic area is devoted to migratory species than to seafloor habitats because the space needs and conservation strategies for these targets fundamentally differ. Our assumption is that, if properly managed or protected, conservation of the combined portfolio will substantially protect the diversity of the system and provide the ecosystem services that are essential for marine life and people.

In this integration of over 50 South Atlantic Bight datasets, we aimed to analyze data logically and to apply reasonable and defensible selection criteria; however, alternate or additional analyses are expected and welcome. We envision that Conservancy staff and others will find these conclusions useful to inform actions aimed at biodiversity conservation and restoration. We hope this report and spatial data may provide a fertile context for additional analysis to inform restoration and climate change adaptation priorities and strategies.

We emphasize that our analysis was conducted at a regional scale and therefore the results can best be used to set conservation priorities at that scale; additional finer scale data and analyses will be needed to support local or state-based marine spatial planning processes and permitting decisions. We also emphasize that individual local or state marine resource management plans will be most successful when developed using a shared regional-scale conservation context. With a regional, ecosystem-based conservation context for such plans, we are more likely to prioritize resource allocations intelligently.

In the near future, we aspire to work with partners to help answer questions concerning the compatibility of each of these areas with specific marine resource uses and their sensitivity to various kinds of impacts. We expect that conservation of many of the identified areas will be or can be ecologically compatible with many consumptive and non-consumptive resource uses. We look forward to working with partners to evaluate the sensitivity of particular areas to specific and cumulative human uses in transparent multi-sector marine spatial planning contexts. The coastal and marine conservation portfolios presented in this report are offered to inform and support marine spatial planning processes that result in tangible actions that better align human uses with the natural resources in any given part of the ocean. We are confident that such efforts can substantially improve biodiversity conservation, increase ecosystem resilience, and help to ensure that the South Atlantic Bight's coastal and marine ecosystems continue to provide the essential life-support services that people want and need.

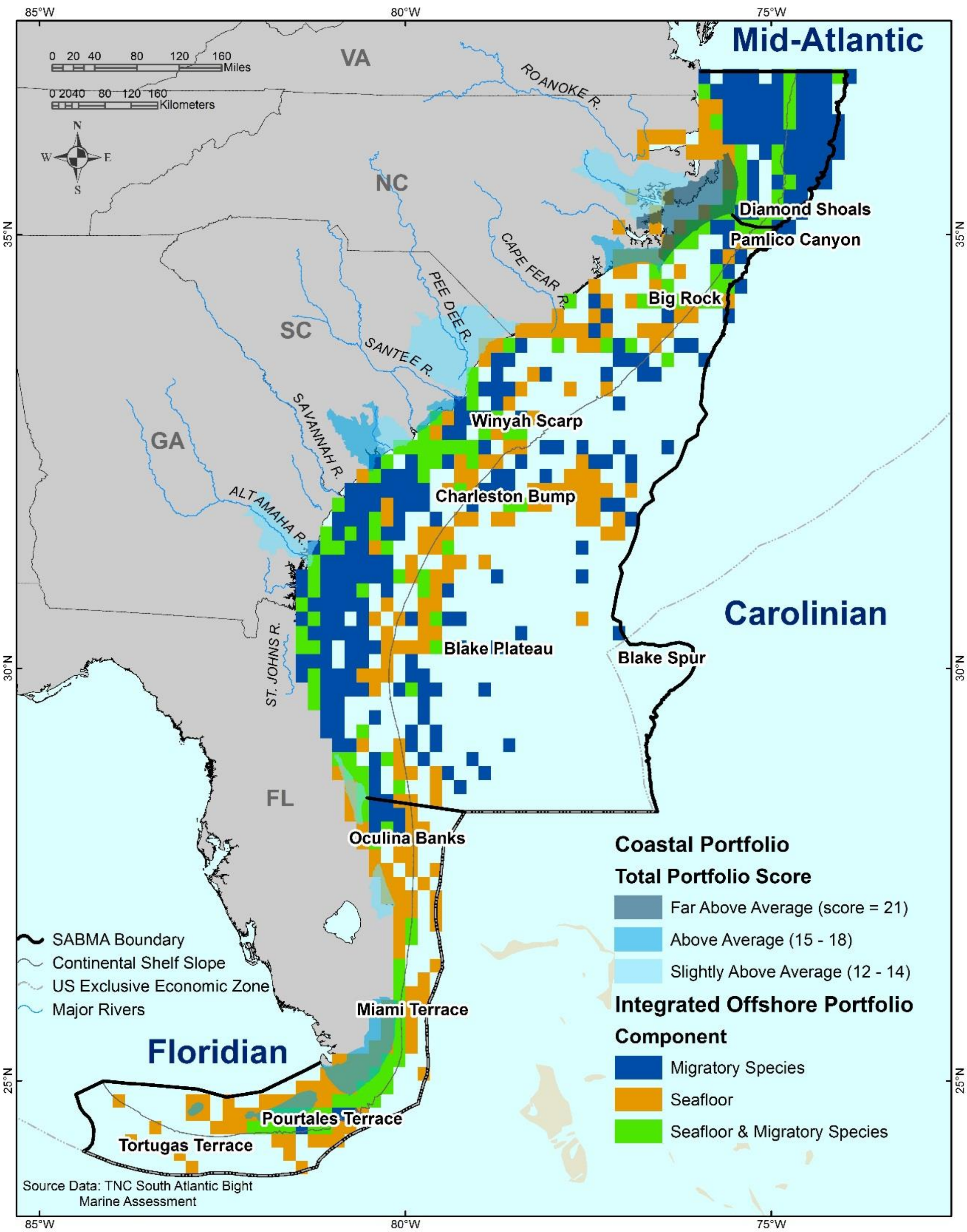

Figure 5.26. The coastal portfolio and integrated offshore portfolio. CSUs (n=13) with a total portfolio score of "slightly above average" or greater are shown in semi-transparent red shades and overlaid on the integrated offshore portfolio.

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APPENDIX

1

SABMA CROSSWALK TO CMECS

Crosswalk of the South Atlantic Bight (SABMA) seafloor and coastal features to the Coastal and Marine Ecological Classification Standard (CMECS)

“Crosswalk” is the term used for the identification of the relationships between units from different classifications. Here we crosswalk the SABMA units to those in the Coastal and Marine Ecological Classification Standard (CMECS), the Federal Geographic Data Committee Standard for describing marine ecosystem components (FGDC 2012). We follow the “Observation-to-Unit” crosswalking methodology provided in Appendix H of the CMECS standards document (FDGC 2012) to make explicit the relationship between the SABMA mapping units and standard CMECS units. Where there are significant differences among the units we also provide maps that express the SABMA data using the terminology from the CMECS classification.

We identify the relationship between the units using the symbols “=,” “>,” and “<” to indicate whether the conceptual SABMA unit is “equal to,” “broader than,” or “finer than” the related conceptual CMECS unit (i.e. do the definitions of the units match?). In some cases the relationship between the units may be identified as “equal,” even though the names of the two units differ. This means that their conceptual circumscription is equivalent, and the types are considered synonyms. The symbol “<>” is used to indicate that there is no equivalent concept in the CMECS classification. The symbol “><” is used to indicate that the relationship between the units is “overlapping.” This means that the two concepts contain at least one common entity, and each concept also contains at least one entity that the other does not contain. Neither concept is fully contained in the other.

CMECS allows users to combine units within the CMECS classification to create "derived" units. Derived units are used to describe how units from the different CMECS components occur together on the seafloor or landscape. They can also be used to combine units for mapping purposes when it is difficult to discern particular units with available data. We have employed this when a SABMA unit was broader than two or more related CMECS units (e.g. SABMA "Infralittoral" = CMECS "Shallow Infralittoral" + "Deep Infralittoral"). We also created derived units when a SABMA unit was best described by units from more than one CMECS Components (e.g. SABMA "Hardbottom Slope" = CMECS "Rock" Substrate + "Slope" Geoform). In all cases where this was done, the SABMA map unit was equivalent to the derived CMECS map unit.

There were some cases where SABMA units were more finely divided than CMECS units (e.g. SABMA "Shallow Mesobenthic" + "Deep Mesobenthic = CMECS "Mesobenthic"). In these cases, the CMECS map portrays only the broader CMECS unit and lumps the distinction recognized by SABMA.

Ecoregions

Both SABMA and CMECS recognize the Marine Ecoregions of the World (MEOW) as the basis for the ecoregions used for this study (Spalding et al., 2007). While the ecoregion boundaries are congruent between these classifications, SABMA uses the name "Mid-Atlantic" for the northernmost ecoregion in the study rather than the name "Virginian" that is used by MEOW and CMECS (Table A1.1). The Mid-Atlantic and Virginian are ecoregions are synonymous. SABMA uses the term "Mid-Atlantic" to be consistent with the terminology used in the previous Northwest Atlantic Marine Ecoregional Assessment (Greene et al 2010).

Table A1.1. Crosswalk between SABMA Ecoregions and CMECS Ecoregions

SABMA Ecoregion	Relationship to CMECS	CMECS Ecoregion
Mid-Atlantic	=	Virginian
Carolinian	=	Carolinian
Floridian	=	Floridian

Bathymetry Zones

The SABMA "Bathymetry Zones" are closely related in concept to the CMECS "Benthic Depth Zones Modifier," though they were developed to highlight distinct, but perhaps co-varying, ecological patterns. The SABMA Bathymetry Zones were identified specifically to elucidate patterns of species distributions by depth for the South Atlantic region using existing species observation data. The CMECS Benthic Depth Zone Modifier was developed to describe general "zones in which surf or ocean swell influences bottom communities, lower limits of vegetation, and overall photic ability and temperature" at a global scale (FGDC 2012). The two depth zone classifications are very similar and the threshold values between major zones equivalent such that more finely resolved SABMA units nest precisely within the broader CMECS units and *vice versa* (Table A1.2).

The CMECS maps units do not distinguish "Shallow Circalittoral" from "Deep Circalittoral" zones nor "Shallow Mesobenthic" from "Deep Mesobenthic" zones.

Table A1.2. Crosswalk between SABMA Bathymetry Zones and CMECS Benthic Depth Zone Modifier

SABMA Bathymetry Zone Units	SABMA Depth Zone Thresholds (m)	Relation-ship to CMECS Units	CMECS Benthic Depth Zone Modifier Units	CMECS Benthic Depth Zone Thresholds (m)	CMECS Derived Units
Infralittoral	0-30	>	Shallow Infralittoral	0-5	Shallow and Deep Infralittoral
		>	Deep Infralittoral	5-30	
Shallow Circalittoral	30-70	<	Circalittoral	30-200	Circalittoral
Deep Circalittoral	70-200	<			
Shallow Mesobenthic	200-600	<	Mesobenthic	200-1000	Mesobenthic
Deep Mesobenthic	600-1000	<			
Bathybenthic/ Shallow Abyssalbenthic	1000-5098	>	Bathybenthic	1000-4000	Bathybenthic and Abyssalbenthic
		>	Abyssalbenthic	4000-6000	

Substrate

The SABMA Soft Sediment classification and CMECS Substrate classifications are essentially equivalent for unconsolidated substrate unit. Both rely on the Wentworth scale thresholds for grain size (Wentworth 1922). SABMA lumps Very Fine and Fine

Sand into a single map unit and does the same for Coarse and Very Coarse Sand. The CMECS derived units are equivalent to the SABMA map units (Table A1.3).

There is one very minor difference between the two classifications as applied in this project. SABMA uses the term "Gravel" to describe grain sizes from 2-2.96mm. Normally CMECS would use the term "Granule" to describe grain sizes in this range, but, as defined in CMECS, "Granule" is finer scale distinction of the "Gravel" group that has grain sizes between 2-4,096mm. SABMA's use of the term "Gravel" is consistent with CMECS terminology at the broader level of classification.

Table A1.3. Crosswalk of SABMA Soft Sediment to CMECS Substrate

SABMA Soft Sediment Units	SABMA Soft Sediment Grain Size Threshold (mm)	Relationship to CMECS Substrate Units	CMECS Substrate Units	CMECS Substrate Grain Size Threshold (mm)	CMECS Derived Units
Mud	0.0008-0.0625	=	Mud	< 0.0625	Mud
Very Fine and Fine Sand	0.0625 - 0.25	>	Very Fine Sand	0.0625 - < 0.125	Very Fine and Fine Sand
		>	Fine Sand	0.125 - < 0.25	
Medium Sand	0.25-0.5	=	Medium Sand	0.25 - < 0.5	Medium Sand
Coarse and Very Coarse Sand	0.5-2	>	Coarse Sand	0.5 < 1	Coarse Sand and Very Coarse Sand
		>	Very Coarse Sand	1 - < 2	
Gravel	2-2.969976425	=	Granule	2 - < 4m	Gravel

Hardbottom

The SABMA Hardbottom units represent a mix of units from different CMECS components. Most of these units are equivalent to a combination of one CMECS Substrate unit plus another unit from a different CMECS component (Table A1.4). If relationship is marked "=" then both terms are equivalent to the SABMA unit.

All but one of the CMECS map units are equivalent to the SABMA Hardbottom units. SABMA recognizes both an "Upper" and "Lower" Hardbottom Shelf Break. Currently

CMECS does not provide a classifier or modifier that allows recognition of positional elements. The resulting CMECS derived units do not portray this distinction.

The SABMA "Platform Reef" unit was defined using the Florida SCHEME Classification (FMRI 2000). While there is no equivalent term in CMECS, CMECS includes definitions for both "Linear Spur and Groove Reef" and "Patch Coral Reef" that are also both derived from SCHEME. Within the SCHEME classification these two units are defined as subgroups of the Platform Reef unit. We combined these two CMECS units to create a derived unit that is equivalent in concept to the SABMA Platform Reef unit.

Table A1.4. Crosswalk of SABMA Hardbottom units to CMECS Substrate, Geoform, and Biotic Component Units

		CMECS Geoform Component		CMECS Biotic Component	CMECS Substrate Component	
SABMA Hardbottom Units	**Relationship to CMECS Units**	**Physiographic Setting Units**	**Geoform Units**	**Biotic Community Units**	**Substrate Units**	**CMECS Derived Units**
Hardbottom Slope	=		Slope		Rock Substrate	Rock Substrate Slope
Hardbottom: Lower Shelf Break	<	Shelf Break			Rock Substrate	Rock Substrate Shelf Break
Hardbottom: Upper Shelf Break	<					
Hardbottom Pavement	=		Pavement		Rock Substrate	Rock Substrate Pavement
Oculina Banks	=			*Oculina* Reef		*Oculina* Reef
Patch Reef	=		Patch Coral Reef			Patch Coral Reef
Patchy Coral and/or Rock in Unconsolidated Substrate	=				Fine Unconsolidated Substrate with Co-occurring Coral Reef Substrate, Coral Rubble, Bedrock or Gravel	Fine Unconsolidated Substrate with Co-occurring Coral Reef Substrate, Coral Rubble, Bedrock or Gravel
Platform Reef	>		Linear Coral Reef			Linear and Spur and Groove Coral Reef
	>		Spur and Groove Reef			

Seabed Forms

SABMA organizes their seabed forms into four main categories according to position relative to the continental shelf and gross geomorphology. These upper level categories can be expressed in CMECS by combining a Physiographic Setting unit with a Geoform unit. Though named differently, these upper level units are conceptually equivalent (Table A1.5).

Table A1.5. Crosswalk of SABMA Upper level Seabed Form Units to CMECS

Upper Level Units				
SABMA Seabed Units	**Relationship to CMECS**	**CMECS Physiographic Setting**	**CMECS Geoform**	**CMECS Derived Units**
Shelf Flats	Equal	Continental Shelf	Flat	Continental Shelf Flat
Shelf Slopes	Equal	Continental Shelf	Slope	Continental Shelf Slopes
Oceanic Flats	Equal	Continental Slope and Rise	Flat	Continental Slope and Rise Flats
Oceanic Slopes	Equal	Continental Slope and Rise	Slope	Continental Slope and Rise Slopes

As described above, SABMA Seabed Forms are a combination of slope and relative topographic position. All but one ("Gentleslope") of the SABMA terms used to describe the slope features are equivalent to CMECS Geoform terms (Table A1.6). CMECS does not, however, provide a means for specifying relative topographic position. The resulting CMECS map therefore, only provides the slope units and conveys less information than is available in the SABMA maps.

Table A1.6. Crosswalk of SABMA Seabed Forms to CMECS

SAMBA Seabed Units	Relationship	CMECS Units
Shelf Flats		**Continental Shelf Flat**
Depression	Equal	Depression
Upper Flat	<	Flat
Mid Flat	<	
Low Flat	<	
Shelf Slopes		**Continental Shelf Slopes**
Upper Slope	<	Slope
Mid Slope	<	
Low Slope	<	
Slope Bottom	<	
Upper Scarp	<	Wall/Scarp
Mid Scarp	<	
Lower Scarp	<	
Oceanic Flats		**Continental Slope and Rise Flats**
Upper Flat	<	Flat
Mid Flat	<	
Low Flat	<	
Oceanic Slopes		**Continental Slope and Rise Slopes**
Canyon Bottom	Equal	Canyon
Upper Ledge	<	Ledge
Mid Ledge	<	
Upper Slope	<	Slope
Mid Slope	<	
Low Slope	<	
Slope Bottom	<	
Mid Gentleslope	<	
Upper Scarp	<	Wall/Scarp
Mid Scarp	<	
Lower Scarp	<	

Coastal Habitats

The SABMA Coastal Habitat Type units are a combination of CMECS Biotic Component, Geoform Component and Aquatic Setting units (Table A1.7). Most of the SABMA units are more broadly defined than the related individual CMECS units, but the CMECS derived units are all equivalent to SABMA units.

The SABMA Freshwater Marsh and Forest units both include Palustrine habitats. The Palustrine system is outside of the domain of CMECS, so there is no equivalent unit in the CMECS classification.

The relationship between the SABMA Tidal Forest units and the CMECS Tidal Forest/Woodlands is complex. There are two different classifiers used to define these units: 1) Dominance of Trees and Shrubs and 2) Dominance of Mangrove species (Table A1.8). The SABMA classification lumps Tree and Shrub dominated habitats and splits out mangrove dominated from non-mangrove dominated habitats. In contrast, CMECS splits Tree-dominated from Shrub dominated habitats and lumps mangroves and non-mangrove species together at their “Subclass” level of the classification. CMECS later separates mangroves from non-mangrove species at the lower “Group” level of the classification.

We created two derived CMECS units help clarify the relationship: “Tidal Forest/Woodland and Tidal Scrub-Shrub Wetland” and “Tidal Mangrove Forest and Shrubland.” All of the individual Tidal Forest and Mangrove polygons on the SABMA maps meet the definitions for these derived units.

Table A1.7. Crosswalk of SABMA Coastal Habitat Types to CMECS

SABMA Coastal Habitat Types	Relationship to CMECS	CMECS Biotic Component Units	CMECS Geoform Units	CMECS Aquatic Setting Units	CMECS Derived Unit
Oceanfront Beach	=		Beach	Marine	Marine Beach
Estuarine Beach	=		Beach	Estuarine	Estuarine Beach
Tidal Flats	=		Tidal Flat	Estuarine	Estuarine Tidal Flats
Shellfish - Oysters	> > >	Oyster Reef Oyster Bed Attached Oysters			Oyster Reefs, Beds and Attached Oysters
Seagrass	=	Seagrass Bed			Seagrass Bed
Saltmarsh	> > > >	High Salt Marsh Low and Intermediate Salt Marsh Brackish Marsh	Panne		High, Low and Intermediate Salt Marsh and Brackish Marsh and Panne
Freshwater Tidal Marsh	=	Freshwater Tidal Marsh			Freshwater Tidal Marsh
Tidal Forests	> >	Tidal Forest/Woodland Tidal Scrub-Shrub Wetland			Tidal Forest/Woodland and Scrub-Shrub Wetland
Mangrove	> >	Tidal Mangrove Forest Tidal Mangrove Shrubland			Tidal Mangrove Forest and Shrubland

Table A1.8. SABMA and CMECS Tidal Forest Classifiers

	Trees	Shrubs
Mangrove	Mangrove	
Non-Mangrove	Tidal Forest	

CMECS

	Trees	Shrubs
Mangrove **Non -Mangrove**	Tidal Forest/Woodland Subclass	Tidal Scrub-Shrub Wetland Subclass

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HARDBOTTOM DATA SOURCES

Table A2.1. Source information for the polygon shapefiles (n=34,062 polygons) used in the hard bottom analysis. A SEAMAP BMWG code identifies datasets originally compiled by the SEAMAP Bottom Mapping Working Group (BMWG).

Source Name	Polygons (n)	SEAMAP BMWG Code	Reference/Note
SEAMAP BMWG - Fernandina Harbor ODMDS	22	CA02	Field Survey of the Fernandina Harbor Candidate Ocean Dredge Material Disposal Site, 22 May 1986 - USACE Jacksonville, Keith D. Spring - Continental Shelf Associates, Inc. (Positional precision to the nearest hundredth of a minute of latitude and longitude)
SEAMAP BMWG - Indian River Co Aerial Photo	149	FL08	Indian River County – Sebastian Inlet Taxation District, Aerial Photographic Survey of Nearshore Waters. Don Donaldson, Indian River County. (Interpolated from aerial photographs onto USGS Quads)
SEAMAP BMWG - Martin Co Shoreline Protection	229	SC01	Shoreline Protection Project, Side Scan Sonar Survey, Martin County, FL, Survey No. 93-206, June 1993. W. T. Sadler Jr., Sea Systems Corporation. (Positional precision reported in state planar coordinates (NAD 27))
Walker BK, Gilliam DS (2013); PLoS ONE 8(11)	201	---	Walker BK, Gilliam DS (2013) Determining the Extent and Characterizing Coral Reef Habitats of the Northern Latitudes of the Florida Reef Tract (Martin County). PLoS ONE 8(11)
Blake Ridge Diapir	1	---	Deepwater Coral HAPC surrounding the Blake Ridge Diapir methane seep live-bottom area. South Atlantic Fisheries Management Council. Florida Fish and Wildlife Research Institute. 2008.
FL FWRI Benthic Habitats - Broward County 2004	297	---	Florida Fish and Wildlife Research Institute. 2004. Benthic Habitats Florida Bay 2004. ftp://gcfi.org/Benthics/benthic_flbay_2004_poly/benthic_flbay_2004_poly.shp.htm
FL FWRI Benthic Habitats - FL Keys 2006 to 2011	6308	---	NOAA National Ocean Service, National Centers for Coastal Ocean Science, Center for Coastal Monitoring and Assessment, Biogeography Branch. 2011. Florida FWRI Benthic Habitats - Florida Keys 2006 to 2011. http://ccma.nos.noaa.gov/ecosystems/coralreef/fl_mapping/
FL FWRI Benthic Habitats - Florida Bay 2004	1	---	Florida Fish and Wildlife Research Institute. 2005. Florida FWRI Benthic Habitats - Florida Bay 2004.
FL FWRI Benthic Habitats - Marquesas 2006	1129	---	Florida Fish and Wildlife Research Institute. 2011. FL FWRI Benthic Habitats - Marquesas 2006.

Table A2.1 continued. Source information for the polygon shapefiles (n=34,062 polygons) used in the hard bottom analysis. A SEAMAP BMWG code identifies datasets originally compiled by the SEAMAP Bottom Mapping Working Group (BMWG).

Source Name	Polygons (n)	SEAMAP BMWG Code	Reference
FL FWRI Benthic Habitats - Miami-Dade 09	946	---	NOVA Southeastern University Oceanographic Center. 2009. FWRI Benthic Habitats - Miami-Dade 2006.
FL FWRI Benthic Habitats - South Florida 2001	2873	---	Florida Fish and Wildlife Research Institute & NOAA Coastal Services Center. 2001. Florida FWRI Benthic Habitats - South Florida 2001.
FL FWRI Benthic Habitats - Tortugas 2010	1379	---	National Park Service, South Florida/Caribbean Network. 2011. Florida FWRI Benthic Habitats - Dry Tortugas 2010.
Palm Beach County Benthic Habitats	20,461	---	Palm Beach County - Countywide GIS. 2012. Palm Beach County Benthic Habitats 2012. http://www.pbcgov.com/iss/itoperations/cwgis/gisorganization.htm
USGS Oculina Banks Benthic Habitat	66	---	U.S. Geological Survey. 1999. USGS Oculina Bank: Sidescan Sonar and Sediment Data from a Deep-Water Coral Reef Habitat off East-Central Florida. http://pubs.usgs.gov/of/1999/of99-010/htm/einterp.htm#Map

Table A2.2. Source information for the hardbottom trawl polylines that were converted to non-overlapping start and end points (n=3,802) for trawls with a maximum length of 1.577 km. All trawl polylines originated from the SEAMAP Bottom Mapping Working Group (BMWG).

Source/SEAMAP BMWG Code	Points (n)	Reference
CA01	282	South Atlantic Hard Bottom Study, June 1979. Continental Shelf Associates, Inc. Tequesta, FL.
CH82	130	R/V Cape Hatteras Geophysical Investigations (May 1982) – Stephen W. Snyder, N.C. State University. (Positional precision reported in LORAN TD units only)
CH83	38	R/V Cape Hatteras Geophysical Investigations (May 1983) - Stephen W. Snyder, N.C. State University. (Positional precision reported in LORAN TD units only)
CH84	209	R/V Cape Hatteras Geophysical Investigations (October 1984) – Stephen W. Snyder, N.C. State University. (Positional precision reported in LORAN TD units only)
CH89	71	R/V Cape Hatteras Geophysical Investigations (June 1989) – Stephen W. Snyder, N.C. State University. (Positional precision reported in LORAN TD units only)
DU02	10	R/V Eastward Studies, Underwater Camera Data 1965-1973 – Joseph Ustach, Duke University Marine Lab. (Positional precision reported in nearest tenth of a minute of latitude and longitude)
E380	684	R/V Eastward Geophysical Investigations (May 1980) – Stephen W. Snyder, N.C. State University. (Positional precision reported in LORAN TD units only)
EN80	498	R/V Endeavor Geophysical Investigations (October 1980) - Stephen W. Snyder, N.C. State University. (Positional precision reported in nearest hundredth of a minute of latitude and longitude)
EP01	32	Environmental Protection Agency survey of offshore disposal area, January 1990 – Phillip Murphy, Environmental Protection Agency. (Positional precision reported in nearest hundredth of a minute of latitude and longitude)
EP02	32	Environmental Protection Agency survey of offshore disposal area, June 1990. Phillip Murphy, Environmental Protection Agency. (Positional precision reported in nearest hundredth of a minute of latitude and longitude)
FC01	2	Unpublished data records, Southeast Fisheries Center, Beaufort Lab. Pete Parker, National Marine Fisheries Service. (Positional precision reported in nearest hundredth of a minute of latitude and longitude)
FL06	8	Florida Dept. Environ. Protection, Florida Marine Research Institute Marine Specimen Collection. Sandra LaGant, Florida Marine Research Institute. (Positional precision reported in LORAN TD units, or to the nearest minute, tenth of minute or hundredth of minute of latitude and longitude)
GO08	54	Geologic Drilling Hazard Survey Federal OCS Lease Block 564 (General Oceanographics, 1978). Faisal M. Idris, GSU Applied Coastal Research Lab. (Interpolated from map to nearest hundredth of minute of latitude and longitude)
HB01	2	Harbor Branch Oceanographic Institution, East Florida Shelf, Trawl and Dredge Survey, 1973-1978. Robert H. Gore, HBOI. (Positional precision reported in nearest tenth of a minute of latitude and longitude)

Table A2.2 continued. Source information for the hardbottom trawl polylines that were converted to non-overlapping start and end points (n=3,802) for trawls with a maximum length of 1.577 km. All trawl polylines originated from the SEAMAP Bottom Mapping Working Group (BMWG).

Source/SEAMAP BMWG Code	Points (n)	Reference
HB05	247	Harbor Branch Oceanographic Institution, East Florida Shelf, Side-scan Survey. John Thompson, HBOI. (Positional precision reported in LORAN TD units only)
HB06	25	Harbor Branch Oceanographic Institution, East Florida Shelf, Fathometer Survey. Charles Hoskins, HBOI. (Positional precision reported in LORAN TD units only)
HB07	5	Harbor Branch Oceanographic Institution, East Florida Shelf, ROV "CORD" Survey. John Reed, HBOI. (Positional precision reported in LORAN TD units only)
I815	64	R/V Columbus Iselin Geophysical Investigations (May 1981). Stephen W. Snyder, N.C. State University. (Positional precision reported in nearest hundredth of a minute of latitude and longitude)
MM01	48	South Atlantic OCS Area Living Marine Resources Study, Year II. Robert Van Dolah, South Carolina Dept. of Natural Resources. (Positional precision reported in nearest tenth of a minute of latitude and longitude)
MR01	110	Identification and location live bottom habitats in five potential borrow sites off Myrtle Beach, SC, 1991 - USACE. Robert Van Dolah, South Carolina Dept. of Natural Resources. (Positional precision reported in nearest hundredth of a minute of latitude and longitude)
MR02	4	A remote survey of bottom characteristics within a potential borrow site near Little River, SC, 1992 - USACE. Robert Van Dolah, South Carolina Dept. of Natural Resources. (Positional precision reported in nearest hundredth of a minute of latitude and longitude)
MR07	97	Biological assessment of beach and nearshore areas along the SC Grand Strand. Robert Van Dolah, South Carolina Dept. of Natural Resources. (Interpolated from map to nearest hundredth of minute of latitude and longitude)
NA01	56	U.S. Navy survey of Charleston Minefield. Phil Maier, SC Dept. of Natural Resources. (Interpolated from map to nearest hundredth of minute of latitude and longitude)
UG01	689	Final Report: Ocean bottom Survey of the U.S. South Atlantic OCS region. V.J. Henry Jr., University of Georgia. (Positional precision reported in nearest hundredth of a minute of latitude and longitude)
UG02	104	Side Scan Sonar Survey of the inner continental Shelf of Georgia. J L Harding, University of Georgia. (Positional precision reported in nearest hundredth of a minute of latitude and longitude)
UG04	22	Results of reconnaissance mapping of the Gray's Reef National Marine Sanctuary. V.J. Henry Jr., University of Georgia. (Positional precision reported in nearest hundredth of a minute of latitude and longitude)
UG05	279	Draft final report: Results of Gray's Reef National Marine Sanctuary Hydrographic & geophysical surveys. V.J. Henry Jr., University of Georgia. (Positional precision reported in nearest hundredth of a minute of latitude and longitude)

Table A2.3. Source information for the points (n=17,070) that were used in the hard bottom analysis. A SEAMAP BMWG code identifies datasets originally compiled by the SEAMAP Bottom Mapping Working Group (BMWG).

Source Name	Points (n)	Type	SEAMAP BMWG Code	Reference
SEAMAP BMWG - MARMAP Program data part 1	540	trap	MR08	MARMAP Program data, SCWMRD 1973-1992. George Sedberry, SC Dept. of Natural Resources.
SEAMAP BMWG - MARMAP Program data part 1	1566	closed circuit TV	MR08	MARMAP Program data, SCWMRD 1973-1992. George Sedberry, SC Dept. of Natural Resources.
SEAMAP BMWG - R/V Eastward Underwater Cam	1	video camera	DU02	R/V Eastward Studies, Underwater Camera Data 1965-1973 – Joseph Ustach, Duke University Marine Lab. (Positional precision reported in nearest tenth of a minute of latitude and longitude)
SEAMAP BMWG - Submersible and Scuba, Ross	11	closed circuit TV	SR01	Submersible (Parker and Ross 1986) and SCUBA (S.W. Ross unpublished data) records. Steve W. Ross, NC Division of Coastal Management. (Positional precision reported in LORAN TD units only)
SEAMAP BMWG - Duke University, unpub data	2	video camera	DU01	Duke University, unpublished data records, 1973-1980 – Orrin Pilkey. (Positional precision unknown)
Chasin' Tails - Natural Reef Sites	105	fishermen points	---	Chasin' Tails Outdoors. Date Unknown. Chasin' Tails Outdoors - Natural Reef Sites. http://www.chasintailsoutdoors.com/gps-numbers.php
Hexacorallians of the World	248	hb coral specimen	---	Fautin, Daphne G. 2011. Hexacorallians of the World. http://geoportal.kgs.ku.edu/hexacoral/anemone2/index.cfm
Grays Reef NMS - Benthic Habitat	3214	sidescan backscatter & multibeam bathymetry with scuba and towed video	---	NOAA/NOS/NCCOS/CCMA Biogeography Team. 2003. Gray's Reef NMS Benthic Habitat Mapping.
Live Wire - Florida Keys	11	coordinates of hb sites	---	Andren Software Company. Unknown date. Team Live Wire Offshore GPS Coordinates – North Carolina, South Carolina, Florida Atlantic & Florida Keys. http://www.andren.com/downloadwaypoints.html

Table A2.3 continued. Source information for the points (n=17,070) that were used in the hard bottom analysis. A SEAMAP BMWG code identifies datasets originally compiled by the SEAMAP Bottom Mapping Working Group (BMWG).

Source Name	Points (n)	Type	SEAMAP BMWG Code	Reference
Live Wire - North Carolina	59	coordinates of hb sites	---	Andren Software Company. Unknown date. Team Live Wire Offshore GPS Coordinates – North Carolina, South Carolina, Florida Atlantic & Florida Keys. http://www.andren.com/downloadwaypoints.html
Live Wire - South Carolina	8	coordinates of hb sites	---	Andren Software Company. Unknown date. Team Live Wire Offshore GPS Coordinates – North Carolina, South Carolina, Florida Atlantic & Florida Keys. http://www.andren.com/downloadwaypoints.html
Live Wire Fishing - Florida Atlantic	225	coordinates of hb sites	---	Andren Software Company. Unknown date. Team Live Wire Offshore GPS Coordinates – North Carolina, South Carolina, Florida Atlantic & Florida Keys. http://www.andren.com/downloadwaypoints.html
Live Wire Fishing Website	9	coordinates of hb sites	---	Andren Software Company. Unknown date. Team Live Wire Offshore GPS Coordinates – North Carolina, South Carolina, Florida Atlantic & Florida Keys. http://www.andren.com/downloadwaypoints.html
Maps Unique - Natural Sites 2013	2167	mapping live bottom reefs	---	Maps Unique. Unknown date. Maps Unique Hard & Live Bottom Reef Areas. http://offshore-fishing-map.com/
NEFSC Benthic - NEMP - Reid, Pearce & Ingham	5	hb coral specimens	---	Woods Hole Laboratories, NOAA. 2012. NOAA NMFS Northeast Fisheries Science Center [NEFSC] Benthic Database. http://www.usgs.gov/obis-usa/
NEFSC Benthic – CMP – Hathaway, J.C., ed. 1971.	23	hb coral specimens	---	Woods Hole Laboratories, NOAA. 2012. NOAA NMFS Northeast Fisheries Science Center [NEFSC] Benthic Database. http://www.usgs.gov/obis-usa/
NEFSC Benthic, Ocean Pulse - Pearce and Steimle, 1	2	hb coral specimens	---	Woods Hole Laboratories, NOAA. 2012. NOAA NMFS Northeast Fisheries Science Center [NEFSC] Benthic Database. http://www.usgs.gov/obis-usa/
NOAA NMFS SEFSC Beaufort - D Willis/P Whitfield	75	trap samples of demersal fish	---	NOAA NMFS Southeast Fisheries Science Center [SEFSC]. NOAA NMFS Southeast Fisheries Science Center [SEFSC] Cruise Reports

Table A2.3 continued. Source information for the points (n=17,070) that were used in the hard bottom analysis. A SEAMAP BMWG code identifies datasets originally compiled by the SEAMAP Bottom Mapping Working Group (BMWG).

Source Name	Points (n)	Type	SEAMAP BMWG Code	Reference
NOAA NMFS SEFSC Beaufort Lab - Demersal Fish	14	trap samples of demersal fish	---	NOAA NMFS Southeast Fisheries Science Center [SEFSC]. NOAA NMFS Southeast Fisheries Science Center [SEFSC] Cruise Reports
SEADESC – Partyka et al. 2007; PI=SW Ross	20	dive locations with hb coral specimens	---	Partyka, M.L., S.W. Ross, A.M. Quattrini, G.R. Sedberry, T.W. Birdsong, J. Potter, S. Gottfried. 2007. Southeastern United States Deep-Sea Corals (SEADESC) Initiative: A Collaborative Effort to Characterize Areas of Habitat-Forming Deep-Sea Corals. NOAA Technical Memorandum OAR OER 1. Silver Spring, MD. 176 pp. http://ocean.floridamarine.org/efh_coral/metadata/seadesc%20dive%20locations.htm
SEADESC – Partyka et al. 2007; PI=GR Sedberry	45	dive locations with hb coral specimens	---	Partyka, M.L., S.W. Ross, A.M. Quattrini, G.R. Sedberry, T.W. Birdsong, J. Potter, S. Gottfried. 2007. Southeastern United States Deep-Sea Corals (SEADESC) Initiative: A Collaborative Effort to Characterize Areas of Habitat-Forming Deep-Sea Corals. NOAA Technical Memorandum OAR OER 1. Silver Spring, MD. 176 pp. http://ocean.floridamarine.org/efh_coral/metadata/seadesc%20dive%20locations.htm
UNEP-WCMC Global Dist Cold Corals - Cairns, 1979	29	sampling and literature review	---	Cairns, S.D. 1979. The deep-water Scleractinia of the Caribbean Sea and adjacent waters. *Studies on the Fauna of Curacao and other Caribbean Islands*, 57(180): 341. In Freiwald A, Rogers A, Hall-Spencer J (2005). Global distribution of cold-water corals (version 2). Update of the dataset used in Freiwald et al. (2004). Cambridge (UK): UNEP World Conservation Monitoring Centre. URL: data.unep-wcmc.org/datasets/1
UNEP-WCMC Global Dist Cold Corals - Cairns, 2001	16	sampling and literature review	---	Cairns, S.D. 2001. A brief history of taxonomic research on azooxanthellate Scleractinia (Cnidaria: Anthozoa). *Bulletin of the Biological Society of Washington*, 10: 191-203. In Freiwald A, Rogers A, Hall-Spencer J (2005). Global distribution of cold-water corals (version 2). Update of the dataset used in Freiwald et al. (2004). Cambridge (UK): UNEP World Conservation Monitoring Centre. URL: data.unep-wcmc.org/datasets/1

Table A2.3 continued. Source information for the points (n=17,070) that were used in the hard bottom analysis. A SEAMAP BMWG code identifies datasets originally compiled by the SEAMAP Bottom Mapping Working Group (BMWG).

Source Name	Points (n)	Type	SEAMAP BMWG Code	Reference
UNEP-WCMC Global Dist Cold Corals -Cairns and Bayer 2003.	1	sampling and literature review	---	Bayer, Frederick M. and Cairns, Stephen D. 2003. A new genus of the scleraxonian family Coralliidae (Octocorallia: Gorgonacea). *Proceedings of the Biological Society of Washington*, 116(1): 222-228. In Freiwald A, Rogers A, Hall-Spencer J (2005). Global distribution of cold-water corals (version 2). Update of the dataset used in Freiwald et al. (2004). Cambridge (UK): UNEP World Conservation Monitoring Centre. URL: data.unep-wcmc.org/datasets/1
UNEP-WCMC Global Dist Cold Corals -Messing et al. (1990).	1	sampling and literature review	---	Messing, C. G., Neuman, A. C., and Lang, J. C., 1990, Biozonation of deep-water lithoherms and associated hardgrounds in the northeastern Straits of Florida. *Palaois* 5:15-33. In Freiwald A, Rogers A, Hall-Spencer J (2005). Global distribution of cold-water corals (version 2). Update of the dataset used in Freiwald et al. (2004). Cambridge (UK): UNEP World Conservation Monitoring Centre. URL: data.unep-wcmc.org/datasets/1
UNEP-WCMC Global Dist Cold Corals - Paull, 2000	1	sampling and literature review	---	Paull CK, Neumann AC, am Ende BA, Ussler III W, Rodriguez, NM (2000) Lithoherms on the Florida-Hatteras slope. Marine Geology 166: 83-101. In Freiwald A, Rogers A, Hall-Spencer J (2005). Global distribution of cold-water corals (version 2). Update of the dataset used in Freiwald et al. (2004). Cambridge (UK): UNEP World Conservation Monitoring Centre. URL: data.unep-wcmc.org/datasets/1
UNEP-WCMC Global Dist Cold Corals -Reed (1992)	7	sampling and literature review	---	Reed, JK. 1992. Submersible studies of deep-water *Oculina* and *Lophelia* coral banks of southeastern USA. In Cahoon LB (ed) Diving for Science. University of North Carolina, Wilmington pp. 143-151. In Freiwald A, Rogers A, Hall-Spencer J (2005). Global distribution of cold-water corals (version 2). Update of the dataset used in Freiwald et al. (2004). Cambridge (UK): UNEP World Conservation Monitoring Centre. URL: data.unep-wcmc.org/datasets/1

Table A2.3 continued. Source information for the points (n=17,070) that were used in the hard bottom analysis. A SEAMAP BMWG code identifies datasets originally compiled by the SEAMAP Bottom Mapping Working Group (BMWG).

Source Name	Points (n)	Type	SEAMAP BMWG Code	Reference
UNEP-WCMC Global Dist Cold Corals - Reed, 2005	1	sampling and literature review	---	Reed et al, 2005. Deep-water sinkholes and bioherms of South Florida and the Pourtales Terrace. In Freiwald A, Rogers A, Hall-Spencer J (2005). Global distribution of cold-water corals (version 2). Update of the dataset used in Freiwald et al. (2004). Cambridge (UK): UNEP World Conservation Monitoring Centre. URL: data.unep-wcmc.org/datasets/1
UNEP-WCMC Global Dist Cold Corals - Rogers, 1999	1	sampling and literature review	---	Rogers, A.D. 1999. The biology of *Lophelia pertusa* (Linnaeus 1758) and other deep-water reef-forming corals and impacts from human activities. International Review of Hydrobiology 84: 315–406. In Freiwald A, Rogers A, Hall-Spencer J (2005). Global distribution of cold-water corals (version 2). Update of the dataset used in Freiwald et al. (2004). Cambridge (UK): UNEP World Conservation Monitoring Centre. URL: data.unep-wcmc.org/datasets/1
UNEP-WCMC Global Dist Cold Corals – Stanley & Cairns 1988	1	sampling and literature review	---	Stanley, G. D. and Cairns, Stephen D. 1988. Constructional azooxanthellate coral communities: an overview with implications for the fossil record. *Palaios*, 5(3): 233-242. In Freiwald A, Rogers A, Hall-Spencer J (2005). Global distribution of cold-water corals (version 2). Update of the dataset used in Freiwald et al. (2004). Cambridge (UK): UNEP World Conservation Monitoring Centre. URL: data.unep-wcmc.org/datasets/1
UNEP-WCMC Global Dist Cold Corals -Stetson et al. (1962).	1	sampling and literature review	---	Stetson, T. R., D. F. Squires, and R. M. Pratt. 1962. Coral banks occurring in deep water on the Blake Plateau. In Freiwald A, Rogers A, Hall-Spencer J (2005). Global distribution of cold-water corals (version 2). Update of the dataset used in Freiwald et al. (2004). Cambridge (UK): UNEP World Conservation Monitoring Centre. URL: data.unep-wcmc.org/datasets/1

Table A2.3 continued. Source information for the points (n=17,070) that were used in the hard bottom analysis. A SEAMAP BMWG code identifies datasets originally compiled by the SEAMAP Bottom Mapping Working Group (BMWG).

Source Name	Points (n)	Type	SEAMAP BMWG Code	Reference
UNEP-WCMC Global Dist Cold Corals - Zibrowius	1	sampling and literature review	---	Zibrowius, H. (1980). Les scléractiniaires de la Méditerranée et de l'Atlantique nord-oriental. Mémoires de l'Institut océanographique, Monaco, 11. Musée océanographique de Monaco: Monaco. 3 volumes, including bibliography and taxonomic index. In Freiwald A, Rogers A, Hall-Spencer J (2005). Global distribution of cold-water corals (version 2). Update of the dataset used in Freiwald et al. (2004). Cambridge (UK): UNEP World Conservation Monitoring Centre. URL: data.unep-wcmc.org/datasets/1
USGS Study of Northern Blake Plateau	472	database of deepwater coral mounds	---	Skidaway Institute of Oceanography. 2004. Deepwater Coral Mounds of the Blake Plateau. Information taken directly from USGS. 1994. Bottom Character Map of the Northern Blake Plateau (OFR-93-724). http://pubs.usgs.gov/of/1993/0724/report.pdf
USGS/NOAA CoWCoG - Brooke and Young, 2003	6	sampling and literature review	---	Brooke, S. and C.M. Young. 2003. Reproductive ecology of a deep water scleractinian coral, Oculina varicosa from the South East Florida Shelf. Continental Shelf Research 23:847-858. In Scanlon, K.M., Waller, R.G., Sirotek, A.R., Knisel, J.M., O'Malley, J.J., and Alesandrini, Stian, 2010, USGS cold-water coral geographic database—Gulf of Mexico and western North Atlantic Ocean, version 1.0: U.S. Geological Survey Open-File Report 2008–1351, CD-ROM. (Also available at http://pubs.usgs.gov/of/2008/1351/).
USGS/NOAA CoWCoG - Cairns, 1976	76	sampling and literature review	---	Cairns, S. D., 1976, Review of the deep-water ahermatypic corals (Scleractinia) of the tropical western Atlantic: Miami, University of Miami, Ph.D. Dissertation, 316 p. In Scanlon, K.M., Waller, R.G., Sirotek, A.R., Knisel, J.M., O'Malley, J.J., and Alesandrini, Stian, 2010, USGS cold-water coral geographic database—Gulf of Mexico and western North Atlantic Ocean, version 1.0: U.S. Geological Survey Open-File Report 2008–1351, CD-ROM. (Also available at http://pubs.usgs.gov/of/2008/1351/).

Table A2.3 continued. Source information for the points (n=17,070) that were used in the hard bottom analysis. A SEAMAP BMWG code identifies datasets originally compiled by the SEAMAP Bottom Mapping Working Group (BMWG).

Source Name	Points (n)	Type	SEAMAP BMWG Code	Reference
USGS/NOAA CoWCoG - Cairns, 1977	8	sampling and literature review	---	Cairns, Stephen D. 1977. A review of the Recent species of *Balanophyllia* (Anthozoa: Scleractinia) in the western Atlantic, with descriptions of four new species. *Proceedings of the Biological Society of Washington*, 90(1): 132-148. In Scanlon, K.M., Waller, R.G., Sirotek, A.R., Knisel, J.M., O'Malley, J.J., and Alesandrini, Stian, 2010, USGS cold-water coral geographic database—Gulf of Mexico and western North Atlantic Ocean, version 1.0: U.S. Geological Survey Open-File Report 2008–1351, CD-ROM. (Also available at http://pubs.usgs.gov/of/2008/1351/).
USGS/NOAA CoWCoG - Cairns, 1978	4	sampling and literature review	---	Cairns, S.D. 1978. A checklist of the ahermatypic Scleractinia of the Gulf of Mexico, with the description of a new species. *Gulf Research Reports*, 6(1): 9-15. In Scanlon, K.M., Waller, R.G., Sirotek, A.R., Knisel, J.M., O'Malley, J.J., and Alesandrini, Stian, 2010, USGS cold-water coral geographic database—Gulf of Mexico and western North Atlantic Ocean, version 1.0: U.S. Geological Survey Open-File Report 2008–1351, CD-ROM. (Also available at http://pubs.usgs.gov/of/2008/1351/).
USGS/NOAA CoWCoG - Cairns, 1979	37	sampling and literature review	---	Cairns, S.D. 1979. The deep-water Scleractinia of the Caribbean Sea and adjacent waters. *Studies on the Fauna of Curacao and other Caribbean Islands*, 57(180): 341. In Scanlon, K.M., Waller, R.G., Sirotek, A.R., Knisel, J.M., O'Malley, J.J., and Alesandrini, Stian, 2010, USGS cold-water coral geographic database—Gulf of Mexico and western North Atlantic Ocean, version 1.0: U.S. Geological Survey Open-File Report 2008–1351, CD-ROM. (Also available at http://pubs.usgs.gov/of/2008/1351/).
2005/USGS/NOAA CoWCoG - Freiwald & Roberts, 2005	74	sampling and historic literature review	---	Freiwald, Andre, and Roberts, J. M., eds., 2005, Cold-water corals and ecosystems:ß Springer-Verlag, Berlin, p. 279-296. In Scanlon, K.M., Waller, R.G., Sirotek, A.R., Knisel, J.M., O'Malley, J.J., and Alesandrini, Stian, 2010, USGS cold-water coral geographic database—Gulf of Mexico and western North Atlantic Ocean, version 1.0: U.S. Geological Survey Open-File Report 2008–1351, CD-ROM. (Also available at http://pubs.usgs.gov/of/2008/1351/).

Table A2.3 continued. Source information for the points (n=17,070) that were used in the hard bottom analysis. A SEAMAP BMWG code identifies datasets originally compiled by the SEAMAP Bottom Mapping Working Group (BMWG).

Source Name	Points (n)	Type	SEAMAP BMWG Code	Reference
USGS/NOAA CoWCoG - George, 2002	1	sampling and historic literature review	---	George, R. Y., 2002, Ben Franklin temperate reef and deep sea 'Agassiz Coral Hills' in the Blake Plateau off North Carolina: Hydrobiologia, v. 471, p. 71-81. In Scanlon, K.M., Waller, R.G., Sirotek, A.R., Knisel, J.M., O'Malley, J.J., and Alesandrini, Stian, 2010, USGS cold-water coral geographic database—Gulf of Mexico and western North Atlantic Ocean, version 1.0: U.S. Geological Survey Open-File Report 2008–1351, CD-ROM. (Also available at http://pubs.usgs.gov/of/2008/1351/).
USGS/NOAA CoWCoG - Reed et al, 2005	11	sampling and historic literature review	---	Reed, J. K., Pomponi, S. A., Weaver, Doug, Paull, C. K., and Wright, A. E., 2005, Deep-water sinkholes and bioherms of South Florida and the Pourtales Terrace—Habitat and Fauna: Bulletin of Marine Science, v. 77, no. 2, p. 267-296. In Scanlon, K.M., Waller, R.G., Sirotek, A.R., Knisel, J.M., O'Malley, J.J., and Alesandrini, Stian, 2010, USGS cold-water coral geographic database—Gulf of Mexico and western North Atlantic Ocean, version 1.0: U.S. Geological Survey Open-File Report 2008–1351, CD-ROM. (Also available at http://pubs.usgs.gov/of/2008/1351/).
USGS/NOAA CoWCoG - Reed et al, 2006	30	sampling and historic literature review	---	Reed, J. K., Weaver, D. C., and Pomponi, S. A., 2006, Habitat and fauna of deep-water *Lophelia pertusa* coral reefs off the southeastern U.S.—Blake Plateau, Straits of Florida, and Gulf of Mexico: Bulletin of Marine Science, v. 78, no. 2, p. 343-375. In Scanlon, K.M., Waller, R.G., Sirotek, A.R., Knisel, J.M., O'Malley, J.J., and Alesandrini, Stian, 2010, USGS cold-water coral geographic database—Gulf of Mexico and western North Atlantic Ocean, version 1.0: U.S. Geological Survey Open-File Report 2008–1351, CD-ROM. (Also available at http://pubs.usgs.gov/of/2008/1351/).
USGS/NOAA CoWCoG - Reed, 1980	18	sampling and historic literature review	---	Reed, J. K., 1980, Distribution and structure of deep-water Oculina varicosa coral reefs off central eastern Florida. Bull Mar Sci 30: 667-677. In Scanlon, K.M., Waller, R.G., Sirotek, A.R., Knisel, J.M., O'Malley, J.J., and Alesandrini, Stian, 2010, USGS cold-water coral geographic database—Gulf of Mexico and western North Atlantic Ocean, version 1.0: U.S. Geological Survey Open-File Report 2008–1351, CD-ROM. (Also available at http://pubs.usgs.gov/of/2008/1351/).

Table A2.3 continued. Source information for the points (n=17,070) that were used in the hard bottom analysis. A SEAMAP BMWG code identifies datasets originally compiled by the SEAMAP Bottom Mapping Working Group (BMWG).

Source Name	Points (n)	Type	SEAMAP BMWG Code	Reference
USGS/NOAA CoWCoG - Smithsonian Inst NMNH	5	sampling and historic literature review	---	Habitat and fauna of deep-water Lophelia pertusa coral reefs off the southeastern U.S.—Blake Plateau, Straits of Florida, and Gulf of Mexico Smithsonian Inst. NMNH - National Museum of Natural History Collection, Search IZ Collections: accessed in July, 2007 at <http://invertebrates.si.edu/index.htm>. In Scanlon, K.M., Waller, R.G., Sirotek, A.R., Knisel, J.M., O'Malley, J.J., and Alesandrini, Stian, 2010, USGS cold-water coral geographic database—Gulf of Mexico and western North Atlantic Ocean, version 1.0: U.S. Geological Survey Open-File Report 2008–1351, CD-ROM. (Also available at http://pubs.usgs.gov/of/2008/1351/).
USGS/NOAA CoWCoG - Viada and Cairns, 1987	2	sampling and historic literature review	---	Viada, S. T., and Cairns, S. D., 1987, Range extensions of ahermatypic scleractinia in the Gulf of Mexico. Northeast Gulf Science 9(2), 131-134. In Scanlon, K.M., Waller, R.G., Sirotek, A.R., Knisel, J.M., O'Malley, J.J., and Alesandrini, Stian, 2010, USGS cold-water coral geographic database—Gulf of Mexico and western North Atlantic Ocean, version 1.0: U.S. Geological Survey Open-File Report 2008–1351, CD-ROM. (Also available at http://pubs.usgs.gov/of/2008/1351/).
USGS/NOAA CoWCoG - Watling, and Auster, 2005	4	sampling and historic literature review	---	Watling, L. & P.J. Auster. 2005. Distribution of deep-water Alcyonacea off the Northeast coast of the United States . Pp. 279-296. In Scanlon, K.M., Waller, R.G., Sirotek, A.R., Knisel, J.M., O'Malley, J.J., and Alesandrini, Stian, 2010, USGS cold-water coral geographic database—Gulf of Mexico and western North Atlantic Ocean, version 1.0: U.S. Geological Survey Open-File Report 2008–1351, CD-ROM. (Also available at http://pubs.usgs.gov/of/2008/1351/).

Table A2.3 continued. Source information for the points (n=17,070) that were used in the hard bottom analysis. A SEAMAP BMWG code identifies datasets originally compiled by the SEAMAP Bottom Mapping Working Group (BMWG).

Source Name	Points (n)	Type	SEAMAP BMWG Code	Reference
USGS/NOAA CoWCoG-Yale University Peabody Museum Collection	4	sampling and historic literature review	---	Yale University Peabody Museum Collection, Yale Invertebrate Zoology—Online Catalog (http://peabody.research.yale.edu/COLLECTIONS/iz/). In Scanlon, K.M., Waller, R.G., Sirotek, A.R., Knisel, J.M., O'Malley, J.J., and Alesandrini, Stian, 2010, USGS cold-water coral geographic database—Gulf of Mexico and western North Atlantic Ocean, version 1.0: U.S. Geological Survey Open-File Report 2008–1351, CD-ROM. (Also available at http://pubs.usgs.gov/of/2008/1351/).
usSEABED ATL PRS - (AMCOR):USGS OFR 76-844	1 of 4 points retained	Surficial sediment data from grabs and cores with a Folk code of "H" and a Shepard code of "solid"	---	US Geological Survey, Coastal and Marine Geology Program. 2005. USGS usSEABED - Offshore Surficial Sediments - parsed and extracted data - hardbottom occurrences. http://pubs.usgs.gov/ds/2005/118/
usSEABED ATL PRS - Smithsonian Institute	1 of 19 points retained	Surficial sediment data from grabs and cores with a Folk code of "H" and a Shepard code of "solid"	---	US Geological Survey, Coastal and Marine Geology Program. 2005. USGS usSEABED - Offshore Surficial Sediments - parsed and extracted data - hardbottom occurrences. http://pubs.usgs.gov/ds/2005/118/

Table A2.3 continued. Source information for the points (n=17,070) that were used in the hard bottom analysis. A SEAMAP BMWG code identifies datasets originally compiled by the SEAMAP Bottom Mapping Working Group (BMWG).

Source Name	Points (n)	Type	SEAMAP BMWG Code	Reference
usSEABED ATL PRS - USGS/WHOI CONMAR 2	7 of 20 points retained	Surficial sediment data from grabs and cores with a Folk code of "H" and a Shepard code of "solid"	---	US Geological Survey, Coastal and Marine Geology Program. 2005. USGS usSEABED - Offshore Surficial Sediments - parsed and extracted data - hardbottom occurrences. http://pubs.usgs.gov/ds/2005/118/
usSEABED GMX PRS - USGS/WHOI CONMAR	2 of 3 points retained	Surficial sediment data from grabs and cores with a Folk code of "H" and a Shepard code of "solid"	---	US Geological Survey, Coastal and Marine Geology Program. 2005. USGS usSEABED - Offshore Surficial Sediments - parsed and extracted data - hardbottom occurrences. http://pubs.usgs.gov/ds/2005/118/
MARMAP Chevron Trap Survey, 1990-2013	7885	Trap locations	---	Marcel Reichert, 2009, MARMAP Chevron Trap Survey 1990-2013, SCDNR/NOAA MARMAP Program, SCDNR MARMAP Aggregate Data Surveys, The Marine Resources Monitoring, Assessment, and Prediction (MARMAP) Program, Marine Resources Research Institute, South Carolina Department of Natural Resources, P. O. Box 12559, Charleston SC 29422-2559, U.S.A.
Watling & Auster 2005-1998. Yankee otter trawl,6.iii.#36	1	hb coral specimens	---	Watling, L., and Auster, P. J., 2005, Distribution of deepwater Alcyonacea off the northeast coast of the United States
Watling & Auster 2005 - 1996. Bottom Trawl,9.iii.	1	hb coral specimens	---	Watling, L., and Auster, P. J., 2005, Distribution of deepwater Alcyonacea off the northeast coast of the United States

Table A2.3 continued. Source information for the points (n=17,070) that were used in the hard bottom analysis. A SEAMAP BMWG code identifies datasets originally compiled by the SEAMAP Bottom Mapping Working Group (BMWG).

Source Name	Points (n)	Type	SEAMAP BMWG Code	Reference
Watling & Auster 2005 - #BLM AA551-CT8-49 (Historical Alvin Dives)	10	hb coral specimens	---	Watling, L., and Auster, P. J., 2005, Distribution of deepwater Alcyonacea off the northeast coast of the United States

APPENDIX

3

NON-TARGET MARINE MAMMAL SPECIES IN STUDY AREA

In addition to the target species included in this analysis, a variety of additional marine mammal species are known to occur in the SABMA region based on the Navy MRA report (Department of the Navy 2008), stranding records (Virginia Aquarium Stranding Response Program 2009; Halpin et al. 2009; NOAA 2014) and other opportunistic observations (Dietrich 2013). These species were not were included in the assessment due to lack of or extremely limited availability of effort-corrected sightings information. The other marine mammals species occurring in the SABMA region include, but are not necessarily limited to:

- Blue Whale (*Balaenoptera musculus)*
- Bryde's whale (*Balaenoptera brydei*)
- Minke whale (*Balaenoptera acutorostrata*)
- Sei whale (*Balaenoptera borealis*)
- Atlantic white-sided dolphin *(Lagenorhynchus acutus),*
- False killer whale *(Pseudorca crassidens)*
- Pygmy Sperm Whale *(Kogia breviceps)*
- Dwarf Sperm Whale *(Kogia sima)*
- Frasers dolphin *(Lagenodelphis hosei)*
- Harbor porpoise *(Phocoena phocoena)*
- Melon-headed whale *(Peponocephala electra)*
- Rough-toothed dolphin *(Steno bredanensis)*
- Killer whale (*Orcinas orca*)
- Pygmy Killer Whale *(Feresa attenuata)*

- Harbor seal (*Phoca vitulina*)
- Atlantic grey seal (*Halichoerus grypus*)
- Harp seal (*Pagophilus groenlandicus*)
- Hooded seal (*Cystophora cristatata*)
- Bearded seal (*Erignathus barbatus*)

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APPENDIX

4

SPECIES/GROUP ACCOUNTS (ALPHABETICALLY)

Marine Mammals

Beaked Whale Group (Family Ziphiidae)

Beaked whales form a large family (Ziphiidae) of 21 species whose distributions and life histories are poorly known because of their cryptic, skittish behavior, low profile, and small, inconspicuous blow at the surface (Waring et al. 2013). Only 350 – 600 beaked whales of various species are thought to inhabit western North Atlantic waters off the U.S. (Waring et al. 2013). Whales within this group are thought to be some of the deepest and longest diving mammals known (Baird et al. 2006). An analysis of shipboard sightings data found that these whales concentrate at the shelf edge (Waring et al. 2001). Several species of beaked whale are present in the study area including Cuvier's (*Ziphius cavirostris*), northern bottlenose whale (*Hyperoodon ampullatus*), Blainville's beaked whale (*Mesoplodon densirostris*), Gervais' beaked whale (*Mesoplodon europaeus*), True's beaked whale (*Mesoplodon mirus*) and Sowerby's beaked whale (*Mesoplodon bidens*) (Shirhai and Jarret 2006; Jefferson et al. 2008; Waring et al. 2013; Swingle 2014). Brief descriptions of these species are provided below.

Cuvier's beaked whale (Ziphius cavirostris) is one of the more familiar species in this group. They are found in temperate, subtropical, tropical and occasionally boreal areas in deep waters (>200 m). They have been observed mostly over and near the Continental Slope, especially in areas with a steep sea floor (Waring et al. 2013).These whales feed near the bottom and in the water column and are known to eat deep-sea squid, fish and crustaceans (Santos et al. 2001). Cuvier's beaked whale has mostly been observed in small groups (2-7 individuals), but is sometimes seen alone (Shirhai and Jarret 2006).

The **northern bottlenose whale (Hyperoodon ampullatus)** is found only in the North Atlantic. In the western North Atlantic it is found from the southern tip of Greenland to New England, but strandings have occurred as far south as North Carolina. The northern bottlenose whale prefers deep waters (>500 m) beyond the Continental Shelf near submarine canyons (Shirhai and Jarret 2006). Hooker and Baird (1999) observed these whales diving in a submarine canyon off Nova Scotia approximately every 80 min to over 800 m (maximum 1453 m) for up to 70 min in duration and hypothesized that they may make greater use of deep portions of the water column than any other marine mammal so far studied. The northern bottlenose whale is known to feed on deep-sea squid (Bloch et al. 1996; Lick and Piatkowski 1998). These whales are typically seen in groups of four but sometimes groups contain as many as 20 individuals. Some evidence suggests that some geographic groups of these whales may migrate (Bloch et al. 1996; Shirhai and Jarret 2006).

Blainville's beaked whale (Mesoplodon densirostris) occurs in warm temperate, subtropical and tropical oceanic waters worldwide with the exception of the Mediterranean, and has been recorded along the eastern coast of the United States (Mead 1989; MacLeod et al. 2006). These whales are typically found in deep (200-1000 m), offshore waters of the Continental Shelf/Slope often near banks, canyons and seamounts (Reeves et al. 2002; Jefferson et al. 2008). In the Northern Bahamas, the whales appeared to prefer ocean habitat within distinct aspect, gradient and depth ranges (gradients ranging from 68 to 296 m/km, depths ranging from 136 to 1,319 m and most northeast facing compared with 0-526 m/km, 10-3,000 m and all aspects for the whole study area) most likely due to prey distribution (MacLeod and Zuur 2005). Blainville’s beaked whales weigh 1,800-2,300 lbs (820-1,030 kg) with lengths ranging from 15-20ft (4.5 -6 m). They reach sexual maturity at about 9 years of age and are typically found alone or in pairs, but are also found in small groups of about 3-7 (Jefferson et al. 2008). These whales are deep divers commonly reaching depths of 1,600-3,300 ft (500-1000 m) and are known to feed on squid and small fish.

The **Gervais' beaked whale (Mesoplodon europaeus)** is endemic to the warm-temperate to tropical Atlantic Ocean (MacLeod et al. 2006). They are not known to migrate seasonally. This whale weighs approximately 2,640 lbs (1200 kg) or more and can reach lengths of about 15-17 ft (4.6-5.2 m; NOAA 2014a). Gervais' beaked whales are usually found individually or in small closely associated social groups (Reeves et al. 2002; Shirhai and Jarret 2006; Jefferson et al. 2008).

Bottlenose Dolphin (*Tursiops truncatus*)

Bottlenose dolphins utilize a wide variety of coastal, inshore, and pelagic habitats in tropical and temperate waters of the world (Wells and Scott 1999). This species has been documented along the entire western Atlantic coast, and in the eastern Atlantic, including the Azores, the British Isles, the Faroe Islands, the Baltic Sea, and the Mediterranean and Black Seas. Bottlenose dolphin ranges are restricted by temperature: they occur in North American waters of about 10 °C to 32°Cand are rarely seen poleward of 45° in either hemisphere (Wells and Scott 2002). Bottlenose dolphins are the most commonly encountered cetacean in the study area and can be found offshore, nearshore (alongshore) and inshore (within bays, lagoons, sounds, tidal marshes and estuarine waters).

Two morphologically and genetically distinct bottlenose dolphin morphotypes are found in the Northwest Atlantic Ocean (Duffield et al. 1983; Duffield 1986): the coastal and offshore forms. The offshore form is found primarily along the outer Continental Shelf and Continental Slope but is found relatively close to shore over the Continental Shelf south of Cape Hatteras, NC (Torres et al. 2005). The coastal form has been differentiated into a number of coastal populations based on genetic analyses, which are managed as separate stocks by NMFS. The separate coastal stocks managed by NMFS in the study area include the following: Biscayne Bay, Charleston Estuarine System, Florida Bay, Indian River Lagoon Estuarine System, Jacksonville Estuarine System, Northern Georgia/Southern South Carolina Estuarine System, Northern North Carolina Estuarine System, Southern Georgia Estuarine System, Southern North Carolina Estuarine System, Western North (W.N.) Atlantic Central Florida Coastal, W.N. Atlantic, Northern Florida Coastal, W.N. Atlantic South Carolina-Georgia Coastal, W.N. Atlantic Southern Migratory Coastal and W.N. Atlantic Northern Migratory Coastal. A genetic analysis of bottlenose dolphin along the U.S. Atlantic coast (Hoelzel et al. 1998 found strong genetic differentiation between bottlenose dolphin from coastal and ocean areas. While some inshore bottlenose dolphin populations have been found to reside in their inshore habitat year round, in some areas such as Charleston Harbor, bottlenose dolphins are year round residents, seasonal migrants and transients that move through the area (Zolman 2002; Speakman et al. 2010).

Bottlenose dolphins tend to feed cooperatively and are commonly found exhibiting gregarious behavior (Caldwell and Caldwell 1972). Females can live more than 50 years and males from 40 to 45 years old (Wells and Scott 1999). Female bottlenose dolphins usually produce calves every three to six years. Breeding whales in captivity are over 20 years of age and females can continue to give birth up to 48 years of age. Spring and summer or spring and autumn calving peaks are known for most populations. Calving occurs after a one-year gestation, peaking in the warmer months. Calves are born at 84-140 cm (33-55 inches) depending on the region and grow rapidly during their first 1.5-2 years. Females often reach sexual maturity before males. Age at sexual maturity is about 5-13 years for females and 9-14 years for males (Wells and Scott 2002).

Florida Manatee (Trichechus manatus latirostris)

The Florida manatee (*Trichechus manatus latirostris*) is one of two subspecies of the West Indian manatee (*T. manatus*) (Haubold et al. 2006). They are found in warm-water areas in winter and areas associated with freshwater in the remaining three seasons (Hartman 1979; Shane 1984; Rathbun et al. 1990; O'Shea and Hartley 1995; Reynolds 1999). Fossil evidence of the Florida manatee's presence in its namesake state dates back 2-3 million years (McDonald and Flamm 2006). The population of this subspecies is approximately 4,800 (FWC, FWRI 2014a) and it is found primarily in marine, estuarine, and fresh waters of Florida but regularly occurs in some other southeastern states.

Most manatees migrate seasonally, dispersing from their winter warm water refugia in the spring throughout tidally connected waters in Florida and southern Georgia and beyond (McDonald et al. 2006). Deutsch et al. (1998) and others found that manatees are capable of traveling long distances: the median one-way distance of migrating Florida manatees was calculated in one study to be 230 km with a maximum of 830 km; however, one adult male traveled approximately 2,300 km from Florida to Rhode Island (Deutsch et al. 2003). Approximately 12% of manatees were observed to remain in a relatively small area (<50 km^2) year round (Deutsch et al. 2003).

Manatees are mostly solitary animals, but will aggregate in areas with critical resources, such as warm water, fresh water, low disturbance, and food (McDonald et al. 2006). These herbivorous animals feed on a variety of marine, freshwater, and terrestrial plants (marine and freshwater submerged and emergent aquatic vegetation including shoalgrass (*Halodule wrightii*), manateegrass (*Syringodium filiforme*), turtlegrass (*Thalassia testudinum*), tapegrass (*Vallisneria americana*), and widgeongrass (*Ruppia maritima*) (Hartman 1979; Packard 1981; Bengtson 1981, 1983; Ledder 1986; Lefebvre and Powell 1990; Smith 1993; Lefebvre et al. 2000 as reported in McDonald and Flamm 2006)). In saltwater systems, manatees showed a preference for shoalgrass (Ledder 1986; Lefebvre and Powell 1990; Lefebvre et al. 2000). In freshwater, manatees were observed to prefer young tapegrass (Hartman 1979).

Florida manatees reach lengths of up to 4 m (13 ft) but average approximately 3 m (10 ft) Average adult weights range from about 363 to 544 kg (800 to 200 lb); adult females are generally larger than adult males (Seaworld 2014). The Florida manatee is known to live up to approximately 60 years of age in the wild (Marmontel et al. 1997). Female manatees first give birth between the ages of 4 and 7 with a median age of about 5 years old (Marmontel 1995; O'Shea and Hartley 1995; Rathbun et al. 1995). On average, one calf is born every 2.5 - 3 years with twins being rare (Marmontel 1995; Odell et al. 1995; O'Shea and Hartley 1995; Rathbun et al. 1995; Reid et al. 1995).

Fin Whale (Balaenoptera physalus)

Fin whales are found in all oceans of the world, but do not range past the ice limit at either pole (Aguilar 2002). They are less common in the tropics (Waring et al. 2013). The fin whale is the most common large whale from Cape Hatteras northward, accounting for 46% of all large whale sightings and 24% of all cetaceans sighted over the Continental Shelf between Cape Hatteras and Nova Scotia during 1978 - 1982 aerial surveys (CeTAP 1982).

Fin whale movement usually occurs offshore rather than along the coastline which makes it difficult to track migration patterns (Mackintosh 1965; Perry et al. 1999). Consequently, little is known about the location of winter breeding grounds (Perry et al. 1999).There is some evidence that fin whales migrate to subtropical waters for mating and calving during the winter months and to the colder areas of the Arctic and Antarctic for feeding during the summer months. Some observations suggest site fidelity and seasonal residency by females. Often, individual whales are sighted on the same feeding grounds year after year (Seipt et al. 1990; Clapham and Seipt 1991; Agler et al. 1993). The Navy's SOSUS program found a substantial deep-ocean presence of fin whales (Clark 1995) and it is likely that western North Atlantic fin whales undergo seasonal movements into Canadian waters, open-ocean areas, and perhaps even subtropical or tropical regions but there is no evidence of a regular seasonal migration as with some other baleen whales (Watkins et al. 2000). Fin whales may be solitary or found small groups, however larger groups may be found near feeding grounds (Gambell 1985).

The fin whale is the second largest animal on Earth (after the blue whale); adult whales are known to range from 20 to 27 m (66 to 89 ft) in length and weigh 45,000-63,000 kg (50 -70 tons). Mature females are approximately 5-10% longer than mature males (Aguilar and Lockyer 1987). Adult males reach sexual maturity at about 5-15 years of age and, as in some other whale species, sexual maturity is reached before physical maturity. Mating occurs in the northern hemisphere from December to February, gestation lasts 11 months, and newborn calves are 6-7m (19.7-23 ft) long and weigh about 900-1,360 kg (1-1.5 tons) (Aguilar 2002). Calves nurse for six months and are weaned when they are 10-12 m (33-39 ft) in length. Fin whales grow rapidly after birth and reach 95% of their maximum body size when they are 9-13 years old. Physical maturity is reached at about 25 years of age and fin whales are known to live up to 80-90 years (Aguilar 2002). The reproductive strategy of fin whales is closely integrated and synchronized with their annual feeding cycle; whales mate during the winter and weaning ends the following summer on productive feeding grounds (Laws 1961).

Humpback Whale (Megaptera novaeangliae)

Humpback whales inhabit all major ocean basins from the equator to subpolar latitudes (Clapham 2002). Most humpback whales are known to spend the summer feeding in northern waters and migrate south to low-latitude tropical waters for the winter where they breed and calve. In the North Atlantic Ocean, humpback whales aggregate in several feeding areas: Iceland-Denmark Strait, Norway, western Greenland, Southern Labrador and east of Newfoundland, Gulf of St. Lawrence, and the Gulf of Maine/Nova Scotia region (Katona and Beard 1990; Stevick et al. 2006). Individual humpback whales maintain fidelity to a specific oceanic feeding ground, a preference that is transmitted from mother to offspring (Martin et al. 1984; Clapham and Mayo 1987). Genetic analyses have found the Gulf of Maine stock to be a discrete subpopulation with little to no mixing with other North Atlantic stocks over thousands of years (Palsbøll et al. 2001) and is managed as a discrete stock (Waring et al. 2012).

During the winter, whales from most North Atlantic feeding areas (including the Gulf of Maine) travel to the West Indies to mate and calve (Katona and Beard 1990; Clapham et al. 1993; Palsbøll et al. 1997; Stevick et al. 1998). In the winter months, habitat requirements appear to be tied to calving needs rather than prey resources. Optimal calving conditions are warm waters and shallow, flat ocean bottoms in protected areas and calm seas often close to islands or coral reefs (Clapham 2002). Recent research suggests that a relatively narrow water temperature range (21.1–28.3°C) is more important than latitude per se in the location of oceanic breeding grounds (Rasmussen et al. 2007). The primary breeding range in the North Atlantic is along the Atlantic margin of the Antilles, from Cuba to Venezuela. Calving takes place there between January and March. Individual females produce a calf every 2–3 years on average with only approximately 2% of observed calving events in consecutive years (Clapham and Mayo 1987; Clapham and Mayo 1990; Robbins 2007).

Humpback whales seen sporadically off the mid-Atlantic and southeast United States in winter are a mixed stock of those that summer in the Northwest Atlantic and those from other oceanic feeding grounds (Barco et al. 2002). This is apparently a supplemental feeding area for young whales, but the factors that drive their presence and distribution are poorly understood. During spring, summer, and fall, humpback whales can be found from the waters off Nantucket north to the Bay of Fundy and east to the edge of the Continental Shelf (Clapham et al. 2003). Humpback whale distribution across the northern study range depends on physical factors such as bottom depth and slope (CeTAP 1982; Hamazaki 2002) as well as the abundance and distribution of herring and sand lance (Payne et al. 1986; Payne et al. 1990; Weinrich et al. 1997). Previous work has shown significant spatial variation by season, with the greatest concentrations occurring in the spring in the southern Gulf of Maine. There is also significant temporal variation correlated with trends in prey abundance (Payne et al. 1986; Payne et al. 1990; Weinrich et al. 1997). On an individual level, humpback whales are known to return preferentially to some areas within their feeding range (Weinrich 1998; Larsen and Hammond 2004; Robbins 2007). However, they also move among available feeding sites within and between years.

Adult humpback whales are 14-17 m (46-56 ft) in length and females are 1-1.5 m (3.3-4.9 ft) longer than males (Clapham and Mead 1999). Age at first birth was estimated to average 5 years in the 1980s (Clapham 1992), but has subsequently increased to over 8 years of age (Robbins 2007). Gestation is about 11 months and lactation is about one year (Clapham 1992). Calves are from 4.0 to 4.6 m (13-15 ft) at birth and 8-10 m after their first year (Clapham 2002). Trends in offspring survival after weaning have been linked to trends in the relative abundance of primary prey (Robbins 2007; Weinrich and Corbelli 2009).

Ocean Dolphins (Stenella attenuate and S. frontalis)

The **pantropical spotted dolphin** (PSD) is found worldwide in tropical and some sub-tropical oceans (Perrin et al. 1987; Perrin and Hohn 1994). Until 1987, it was thought that all spotted dolphin occurring in the Atlantic were one species, but a comprehensive morphological analysis found them to be two, the Atlantic spotted dolphin, *Stenella frontalis*, and the PSD, *S. attenuata* (Perrin et al.1987). Where they co-occur, the Atlantic spotted dolphin and the PSD can be difficult to differentiate at sea. PSD are found in the North Atlantic as well as the Gulf of Mexico and investigations are underway to determine whether these populations should be considered separate stocks.

PSDs are typically found within 160 m (100 miles) of the coast. They spend most of their day in shallower water, typically 90 to 300 m (300 - 1,000 feet), going into deeper waters to search for prey (NMFS 2007). Specific migratory patterns have yet to be described for the PSD; however, they seem to be present in inshore waters in the fall and winter months and offshore waters in the spring (Waring et al. 2008). During winter aerial surveys, PSD were observed offshore of the southeastern U.S. Atlantic coast (SEFSC unpublished data as reported in Waring et al. 2008). North of Cape Hatteras, sightings have been concentrated in the slope waters. South of Cape Hatteras sightings extend into the deeper slope and offshore waters of the mid-Atlantic (Waring et al. 2008). They feed primarily on mesopelagic cephalopods and fishes.

PSDs are a social and gregarious species often occurring in large groups of several hundred to one thousand animals and with other dolphin species, such as spinner dolphins. PSD reach maturity at approximately 11 years of age and live a maximum of 46 years. They are relatively small, reaching lengths of 2 m (6 to 7 ft). PSD weigh approximately 114 kg (250 pounds) at adulthood (NOAA 2014a). They breed and calve year-round. Gestation lasts approximately eleven months. Calving intervals vary by population, but ranges from 2.5 to 4 years.

The **Atlantic spotted dolphin** (*S. frontalis*) is endemic to the Atlantic Ocean. Common in the western North Atlantic, it is found from northern New England to Florida, and in the Gulf of Mexico and the Caribbean as far south as the coast of Venezuela. Within this range, two distinct morphotypes are present: a larger, heavily spotted form found in Continental Shelf waters and a smaller, less spotted form found in pelagic waters, the Caribbean, and around oceanic islands (Perrin et al. 1987; Adams and Rosel 2006). A genetic analysis of Western North Atlantic and Gulf of Mexico individuals by Adams and Rosel (2006) found significant genetic differentiation among Mid-Atlantic Bight, South Atlantic Bight, and Gulf of Mexico populations. The point of demarcation between the Mid- and South Atlantic Bight populations appears to occur at about 35°N latitude (near Cape Hatteras, North Carolina). Although this species is common in the Gulf of Mexico and Northwest Atlantic, little is known of its life history, migratory patterns or population dynamics (Adams and Rosel 2006). The population in the western North Atlantic has been estimated at 36,000-51,000 animals (Waring et al. 2013).

Atlantic spotted dolphins are typically found in moderately sized groups of fewer than 50 individuals, but have sometimes been observed in much larger groups of approximately 200 animals. Inshore/coastal pods are smaller, typically 5-15 animals. This dolphin species has sometimes been seen in association with other cetacean species such as bottlenose dolphins (Shirihai and Jarrett 2006; Jefferson et al. 2008). Atlantic spotted dolphins feed on small fish, benthic invertebrates, and cephalopods (e.g., squid and octopus) and have been seen coordinating their movements to feed cooperatively. Another feeding strategy that has been observed is digging their rostrums into sandy substrates to capture buried fish (Shirihai and Jarrett 2006; Jefferson et al. 2008). Atlantic spotted dolphins are about 1.6-2.3 m (5-7.5 ft) long and weigh 100-143 kg (220-315 lbs; NOAA 2014a). They reach sexual maturity between 8 and 15 years and females bear a single calf every 1-5 years (3 years on average; Herzig 2006).

Long-finned (*Globicephala melas melas)* and Short-finned (*G. macrorhynchus*) Pilot Whales

The two species of pilot whale that inhabit the western North Atlantic, the long-finned and short-finned pilot whale, are difficult to distinguish at sea and so assessment of the individual stocks is limited. The long-finned pilot whale (LFPW) is found in temperate portions the North Atlantic Ocean, the Mediterranean Sea and sub-polar waters near

Iceland, Greenland and the Barents Sea (Sergeant 1962; Leatherwood et al. 1976; Abend 1993; Buckland et al. 1993; Abend and Smith 1999).

In the western North Atlantic, both pilot whales are found primarily along the Continental Shelf edge off the northeastern U.S. coast from North Carolina to Maine in winter and early spring (CeTAP 1982; Payne and Heinemann 1993; Abend and Smith 1999; Hamazaki 2002). In late spring, pilot whales move onto Georges Bank and into the Gulf of Maine and more northern waters and remain through late fall (CeTAP 1982; Payne and Heinemann 1993). Pilot whales seem to associate with areas of high relief or submerged banks as well as the Gulf Stream wall and thermal fronts along the Continental Shelf edge (Waring et al. 1992; NMFS unpublished data as reported in Waring et al. 2012). Between Cape Hatteras, North Carolina, and New Jersey the two species of pilot whales overlap spatially along the mid-Atlantic shelf break (Payne and Heinemann 1993; Garrison et al. in prep. as reported in NMFS 2011).

LFPWs associate in cohesive pods and sub-groups of usually 10-20 individuals, but have been reported in loose aggregations of several hundred or even up to a thousand animals (Ottensmeyer and Whitehead 2003; Waring et al. 2012). Genetic analysis has revealed that these established pods are maternally-based (Amos et al. 1993). They dive to depths of 1,018 m (3,340 ft) or more for 10 - 21 minutes (Soto et al. 2008; Waring et al. 2012). LFPWs feed primarily on long-finned squid (*Loligo pealei*) with fish being relatively unimportant in the diet (Gannon et al. 1997b). LFPWs are one of the largest members of the dolphin family with males reaching lengths of about 7.6 m (25 ft) and females reaching up to 5.8 m (19 ft). Males weigh as much as 2,300 kg (5,000 lbs), while females weigh up to 1,300 kg (2,900 lbs) (NOAA 2014a). Male LFPWs live 35-45 years, while females may live 60 years or more. North Atlantic LFPWs typically breed and mate from April to September. Females have a single calf every 3-6 years, one of the longest known birth intervals for cetaceans (NOAA 2014a).

The short-finned pilot whale (SFPW) occurs in warm temperate and tropical waters of the Pacific and the Atlantic including the Gulf of Mexico and the Caribbean (Kasuya and Marsh 1984; Hansen et al. 1996; Mullin and Hoggard 2000; Mullin and Fulling 2003). In the western North Atlantic, sightings of the SFPW occur most frequently along the shelf break between the 200- and 1000-m isobaths from Florida north to the Nova Scotian Shelf with highest densities found between Cape Hatteras, North Carolina and New Jersey and along the southern flank of Georges Bank (Payne and Heinemann, 1993; Mullin and Fulling, 2003; Waring et al. 2006). The population in the western North Atlantic has been estimated at 31,100 individuals, but this figure includes long-finned pilot whales (Waring et al. 2012).

The SFPW is a pelagic predator that feeds primarily on squid at water depths of up to 3,340 feet (1,018 m; Overholtz and Waring, 1991; Gannon et al. 1997a; Kruse et al.

1999, Soto et al. 2008). Longfin and shortfin squids are the most prevalent species eaten and both concentrate near the shelf-slope convergence zone during summer and fall (Brodziak and Hendrickson 1999). Day and night foraging dives have been recorded with durations up to 21 min (Soto et al. 2008). Female SFPWs reach average lengths of approximately 3.7 m (12 feet) and males reach average lengths of 5.5 m (18 feet). Maximum recorded length in a male was 7.3 m (24 feet) (Waring et al. 2012). Adults weigh between 1,000 and 3,000 kg (2,200 and 6,600 pounds).

North Atlantic Right Whale (*Eubalaena glacialis*)

North Atlantic right whales historically ranged from Florida and northwestern Africa to Labrador, southern Greenland, Iceland, and Norway (see complete review in Kraus and Rolland 2007). Currently, this species is found in the Northwest Atlantic in Continental Shelf waters between Florida and Nova Scotia (Winn et al. 1986) in six known habitats: the coastal waters of the southeastern United States; the Great South Channel; Georges Bank/Gulf of Maine; Cape Cod and Massachusetts Bays; the Bay of Fundy; and the Scotian Shelf (Waring et al. 2008). The southeastern United States off Georgia and Florida, Great South Channel, and Cape Cod Bay are explicitly defined as critical habitat under the Endangered Species Act.

North Atlantic right whales move seasonally (Kraus and Rolland 2007). In the spring, feeding aggregations are found in the Gulf of Maine, Cape Cod Bay and Bay of Fundy (Kenney and Winn 1986; Kenney et al. 1995). These feeding grounds are areas where bottom topography, water column structure, currents, and tides combine to concentrate zooplankton (Wishner et al. 1988; Baumgartner et al. 2003). Historical whaling records include accounts of whales taken in areas other than current feeding grounds, indicating that there may have been offshore feeding grounds that are unknown today (Kenney 2002). During the winter, many mature females are found in coastal waters off Georgia and northern Florida, where they are known to give birth (Winn et al. 1986; Kenney 2002). However, the geographic location of most of the population, including adult males and juveniles, during the winter months is poorly known. Recent passive acoustic monitoring efforts in the Stellwagen Bank National Marine Sanctuary and Jeffreys Ledge in the Gulf of Maine indicate that right whales are predictably present in both areas during the winter months (Mussoline et al. 2012).

Right whale calving takes place between December and April in the North Atlantic (Kraus and Rolland 2007). Calving grounds along the southern U.S. coast are in cool, shallow coastal regions inshore off Georgia and northeastern Florida (Kraus et al. 1993; Kraus and Rolland 2007). Although the average age of first calving is nine to ten years, calving has been observed in females as young as five years old (Kenney 2002). Calving occurs at three- to five-year intervals, which may be so that the mother can replenish energy stores lost in long migrations and calving (Kraus et al. 2001; Kenney 2002). Right whale calves are usually born after 12-13 months of gestation at 4.5–6.0 m (14.8-19.7 ft) in length (Best 1994; Kenney 2002).

Right whale calves weigh approximately 900 kg (1 ton) at birth, and they grow more than a centimeter every day for the first ten months of their lives. Mothers and calves form a strong bond and the calf spends most of its time swimming close to its mother, often carried in the mother's "slip stream," the wake which develops as the mother swims (Hamilton and Marx 1995). Calves reach 9-11 m (29.5-36.1 ft) in length and are weaned at one year. After year one, growth rates vary depending on the population and feeding success (Kenney 2002). Because of an absence of teeth (which can be used to estimate age in other mammals), it is difficult to tell how old right whales are when they die, but it is estimated that they live up to 70 years and perhaps even more (Kenney 2002).

Risso's Dolphin (*Grampus griseus*)

Risso's dolphins are found in temperate, subtropical and tropical waters throughout the world from latitudes 60°N to 60°S, most commonly in waters of 15-20°C (59-68°F), and may be limited by water temperature. They are typically found in deep waters in excess of 1,000 m (3,300 ft) seaward of the Continental Shelf and slope, however, in some locations outside of the study area they are found in shallow coastal waters (Waring et al. 2013). In the western North Atlantic, Risso's dolphins are found from Florida to southern New England, but are most often observed from New Jersey to southern New England (Waring et al. 2006).

Little or nothing is known of their migration patterns or movements, but they may be affected by movements of spawning squid and oceanographic conditions (Waring et al. 2013). They have been reported as solitary individuals, pairs, or in loose aggregations in the hundreds or thousands, but groups typically average between 10 and 30 animals This species has been observed associating with other species of dolphins and whales including bottlenose dolphins, gray whales, northern right whale dolphins, and Pacific white-sided dolphins (Waring et al. 2013).

Risso's dolphins can dive to 300 m (1,000 feet) or more and hold their breath for up to 30 minutes, but typical dives are shorter, usually 1-2 minutes. They feed primarily on squid, but also eat fish, krill, and other cephalopods (e.g., octopus and cuttlefish). The mainly feed at night when their prey is closer to the surface and they have been observed moving into Continental Shelf waters to follow their preferred prey.

Risso's dolphins are a medium-sized cetacean that reaches lengths of approximately 2.6-4 m (8.5-13 feet) and weights of approximately 300-500 kg (660-1,100 pounds).

They become sexually mature at about 2.6-2.8 m (8.5-9 ft; NOAA 2014a). Breeding and calving are thought to occur year-round and gestation lasts approximately 13-14 months. Lifespan has been estimated at 35 years or more and the western North Atlantic stock is thought to number 13,000-20,500 animals (Waring et al.2013).

Short-Beaked Common Dolphin (*Delphinus delphis delphis*)

Prior to 2008, confusion of various species of common dolphin (*Delphinus* spp.) with *Stenella* spp. led to misidentification and inaccurate assumptions regarding species distribution. Subsequent studies have shown that the common dolphin (genus *Delphinus*) is in fact two species (Heyning and Perrin 1994) and that the short-beaked common dolphin (SBCD) is not as widely distributed as once thought. The SBCD (formerly the common dolphin) appears to be present in only two areas in the western Atlantic: off the U.S./Canada East Coast off Newfoundland south to approximately the Georgia/South Carolina border and off the east coast of South America from the South Brazil Bight south to northern Argentina and perhaps beyond (Jefferson et al. 2009). In the western North Atlantic, while less common south of Cape Hatteras, schools of SBCD have been observed as far south as the east coast of Florida (Gaskin 1992). Genetic analyses of North Atlantic stocks have found that the western North Atlantic population is comprised of a single stock that is genetically isolated from the SBCD population in the eastern North Atlantic (Westgate 2005; 2007). Selzer and Payne (1988) reported that SBCD were more commonly seen in areas with high benthic diversity and appear to favor Continental Slope and Gulf Stream features (Waring et al. 2013) at depths of 100 - 2000 m (328-6,560 ft) Doksaeter et al. 2008; Waring et al. 2008). Seasonal movements have been observed in the western North Atlantic: from mid-January to May, SBCD can be found from Cape Hatteras northeast to Georges Bank; they then migrate north from mid-summer to fall to Georges Bank and the Scotian Shelf (Hain et al. 1981; CeTAP 1982; Payne et al. 1984).

SBCD are usually found in large social groups averaging hundreds of individuals, but have occasionally been seen in larger groups of up to 10,000 (Seltzer and Payne 1988; NOAA 2014a). Adults reach approximately 2.7 m (9 ft) in length and weigh approximately 200 kg (440 lbs, NOAA 2014a). SBCD become sexually mature at about 8.3 years for females and 9.5 years for males (Westgate 2005; Westgate and Read 2007), and females give birth every 2-3 years.

Sperm Whale (Physeter macrocephalus)

Sperm whales have the most extensive geographic distribution of any marine mammal besides the killer whale (Orcinus orca). They are found in all deep, ice-free marine waters from the equator to the edges of polar pack ice (Rice 1989). Sperm whales are also known to be present in some warm-water areas; these might be discrete resident populations (Jaquet et al. 2003; Mellinger et al. 2004). Sperm whales exhibit sex-specific migratory behavior. Only adult males move into high latitudes, while all age classes and both sexes range throughout tropical and temperate seas (Whitehead 2002b). There is some evidence of north-south migration, as whales move towards the poles in the summer months, but in many areas of the world sperm whale migration patterns remain unknown (Whitehead 2002a). Offshore surveys have shown that sperm whales are often solitary and can stay submerged for over 60 minutes at recorded depths of over 2,000 m (6,560 ft; Watkins et al. 1993), which makes them difficult to spot by surveyors.

Sperm whale distribution on the East Coast of the United States is centered along the Continental Shelf break and over the Continental Slope from 100 to 2,000 m depth and in submarine canyons and edges of banks (CeTAP 1982; Waring et al. 2008; Mitchell 1975). Sperm whales are also known to move into waters less than 100 m (328 ft) deep on the southern Scotian Shelf and south of New England, particularly between late spring and autumn (CeTAP 1982; Scott and Sadove 1997). Those areas with historically large numbers of sperm whales and resident populations often coincide with areas of high primary productivity from upwelling (Whitehead 2002b). In addition, sperm whale habitats usually have high levels of deep water biomass. Female sperm whales may be restricted by water temperature, as they have only been sighted in areas with sea surface temperatures greater than 15°C (59°F).

Sperm whale life span can be greater than 60 years (Rice 1989). Adult female sperm whales reach up to 11 m (36 ft) in length and 13,600 kg (15 tons), while males are much larger at 16 m (52 ft) and 40,800 kg (45 tons; Whitehead 2002b). Sperm whales have low birth rates, slow growth and maturation, and high survival rates. Although much about sperm whale breeding is unknown, it is thought that the peak breeding season in the North Atlantic occurs during spring (March/April to May). Gestation for females is estimated to last 15-18 months and calves average 4 m (13.1 ft) at birth (Perry et al. 1999). Female sperm whales reach physical maturity at 30 years old and 10.6 m (34.8 ft) long. Males continue growing into their thirties and do not reach physical maturity until about 50 years old. Males reach sexual maturity at 10-20 years of age, but do not appear to breed until their late twenties (Whitehead 2002b). Female sperm whales are inherently social; related and unrelated female sperm whales live in groups of up to a dozen individuals accompanied by their male and female offspring (Christal and Whitehead 1997). Males leave the female groups when they are 4-21 years old, after which they live in “bachelor schools” with other juvenile males (Whitehead 2002b). Male sperm whales in these bachelor schools in their late twenties and older are known to rove among groups of females on tropical breeding grounds.

Sea Turtles

Loggerhead Turtle (*Caretta caretta*)

Loggerhead turtles reach approximately 1 m (3 ft) in length and 113 kg (250 lbs) in weight as adults. They were named for their relatively large heads which support powerful jaws that enable them to eat thick-shelled mollusks such as conch and whelks (NOAA Fisheries 2014b). Loggerheads are distributed globally in temperate and tropical portions of the Indian, Pacific, and Atlantic Oceans. Distribution in the Atlantic Ocean extends from Argentina to Newfoundland while distribution in the eastern Pacific Ocean ranges from Chile to Alaska (Dodd 1988). This species nests on highly energetic, oceanic beaches, primarily along the western rims of the Atlantic and Indian Oceans (Conant et al. 2009). Hatchlings utilize the neritic convergent zones along the Continental Shelf while juveniles occupy oceanic (> 200m or 656 ft) areas. Studies of juvenile turtle movement patterns have shown that this life stage successfully completes transatlantic migrations using major current systems such as the Gulf Stream, North Atlantic Gyre and North Equatorial Current as a means for passive transport (Manzella and Fountains 1988, Eckert and Martins 1989; Bolten et al. 1990; Bolten et al. 1993; Musick and Limpus 1997). This ocean stage and passive migration back to the western North Atlantic might take as much as a decade (Musick and Limpus 1997) but is eventually followed by a transition back to neritic habitats. Adults are considered primarily neritic with occasional use of oceanic habitat. Adults migrate back to neritic habitats off there natal beaches for mating and egg laying (NOAA Fisheries 2014b).

The Florida Atlantic coast represents one of two worldwide loggerhead nesting areas with an excess of 10,000 nests annually. Other globally significant nesting areas within the SAB Region include the Georgia to North Carolina coasts with 1,000 to 9,999 nests annually (Conant et al. 2009). Nest size averages 100 – 130 eggs per clutch (Dodd 1988). After hatching, juveniles move offshore to areas with large concentrations of the floating seaweed Sargassum, driftlines and areas with converging currents (Carr 1986, Witherington 2002). A large concentration of oceanic juveniles of both western and eastern North Atlantic origin has been identified in waters off Newfoundland on the Grand Banks (LaCasella et al. 2005, Bowen et al. 2005), Upon leaving oceanic areas, juvenile loggerheads head to the neritic zone along the U.S. Atlantic and Gulf coasts (Conant et al. 2009). Some of these juvenile turtles can be found in protected estuarine areas such as Pamlico Sound in North Carolina and Indian River Lagoon in Florida (Conant et al. 2009). Adults eventually return to waters off their natal beaches to mate and in the case of the females nest.

Green Sea Turtle (*Chelonia mydas*)

Green turtles are the largest of the hardshell turtles and reach approximately 137 – 159 kg (300 – 350 lbs) in weight and 1 m (3 ft) in length (NOAA Fisheries 2014b). The green turtle is distributed globally in tropical and subtropical waters in association with inshore and neritic waters of 140 countries (Groombridge 1982; NMFS USFWS 1991). Along the Gulf of Mexico and the Atlantic coast the species ranges from Texas to Massachusetts with breeding subpopulations in the State of Florida.

Green turtle hatchlings are pelagic and move into convergence zones for an unknown amount of time (Carr 1986). At about 20 to 25 cm in length, juveniles move to benthic feeding grounds. Important feeding areas along the U.S. Atlantic Coast include the Indian River Lagoon, Florida Bay and the Florida Keys (NMFS USFWS 1991). Adults are both oceanic and neritic, returning to shallow coastal waters for breeding and nesting, which occurs on coastal beaches located between 30° north and south latitude. . While in benthic areas, adults feed primarily on seagrasses and algae. In oceanic areas, adults are not strictly herbivores and fed on benthic invertebrates such as sponges and sea pens as well as pelagic prey including jellyfish (Godley et al. 1998; Heithaus et al. 2002; Seminoff et al. 2002; Hatase et al. 2006; Parker et al. 2011).

Leatherback Turtle (*Dermochelys coriacea*)

The leatherback turtle is the largest of the world's sea turtles with adults reaching up to 900 kg (2,000 lbs) in weight and 2 m (6.4 ft) in length (NOAA Fisheries 2014b). It has no bony carapace as do all other species of sea turtles. Leatherbacks are believed to be the most pelagic of all the sea turtles and their diet consists mainly of jellyfish, siphonophores, and salps (NMFS USFWS 1992). They may dive as deep as 1300 m, but are thought to spend most of their time diving to depths less of less than 200 m (Eckert et al. 1989).

The leatherback is distributed globally in sub-polar, temperate, and tropical portions of the Indian, Pacific, and Atlantic Oceans. Distribution in the western north Atlantic includes the entire eastern United States continental coast from the Gulf of Maine south to Puerto Rico and the Gulf of Mexico. Nesting grounds are circumglobal in distribution from about 38°N to 34°S (Eckert et al. 2012) on high energy, beaches. The world's largest nesting area for leatherback turtles is the Pacific Coast of Mexico (NMFS USFWS 1992). Within the SABMA area, leatherback turtles nest regularly on Florida Atlantic Coast beaches with documented nesting growing from an estimated 11 nests in 1957 to 1600 nests in 2014 (NMFS USFWS 1992; FWC, FWRI 2014b). Rare nesting events have also been reported on U.S. Atlantic Coast beaches north of Florida (NMFS USFWS 2013).

Although little data is available, hatchlings likely occupy oceanic zones in tropical waters while juveniles (<100 cm (39.4 in) CCL) are associated with both oceanic and coastal waters with temperatures above 26° C (78.8°F). Adults are known to migrate long distances, up to 11,000 km from their breeding areas (Benson et al. 2011) utilizing both oceanic and coastal waters. . U.S. Atlantic Coast waters are an important area for leatherback turtles of both U.S. and Caribbean origin (NMFS USFWS 1992). Equatorial waters appear to serve as a barrier between breeding populations with post-nesting females of western North Atlantic origin restricting their migrations to north Atlantic regions (Eckert et al. 2012; Saba 2013; NMFS USFWS 2013).

Hawksbill sea turtle (Eretmochelys imbricata)

The hawksbill is a small to medium-sized sea turtle that can reach up to 90 cm (35 in) in length and 70 kg (150 pounds) in weight (NOAA Fisheries 2014b). It is distributed globally in tropical, and to a lesser extent subtropical, waters of the Indian, Pacific, and Atlantic Oceans (NMFS USFWS 1993). Distribution within the western Atlantic ranges from Florida north as far as Massachusetts, but sightings north of Florida are rare (NMFS USFWS 1993). They are regularly observed in Florida nearshore waters on reefs in the Florida Keys and Palm Beach County where the Gulf Stream comes in close to shore (Lund 1985, NMFS USFWS 1993, NOAA Fisheries 2014b). The Florida Keys were once considered the world's finest fishing ground for this species before it was over harvested (DeSola 1932). The hawksbill turtle nests on insular and mainland sandy beaches throughout the tropics and subtropics (Mortimer and Donnelly 2008). In the SABMA region, this turtle nests mostly in southeast Florida from Volusia County south to the Florida Keys but rarely in the last few decades (Meylan 1999; NMFS USFWS 1993; FWC, FWRI 2014b).

The hawksbill utilizes different habitat during different life stages. Hatchlings enter the pelagic environment and are thought to occupy in weedlines that form at current convergence zones (NMFS USFWS 1993). After reaching approximately 20 to 30 cm (7.9 to 11.8 in) in carapace length, juveniles recruit to neritic foraging habitat on coral reefs and other hardbottom habitat, seagrass, algal bed or shallow mangrove lined bays and creeks (Musick and Limpus 1997). Adults are most commonly associated with coral reefs but are also found in mangrove-fringed bays and estuaries (NOAA Fisheries 2014b). While in the coastal waters, hawksbills are known to eat a wide variety of benthic organisms, however, the principle component of their diet is sponges (Meylan 1988, NMFS USFWS 1993). Adult hawksbill turtles may stay close to breeding and nesting areas or travel long distances between breeding and feeding grounds (Hawkes et al. 2012; Horrocks et al. 2011; Moncada et al. 2012; Musick and Limpus 1997; Plotkin 2003; Tagarino and Saili in press; van Dam et al. 2008).

Kemp's ridley sea turtle (*Lepidochelys kempii*)

The Kemp's ridley is the smallest sea turtle with adults reaching only between 60-70 cm (24-28 inches) in length and 45 kg (100 lb) in weight (NOAA Fisheries 2014b). It is distributed waters of the Gulf of Mexico and Northwest Atlantic as far north as the Grand Banks and Nova Scotia (NMFS USFWS 2011; NOAA Fisheries 2014b). A few individuals have also been found in the Mediterranean Sea, off Morocco and near the Azores. Nearly 95% of all Kemp's ridley nesting occurs in the state of Tamaulipas, Mexico on three main nesting beaches, often in large daytime aribadas. Much smaller scale nesting also occurs in Veracruz, Mexico and Texas, and the occasional nest has been observed in Florida, South Carolina, North Carolina and Virginia (Hampton Roads 2012; NOAA Fisheries 2014b). The arribadas in Rancho Nuevo, Mexico was discovered in 1947 and filmed sometime after that (circa 1947 – 1955). The number of individual turtles nesting in this film was estimated to be 40,000. By 1985, the number of nests discovered at this same beach had been reduced to 702 (estimated to represent approximately 300 nesting females) through overharvesting (Carr 1963; NMFS USFWS 2011). Conservation efforts since the mid-1980s have resulted in increased nests in Mexico and Texas with nests at Rancho Nuevo exceeding 10,000 per year over the last decade (NMFS USFWS 2011; Gallaway et al. 2013).

Newly hatched turtles begin to swim offshore as soon as they reach the surf zone and are thought to reach the pelagic environment within 4 days (NMFS USFWS 2011). Most hatchlings likely remain in currents within the Gulf of Mexico. Others are transported to the Northern Gulf and around Florida via current systems including the Loop Current, Florida Current and into the Atlantic Ocean by the Gulf Stream (Collard and Ogren 1990; Putman et al. 2010; NOAA Fisheries 2014b). Evidence suggests that juvenile Kemp's ridley turtles utilize the *Sargassum* community for food and shelter as in other species of sea turtle (Carr 1986; Shaver 1991, NMFS USFWS 2011).

Adult Kemp's ridleys are primarily found in the Gulf of Mexico and occasionally along the U.S. Atlantic coast (NMFS USFWS 2011. Their mating habits are largely unknown, but are thought to occur near nesting beaches about 30 days prior to egg laying (NMFS USFWS 2011). Nesting females lay an average of 2.5 clutches in a season with an average of 97 eggs per clutch.

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APPENDIX

5

CALCULATING Z-SCORES

To identify CSUs with regionally important characteristics, we transformed each attribute metric to standardized normalized scores (z-scores) so that each had a mean of zero and a standard deviation of one. The resultant z-score indicates how many standard deviations a particular CSU is from the mean. For example, a CSU with a z-score of 1 indicates that the CSU value for the attribute is 1 standard deviation greater than the attribute mean of all the CSUs.

A z-score is calculated using the following formula:

$$z = (X - \mu) / \sigma$$

where X is the value of the CSU attribute, μ is the mean of the attribute for all CSUs, and σ is the standard deviation of the attribute for all CSUs.

Calculation of standardized normal scores assumes that the data themselves are normally distributed. Many of the CSU attribute values were not normally distributed and various approaches to normally transform the CSU attributes were unsuccessful. We thus used rank-based z-scores which do not require a normal distribution.

To calculate a rank-based z-score, we used the following steps:

1. Rank the attribute values from lowest to highest
2. Compute a percentile for each attribute value in the dataset as follows:
   100(i-0.5)/n where i is the rank and n is the sample size
3. For each percentile, calculate the inverse of the standard normal cumulative distribution function to determine how many standard deviations from the mean that particular percentile is on a normal distribution.

The resultant rank-based z-scores are interpreted in the same manner as standard z-scores. That is, a rank-based z-score of 1 indicates that the CSU value for this attribute is 1 standard deviation greater than the attribute mean of all the CSUs.

To identify regionally important CSUs for each attribute, we assigned all rank-based z-scores to the following categories:

- Far Above Average (FAA): > 2 Standard Deviations (SD) above the mean
- Above Average (AA): > 1 SD
- Slightly Above Average (SAA): 1 to 0.5 SD
- Average (A): 0.5 to -0.5 SD
- Slightly Below Average (SBA): -0.5 to -1 SD
- Below Average (BA): < -1 SD
- Far Below Average (FBA): < 2 SD

APPENDIX

6

CETACEAN AND SEA TURTLE SPUE RANGES

Table A6.1. Cetacean and Sea Turtle Sightings per Unit Effort (SPUE) Ranges for Species/Species Group Z Scores*

Species/Specie	Far > 2 SD	Above > 1 SD	Slightly 1 to 0.5 SD	Average 0.5 to -0.5	Slightly Below -0.5 to -1 SD	Below < -1 SD	Far Below < 2 SD
Whales							
Fin whale							
Winter	na	62	33-56	7-26	3-5	0.1	na
Fall	na	na	na	na	na	na	na
Spring	na	35	17	2.2-10	2.2	1.9	na
Summer	na	na	37	na	5	na	na
Humpback							
Winter	na	12-22	2-11	0.2-2	0.01-0.2	0.04-0.06	na
Fall	na	na	na	na	na	na	na
Spring	na	na	na	na	na	na	na
Summer	na	na	na	na	na	na	na
Beaked whales							
Winter	na	215	183-197	12-99	0.3 - 7	0.2	na
Fall	na	na	na	na	na	na	na
Spring	na	151	89-149	59-84	4-58	3	na
Summer	na	na	52-65	51	20-32	na	na

* SPUE = 1000 * (number of animals sited)/effort

** Only winter SPUE is available for this analysis.

Table A6.1 continued. Cetacean and Sea Turtle Sightings per Unit Effort (SPUE) Ranges for Species/Species Group Z Scores*

Species/Specie	Far > 2 SD	Above > 1 SD	Slightly 1 to 0.5 SD	Average 0.5 to -0.5	Slightly Below -0.5 to -1 SD	Below < -1 SD	Far Below < 2 SD
Bottlenose							
Winter	3331-	588-3125	133-588	41-133	8-41	3-8	2
Fall	9800	1099-4147	183-1002	45-182	11-43	7-10	6
Spring	3156-	1562-3155	264-1561	58-264	16-57	9-15	6-8
Summer	7959-	1063-4928	295-1036	61-293	17-61	7-16	4
Oceanic							
Winter	18293	540-5011	89-507	13-87	2.18-12	0.27-2.15	0.1
Fall	na	6756-	294-5781	32-213	3-26	1.5-2.0	na
Spring	38584	7490-	533-4431	106-488	17-103	6-14	5
Summer	12938	1290-5453	442-1240	126-435	28-123	10-24	7
Common							
Winter	na	7514-	1123-7271	65-786	7-61	3-4	na
Fall	na	na	na	188	na	na	na
Spring	na	22236	824-4886	232-606	96-173	78	na
Summer	na	na	283-1749	230-261	18-24	na	na
Pilot whales							
Winter	na	1990-6335	462-1114	99-448	2-89	0.2-2	na
Fall	na	5327-7950	1257-5326	543-1256	237-542	86-236	na
Spring	na	2546-3318	784-1966	196-753	42-160	10-39	na
Summer	na	3044	809-1727	204-710	27-202	11	na
Risso's dolphin							
Winter	na	12826	331-8013	162-269	51-142	7	na
Fall	na	na	478-1358	77-284	29-33	na	na
Spring	na	1094-2253	191-724	34-161	6-33	2.0-2.2	na
Summer	na	964-4066	402-783	131-372	12-137	5-7	na

* SPUE = 1000 * (number of animals sited)/effort

** Only winter SPUE is available for this analysis.

Table A6.1 continued. Cetacean and Sea Turtle Sightings per Unit Effort (SPUE) Ranges for Species/Species Group Z Scores*

Species/Specie	Far > 2 SD	Above > 1 SD	Slightly 1 to 0.5 SD	Average 0.5 to -0.5	Slightly Below -0.5 to -1 SD	Below < -1 SD	Far Below < 2 SD
Sperm Whale							
Winter	na	314	144-246	48-115	15-27	6	na
Fall	na	na	220-652	200-210	28-70	na	na
Spring	na	482-720	151-268	58-126	5-45	2-4	na
Summer	na	261-337	122-216	48-115	14-44	12-13	na
North Atlantic	17-52	9-16	6-9	2.7-6	1.63-2.7	0.61-1.62	0.35-0.60
Sea Turtles							
Hardshell							
Winter	305-334	102-242	62-101	17-61	4-16	2-4	0.9-1.8
Fall	583-782	271-501	51-261	26-51	8-25	4-7	2
Spring	578	212-441	81-194	21-80	5-20	2-5	1.6
Summer	439	117-336	54-116	20-53	7-20	2-7	1.6
Leatherback							
Winter	51	12-39	5-12	2-5	0.9-2	0.5-0.9	0.4
Fall	na	27-64	7-19	3-7	1.3-3	0.8-1.1	na
Spring	na	33-36	16-32	8-16	4-8	3-4	na
Summer	na	81-165	16-78	5-15	2-5	1-2	na

* SPUE = 1000 * (number of animals sited)/effort

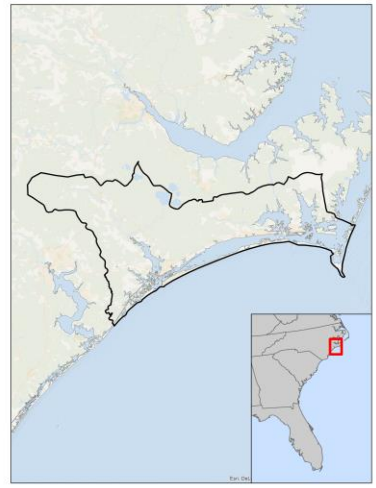
** Only winter SPUE is available for this analysis.

APPENDIX 7

COASTAL SHORELINE UNIT (CSU) PORTFOLIO RESULTS

Bogue Sound, North Carolina

- Subregion: Carolinian
- Type: Lagoonal
- Total area: 181,947 ha (147,873 land ha; 34,074 water ha)
- Cumulative Portfolio Score: 15, Above Average



HABITAT	Ocean Beach (ha)	Salt Marsh (ha)	Fresh Tidal Marsh (ha)	Tidal Forest (ha)	Mangrove (ha)	Tidal Flat (ha)	Seagrass (ha)	Intertidal Oysters (#)
Value	636	8307	316	1618	NA	1835	3474	84
Subregion[1]	3	2	2	1	NA	3	2	3
Region[2]	AA	A	A	A	NA	SAA	SAA	AA

SPECIES	Loggerhead Beach (nests/km)	Diadromous Fish (# Spp/km)	Manatee (Avg. wtd. persistence)	Estuarine Fish (Score)	CONDITION Shoreline/ Watershed (Score)
Value	0	2.60	NA	20	0
Subregion[1]	NA	1	NA	1	NA
Region[2]	NA	A	NA	AA	NA

RARE & EXEMPLARY FEATURES	Birds	Low Eutrophication	Low Pollution (sites/km^2)	Small Florida Lagoon (Rank)	CLIMATE CHANGE SLR Vulnerability (% area < 0.5 m)
Value	None	NA	0.0098	NA	23
Region[2]	NA	NA	A	NA	SAA

[1] *Numeric rank by Coastal Shoreline Unit (CSU) Type and Subregion*

[2] *Regional Z-Score:*
- FAA = Far Above Average
- AA = Above Average
- SAA = Slightly Above Average
- A = Average
- SBA = Slightly Below Average
- BA = Below Average
- FBA = Far Below Average
- NA = Not applicable

Southeast North Carolina Estuaries, North Carolina

- Subregion: Carolinian
- Type: Lagoonal
- Total area: 44,359 ha (37,039 land ha; 7320 water ha)
- Cumulative Portfolio Score: 7, Average

HABITAT	Ocean Beach (ha)	Salt Marsh (ha)	Fresh Tidal Marsh (ha)	Tidal Forest (ha)	Mangrove (ha)	Tidal Flat (ha)	Seagrass (ha)	Intertidal Oysters (#)
Value	523	5470	113	244	NA	1882	108	134
Subregion[1]	6	4	3	5	NA	2	3	1
Region[2]	SAA	A	A	SBA	NA	SAA	A	AA

SPECIES	Loggerhead Beach (nests/km)	Diadromous Fish (# Spp/km)	Manatee (Avg. wtd. persistence)	Estuarine Fish (Score)	CONDITION Shoreline/ Watershed (Score)
Value	0	0	NA	20	0
Subregion[1]	NA	NA	NA	2	NA
Region[2]	NA	NA	NA	AA	NA

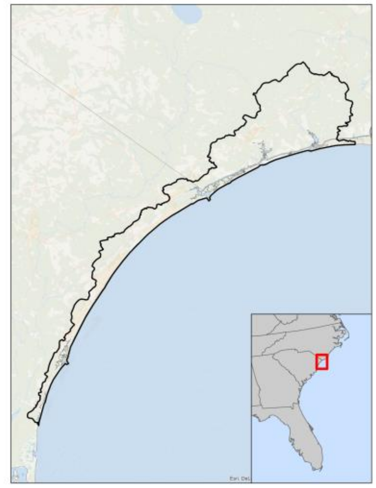
RARE & EXEMPLARY FEATURES	Birds	Low Eutrophication	Low Pollution (sites/km^2)	Small Florida Lagoon (Rank)	CLIMATE CHANGE SLR Vulnerability (% area < 0.5 m)
Value	None	NA	.0057	NA	28
Region[2]	NA	NA	AA	NA	SAA

[1] *Numeric rank by Coastal Shoreline Unit (CSU) Type and Subregion*

[2] *Regional Z-Score:*

- FAA = Far Above Average
- AA = Above Average
- SAA = Slightly Above Average
- A = Average
- SBA = Slightly Below Average
- BA = Below Average
- FBA = Far Below Average
- NA = Not applicable

Long Bay, North Carolina and South Carolina



- Subregion: Carolinian
- Type: Lagoonal
- Total area: 98,038 ha (92,227 land ha; 5811 water ha)
- Cumulative Portfolio Score: 7, Average

HABITAT	Ocean Beach (ha)	Salt Marsh (ha)	Fresh Tidal Marsh (ha)	Tidal Forest (ha)	Mangrove (ha)	Tidal Flat (ha)	Seagrass (ha)	Intertidal Oysters (#)
Value	694	4658	68	336	NA	327	3.8	78
Subregion[1]	1	5	4	3	NA	7	4	4
Region[2]	AA	A	A	A	NA	A	A	SAA

SPECIES	Loggerhead Beach (nests/km)	Diadromous Fish (# Spp/km)	Manatee (Avg. wtd. persistence)	Estuarine Fish (Score)	**CONDITION** Shoreline/ Watershed (Score)
Value	0	0	NA	11	28
Subregion[1]	NA	NA	NA	5	1
Region[2]	NA	NA	NA	A	SAA

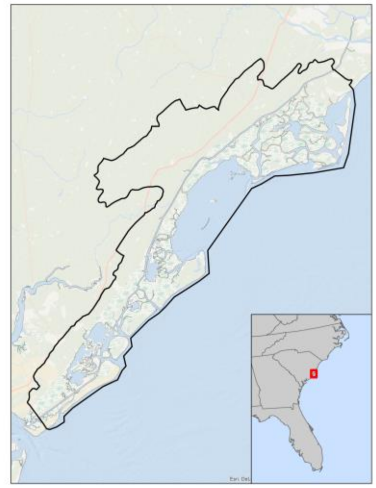
RARE & EXEMPLARY FEATURES	Birds	Low Eutrophication	Low Pollution (sites/km^2)	Small Florida Lagoon (Rank)	**CLIMATE CHANGE** SLR Vulnerability (% area < 0.5 m)
Value	None	NA	.0008	NA	7
Region[2]	NA	NA	AA	NA	SBA

[1] *Numeric rank by Coastal Shoreline Unit (CSU) Type and Subregion*

[2] *Regional Z-Score:*

- FAA = Far Above Average
- AA = Above Average
- SAA = Slightly Above Average
- A = Average
- SBA = Slightly Below Average
- BA = Below Average
- FBA = Far Below Average
- NA = Not applicable

Cape Romain, South Carolina



- Subregion: Carolinian
- Type: Lagoonal
- Total area: 68,082 ha (47,909 land ha; 20,173 water ha)
- Cumulative Portfolio Score: 17, Above Average

HABITAT	Ocean Beach (ha)	Salt Marsh (ha)	Fresh Tidal Marsh (ha)	Tidal Forest (ha)	Mangrove (ha)	Tidal Flat (ha)	Seagrass (ha)	Intertidal Oysters (#)
Value	640	20,205	1433	481	NA	1893	NA	111
Subregion[1]	2	1	1	2	NA	1	NA	2
Region[2]	AA	SAA	SAA	A	NA	AA	NA	AA

SPECIES	Loggerhead Beach (nests/km)	Diadromous Fish (# Spp/km)	Manatee (Avg. wtd. persistence)	Estuarine Fish (Score)	CONDITION	Shoreline/ Watershed (Score)
Value	27	0	NA	14		15
Subregion[1]	1	NA	NA	3		2
Region[2]	AA	NA	NA	SAA		A

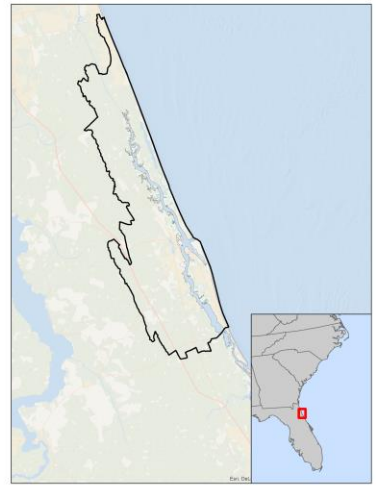
RARE & EXEMPLARY FEATURES	Birds	Low Eutrophication	Low Pollution (sites/km^2)	Small Florida Lagoon (Rank)	CLIMATE CHANGE	SLR Vulnerability (% area < 0.5 m)
Value	Intl	NA	.0118	NA		28
Region[2]	NA	NA	A	NA		SAA

[1] *Numeric rank by Coastal Shoreline Unit (CSU) Type and Subregion*

[2] *Regional Z-Score:*

- FAA = Far Above Average
- AA = Above Average
- SAA = Slightly Above Average
- A = Average
- SBA = Slightly Below Average
- BA = Below Average
- FBA = Far Below Average
- NA = Not applicable

St. Augustine Inlet, Florida



- Subregion: Carolinian
- Type: Lagoonal
- Total area: 52,652 ha (47,031 land ha; 5621 water ha)
- Cumulative Portfolio Score: 7, Average

HABITAT	Ocean Beach (ha)	Salt Marsh (ha)	Fresh Tidal Marsh (ha)	Tidal Forest (ha)	Mangrove (ha)	Tidal Flat (ha)	Seagrass (ha)	Intertidal Oysters (#)
Value	628	5735	23	33	34	581	0	0
Subregion[1]	4	3	6	8	4	5	NA	NA
Region[2]	AA	A	SBA	BA	A	A	NA	NA

SPECIES	Loggerhead Beach (nests/km)	Diadromous Fish (# Spp/km)	Manatee (Avg. wtd. persistence)	Estuarine Fish (Score)	CONDITION	Shoreline/ Watershed (Score)
Value	22	0	1.1	12		0
Subregion[1]	2	NA	1	4		NA
Region[2]	AA	NA	A	A		NA

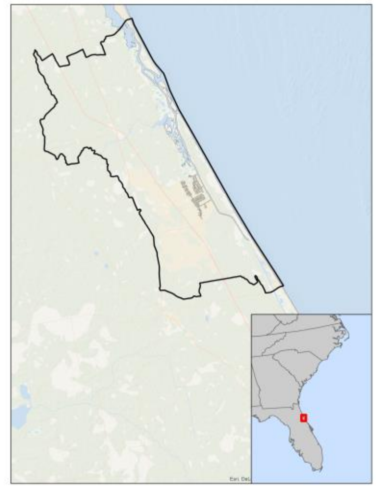
RARE & EXEMPLARY FEATURES	Birds	Low Eutrophication	Low Pollution (sites/km²)	Small Florida Lagoon (Rank)	CLIMATE CHANGE	SLR Vulnerability (% area < 0.5 m)
Value	None	NA	.0144	2		11
Region[2]	NA	NA	SBA	NA		A

[1] *Numeric rank by Coastal Shoreline Unit (CSU) Type and Subregion*

[2] *Regional Z-Score:*

- FAA = Far Above Average
- AA = Above Average
- SAA = Slightly Above Average
- A = Average
- SBA = Slightly Below Average
- BA = Below Average
- FBA = Far Below Average
- NA = Not applicable

Mantanzas Inlet, Florida



- Subregion: Carolinian
- Type: Lagoonal
- Total area: 34,824 ha (32,099 land ha; 2725 water ha)
- Cumulative Portfolio Score: 2, Below Average

HABITAT	Ocean Beach (ha)	Salt Marsh (ha)	Fresh Tidal Marsh (ha)	Tidal Forest (ha)	Mangrove (ha)	Tidal Flat (ha)	Seagrass (ha)	Intertidal Oysters (#)
Value	354	2049	0.8	66	175	283	0	0
Subregion[1]	8	8	7	6	3	8	NA	NA
Region[2]	A	SBA	SBA	SBA	SAA	A	NA	NA

SPECIES	Loggerhead Beach (nests/km)	Diadromous Fish (# Spp/km)	Manatee (Avg. wtd. persistence)	Estuarine Fish (Score)	**CONDITION** Shoreline/ Watershed (Score)
Value	15	0	0	9	0
Subregion[1]	3	NA	NA	6	NA
Region[2]	SAA	NA	NA	A	NA

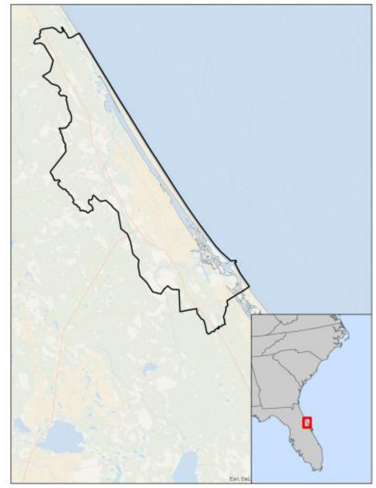
RARE & EXEMPLARY FEATURES	Birds	Low Eutrophication	Low Pollution (sites/km^2)	Small Florida Lagoon (Rank)	**CLIMATE CHANGE** SLR Vulnerability (% area < 0.5 m)
Value	None	NA	.0144	NA	12
Region[2]	NA	NA	SBA	NA	A

[1] *Numeric rank by Coastal Shoreline Unit (CSU) Type and Subregion*

[2] *Regional Z-Score:*

- FAA = Far Above Average
- AA = Above Average
- SAA = Slightly Above Average
- A = Average
- SBA = Slightly Below Average
- BA = Below Average
- FBA = Far Below Average
- NA = Not applicable

Ponce Inlet, Florida



- Subregion: Carolinian
- Type: Lagoonal
- Total area: 68,824 ha (62,062 land ha; 6762 water ha)
- Cumulative Portfolio Score: 3, Below Average

HABITAT	Ocean Beach (ha)	Salt Marsh (ha)	Fresh Tidal Marsh (ha)	Tidal Forest (ha)	Mangrove (ha)	Tidal Flat (ha)	Seagrass (ha)	Intertidal Oysters (#)
Value	525	2765	51	324	879	375	0.6	0
Subregion[1]	5	6	5	4	2	6	5	NA
Region[2]	AA	SBA	SBA	A	SAA	A	A	NA

SPECIES	Loggerhead Beach (nests/km)	Diadromous Fish (# Spp/km)	Manatee (Avg. wtd. persistence)	Estuarine Fish (Score)	CONDITION	Shoreline/ Watershed (Score)
Value	6.5	0	0	8		0
Subregion[1]	4	NA	NA	8		NA
Region[2]	A	NA	NA	BA		NA

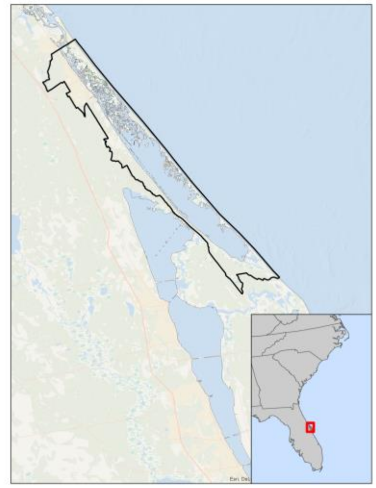
RARE & EXEMPLARY FEATURES	Birds	Low Eutrophication	Low Pollution (sites/km^2)	Small Florida Lagoon (Rank)	CLIMATE CHANGE	SLR Vulnerability (% area < 0.5 m)
Value	None	NA	.0185	NA		16
Region[2]	NA	NA	BA	NA		A

[1] *Numeric rank by Coastal Shoreline Unit (CSU) Type and Subregion*

[2] *Regional Z-Score:*

- FAA = Far Above Average
- AA = Above Average
- SAA = Slightly Above Average
- A = Average
- SBA = Slightly Below Average
- BA = Below Average
- FBA = Far Below Average
- NA = Not applicable

Mosquito Lagoon, Florida



- Subregion: Carolinian
- Type: Lagoonal
- Total area: 31,638 ha (15,966 land ha; 15,672 water ha)
- Cumulative Portfolio Score: 7, Average

HABITAT	Ocean Beach (ha)	Salt Marsh (ha)	Fresh Tidal Marsh (ha)	Tidal Forest (ha)	Mangrove (ha)	Tidal Flat (ha)	Seagrass (ha)	Intertidal Oysters (#)
Value	387	2359	0	34	2040	772	6686	9
Subregion[1]	7	7	NA	7	1	4	1	5
Region[2]	SAA	SBA	NA	BA	AA	A	SAA	A

SPECIES	Loggerhead Beach (nests/km)	Diadromous Fish (# Spp/km)	Manatee (Avg. wtd. persistence)	Estuarine Fish (Score)	CONDITION	Shoreline/ Watershed (Score)
Value	0	0	1	8		0
Subregion[1]	NA	NA	2	7		NA
Region[2]	NA	NA	A	SBA		NA

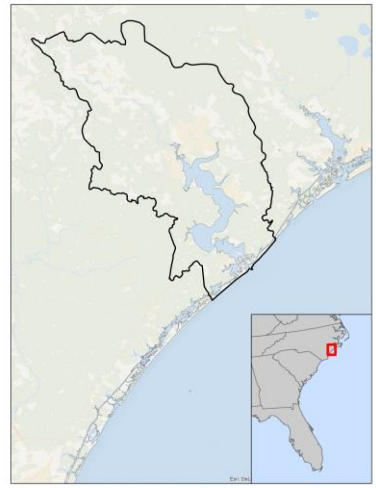
RARE & EXEMPLARY FEATURES	Birds	Low Eutrophication	Low Pollution (sites/km^2)	Small Florida Lagoon (Rank)	CLIMATE CHANGE	SLR Vulnerability (% area < 0.5 m)
Value	None	Moderate	.0100	2		64
Region[2]	NA	NA	A	NA		FAA

[1] *Numeric rank by Coastal Shoreline Unit (CSU) Type and Subregion*

[2] *Regional Z-Score:*

- FAA = Far Above Average
- AA = Above Average
- SAA = Slightly Above Average
- A = Average
- SBA = Slightly Below Average
- BA = Below Average
- FBA = Far Below Average
- NA = Not applicable

New River, North Carolina



- Subregion: Carolinian
- Type: Riverine (Coastal Plain Basin)
- Total area: 120,459 ha (110,820 land ha; 9639 water ha)
- Cumulative Portfolio Score: 4, Below Average

HABITAT	Ocean Beach (ha)	Salt Marsh (ha)	Fresh Tidal Marsh (ha)	Tidal Forest (ha)	Mangrove (ha)	Tidal Flat (ha)	Seagrass (ha)	Intertidal Oysters (#)
Value	98	1095	76	1191	NA	1004	84	0
Subregion[1]	10	10	10	6	NA	7	1	NA
Region[2]	BA	SBA	A	A	NA	A	A	NA

SPECIES	Loggerhead Beach (nests/km)	Diadromous Fish (# Spp/km)	Manatee (Avg. wtd. persistence)	Estuarine Fish (Score)	CONDITION	Shoreline/ Watershed (Score)
Value	0	2	NA	14		0
Subregion[1]	NA	8	NA	3		NA
Region[2]	NA	A	NA	SAA		NA

RARE & EXEMPLARY FEATURES	Birds	Low Eutrophication	Low Pollution (sites/km^2)	Small Florida Lagoon (Rank)	CLIMATE CHANGE	SLR Vulnerability (% area < 0.5 m)
Value	None	Moderate	.0078	NA		11
Region[2]	NA	NA	SAA	NA		A

[1] *Numeric rank by Coastal Shoreline Unit (CSU) Type and Subregion*

[2] *Regional Z-Score:*

- FAA = Far Above Average
- AA = Above Average
- SAA = Slightly Above Average
- A = Average
- SBA = Slightly Below Average
- BA = Below Average
- FBA = Far Below Average
- NA = Not applicable

Stono North Edisto Rivers, South Carolina

- Subregion: Carolinian
- Type: Riverine (Coastal Plain Basin)
- Total area: 122,561 ha (109,067 land ha; 13,494 water ha)
- Cumulative Portfolio Score: 12, Slightly Above Average

HABITAT	Ocean Beach (ha)	Salt Marsh (ha)	Fresh Tidal Marsh (ha)	Tidal Forest (ha)	Mangrove (ha)	Tidal Flat (ha)	Seagrass (ha)	Intertidal Oysters (#)
Value	322	20,242	619	536	NA	2109	NA	80
Subregion[1]	6	6	4	8	NA	1	NA	2
Region[2]	A	SAA	A	A	NA	AA	NA	AA

SPECIES	Loggerhead Beach (nests/km)	Diadromous Fish (# Spp/km)	Manatee (Avg. wtd. persistence)	Estuarine Fish (Score)	**CONDITION** Shoreline/ Watershed (Score)
Value	18	5	NA	16	14
Subregion[1]	2	4	NA	1	3
Region[2]	SAA	AA	NA	SAA	A

RARE & EXEMPLARY FEATURES	Birds	Low Eutrophication	Low Pollution (sites/km^2)	Small Florida Lagoon (Rank)	**CLIMATE CHANGE** SLR Vulnerability (% area < 0.5 m)
Value	None	Moderate	.0096	NA	15
Region[2]	NA	NA	A	NA	A

[1] *Numeric rank by Coastal Shoreline Unit (CSU) Type and Subregion*

[2] *Regional Z-Score:*

- FAA = Far Above Average
- AA = Above Average
- SAA = Slightly Above Average
- A = Average
- SBA = Slightly Below Average
- BA = Below Average
- FBA = Far Below Average
- NA = Not applicable

St. Helena Sound, South Carolina

- Subregion: Carolinian
- Type: Riverine (Coastal Plain Basin)
- Total area: 292,346 ha (264,108 land ha; 28,238 water ha)
- Cumulative Portfolio Score: 15, Above Average

HABITAT	Ocean Beach (ha)	Salt Marsh (ha)	Fresh Tidal Marsh (ha)	Tidal Forest (ha)	Mangrove (ha)	Tidal Flat (ha)	Seagrass (ha)	Intertidal Oysters (#)
Value	342	38,364	10,194	5027	NA	1385	NA	65
Subregion[1]	4	3	1	2	NA	3	NA	3
Region[2]	A	AA	FAA	SAA	NA	SAA	NA	SAA

SPECIES	Loggerhead Beach (nests/km)	Diadromous Fish (# Spp/km)	Manatee (Avg. wtd. persistence)	Estuarine Fish (Score)	CONDITION	Shoreline/ Watershed (Score)
Value	19	5	NA	8		15
Subregion[1]	1	5	NA	8		1
Region[2]	SAA	SAA	NA	SBA		A

RARE & EXEMPLARY FEATURES	Birds	Low Eutrophication	Low Pollution (sites/km^2)	Small Florida Lagoon (Rank)	CLIMATE CHANGE	SLR Vulnerability (% area < 0.5 m)
Value	None	Moderate	.0082	NA		19
Region[2]	NA	NA	SAA	NA		A

[1] *Numeric rank by Coastal Shoreline Unit (CSU) Type and Subregion*

[2] *Regional Z-Score:*

- FAA = Far Above Average
- AA = Above Average
- SAA = Slightly Above Average
- A = Average
- SBA = Slightly Below Average
- BA = Below Average
- FBA = Far Below Average
- NA = Not applicable

Port Royal Sound, South Carolina

- Subregion: Carolinian
- Type: Riverine (Coastal Plain Basin)
- Total area: 232,291 ha (204,748 land ha; 27,543 water ha)
- Cumulative Portfolio Score: 6, Slightly Below Average

HABITAT	Ocean Beach (ha)	Salt Marsh (ha)	Fresh Tidal Marsh (ha)	Tidal Forest (ha)	Mangrove (ha)	Tidal Flat (ha)	Seagrass (ha)	Intertidal Oysters (#)
Value	163	28,647	251	428	NA	1132	NA	168
Subregion[1]	8	5	8	9	NA	5	NA	1
Region[2]	A	AA	A	A	NA	A	NA	FAA

SPECIES	Loggerhead Beach (nests/km)	Diadromous Fish (# Spp/km)	Manatee (Avg. wtd. persistence)	Estuarine Fish (Score)	CONDITION	Shoreline/ Watershed (Score)
Value	10	3	NA	9		14
Subregion[1]	5	7	NA	7		2
Region[2]	A	SAA	NA	SBA		A

RARE & EXEMPLARY FEATURES	Birds	Low Eutrophication	Low Pollution (sites/km^2)	Small Florida Lagoon (Rank)	CLIMATE CHANGE	SLR Vulnerability (% area < 0.5 m)
Value	None	Moderate Low	.0082	NA		21
Region[2]	NA	NA	SAA	NA		SAA

[1] *Numeric rank by Coastal Shoreline Unit (CSU) Type and Subregion*

[2] *Regional Z-Score:*

- FAA = Far Above Average
- AA = Above Average
- SAA = Slightly Above Average
- A = Average
- SBA = Slightly Below Average
- BA = Below Average
- FBA = Far Below Average
- NA = Not applicable

Ossabaw Wassaw Sounds, Georgia

- Subregion: Carolinian
- Type: Riverine (Coastal Plain Basin)
- Total area: 373,044 ha (350,528 land ha; 22,516 water ha)
- Cumulative Portfolio Score: 9, Average

HABITAT	Ocean Beach (ha)	Salt Marsh (ha)	Fresh Tidal Marsh (ha)	Tidal Forest (ha)	Mangrove (ha)	Tidal Flat (ha)	Seagrass (ha)	Intertidal Oysters (#)
Value	408	32,369	773	3232	NA	265	NA	21
Subregion[1]	1	4	3	4	NA	8	NA	5
Region[2]	SAA	AA	A	SAA	NA	A	NA	SAA

SPECIES	Loggerhead Beach (nests/km)	Diadromous Fish (# Spp/km)	Manatee (Avg. wtd. persistence)	Estuarine Fish (Score)	CONDITION Shoreline/ Watershed (Score)
Value	13	5	NA	8	7
Subregion[1]	4	2	NA	9	9
Region[2]	A	AA	NA	SBA	A

RARE & EXEMPLARY FEATURES	Birds	Low Eutrophication	Low Pollution (sites/km^2)	Small Florida Lagoon (Rank)	CLIMATE CHANGE SLR Vulnerability (% area < 0.5 m)
Value	None	Moderate Low[3]	.0101	NA	8
Region[2]	NA	NA	A	NA	SBA

[1] *Numeric rank by Coastal Shoreline Unit (CSU) Type and Subregion*

[3] *No data for Wassaw Sound*

[2] *Regional Z-Score:*
- FAA = Far Above Average
- AA = Above Average
- SAA = Slightly Above Average
- A = Average
- SBA = Slightly Below Average
- BA = Below Average
- FBA = Far Below Average
- NA = Not applicable

St. Catherines Sapelo Sounds, Georgia

- Subregion: Carolinian
- Type: Riverine (Coastal Plain Basin)
- Total area: 197,976 ha (176,639 land ha; 21,337 water ha)
- Cumulative Portfolio Score: 4, Below Average

HABITAT	Ocean Beach (ha)	Salt Marsh (ha)	Fresh Tidal Marsh (ha)	Tidal Forest (ha)	Mangrove (ha)	Tidal Flat (ha)	Seagrass (ha)	Intertidal Oysters (#)
Value	170	38,855	514	1100	NA	2.7	NA	47
Subregion[1]	7	2	5	7	NA	10	NA	4
Region[2]	A	AA	A	A	NA	FBA	NA	SAA

SPECIES	Loggerhead Beach (nests/km)	Diadromous Fish (# Spp/km)	Manatee (Avg. wtd. persistence)	Estuarine Fish (Score)	CONDITION	Shoreline/ Watershed (Score)
Value	14	0	NA	4		11
Subregion[1]	3	NA	NA	10		5
Region[2]	SAA	NA	NA	BA		A

RARE & EXEMPLARY FEATURES	Birds	Low Eutrophication	Low Pollution (sites/km²)	Small Florida Lagoon (Rank)	CLIMATE CHANGE	SLR Vulnerability (% area < 0.5 m)
Value	Regional	NA	.0027	NA		18
Region[2]	NA	NA	AA	NA		A

[1] *Numeric rank by Coastal Shoreline Unit (CSU) Type and Subregion*

[2] *Regional Z-Score:*

- FAA = Far Above Average
- AA = Above Average
- SAA = Slightly Above Average
- A = Average
- SBA = Slightly Below Average
- BA = Below Average
- FBA = Far Below Average
- NA = Not applicable

Satilla River, Georgia

- Subregion: Carolinian
- Type: Riverine (Coastal Plain Basin)
- Total area: 372,614 ha (347,179 land ha; 25,435 water ha)
- Cumulative Portfolio Score: 11, Average

HABITAT	Ocean Beach (ha)	Salt Marsh (ha)	Fresh Tidal Marsh (ha)	Tidal Forest (ha)	Mangrove (ha)	Tidal Flat (ha)	Seagrass (ha)	Intertidal Oysters (#)
Value	353	41,192	1703	7140	NA	1319	NA	3
Subregion[1]	3	1	2	1	NA	4	NA	6
Region[2]	A	FAA	SAA	SAA	NA	SAA	NA	A

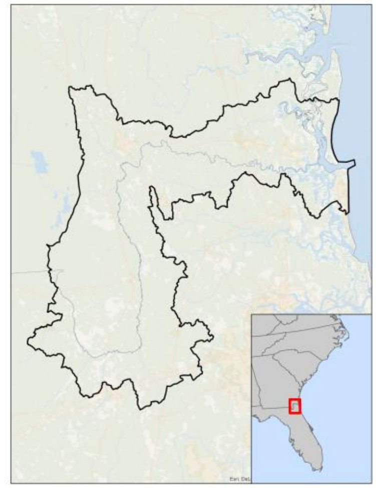
SPECIES	Loggerhead Beach (nests/km)	Diadromous Fish (# Spp/km)	Manatee (Avg. wtd. persistence)	Estuarine Fish (Score)	CONDITION Shoreline/ Watershed (Score)
Value	0	5	1.14	9	7
Subregion[1]	NA	3	2	6	7
Region[2]	NA	AA	SAA	A	A

RARE & EXEMPLARY FEATURES	Birds	Low Eutrophication	Low Pollution (sites/km^2)	Small Florida Lagoon (Rank)	CLIMATE CHANGE SLR Vulnerability (% area < 0.5 m)
Value	None	NA	.0096	NA	12
Region[2]	NA	NA	A	NA	A

[1] *Numeric rank by Coastal Shoreline Unit (CSU) Type and Subregion*

[2] *Regional Z-Score:*

- FAA = Far Above Average
- AA = Above Average
- SAA = Slightly Above Average
- A = Average
- SBA = Slightly Below Average
- BA = Below Average
- FBA = Far Below Average
- NA = Not applicable



St. Marys River, Georgia and Florida

- Subregion: Carolinian
- Type: Riverine (Coastal Plain Basin)
- Total area: 303,541 ha (290,029 land ha; 13,512 water ha)
- Cumulative Portfolio Score: 9, Average

HABITAT	Ocean Beach (ha)	Salt Marsh (ha)	Fresh Tidal Marsh (ha)	Tidal Forest (ha)	Mangrove (ha)	Tidal Flat (ha)	Seagrass (ha)	Intertidal Oysters (#)
Value	367	14,447	453	3999	NA	1574	NA	0
Subregion[1]	2	7	6	3	NA	2	NA	NA
Region[2]	A	SAA	A	SAA	NA	SAA	NA	NA

SPECIES	Loggerhead Beach (nests/km)	Diadromous Fish (# Spp/km)	Manatee (Avg. wtd. persistence)	Estuarine Fish (Score)	CONDITION Shoreline/ Watershed (Score)
Value	0	5	2	12	7
Subregion[1]	NA	1	1	4	8
Region[2]	NA	AA	SAA	A	A

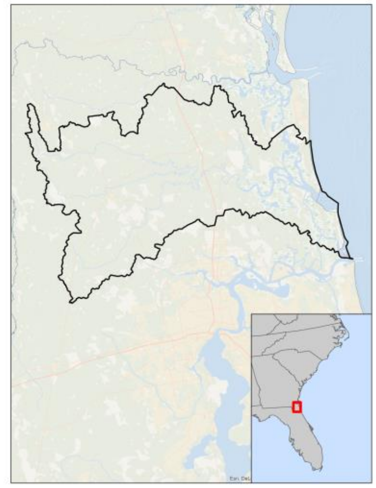
RARE & EXEMPLARY FEATURES	Birds	Low Eutrophication	Low Pollution (sites/km^2)	Small Florida Lagoon (Rank)	CLIMATE CHANGE SLR Vulnerability (% area < 0.5 m)
Value	None	Moderate Low	.0078	NA	7
Region[2]	NA	NA	SAA	NA	SBA

[1] *Numeric rank by Coastal Shoreline Unit (CSU) Type and Subregion*

[2] *Regional Z-Score:*

- FAA = Far Above Average
- AA = Above Average
- SAA = Slightly Above Average
- A = Average
- SBA = Slightly Below Average
- BA = Below Average
- FBA = Far Below Average
- NA = Not applicable

Nassau River, Florida



- Subregion: Carolinian
- Type: Riverine (Coastal Plain Basin)
- Total area: 112,296 ha (105,069 land ha; 7227 water ha)
- Cumulative Portfolio Score: 1, Far Below Average

HABITAT	Ocean Beach (ha)	Salt Marsh (ha)	Fresh Tidal Marsh (ha)	Tidal Forest (ha)	Mangrove (ha)	Tidal Flat (ha)	Seagrass (ha)	Intertidal Oysters (#)
Value	330	11,944	386	3061	NA	1020	NA	0
Subregion[1]	5	8	7	5	NA	6	NA	NA
Region[2]	A	SAA	A	A	NA	A	NA	NA

SPECIES	Loggerhead Beach (nests/km)	Diadromous Fish (# Spp/km)	Manatee (Avg. wtd. persistence)	Estuarine Fish (Score)	CONDITION	Shoreline/ Watershed (Score)
Value	0	0	0	10		9
Subregion[1]	NA	NA	NA	5		6
Region[2]	NA	NA	NA	A		A

RARE & EXEMPLARY FEATURES	Birds	Low Eutrophication	Low Pollution (sites/km^2)	Small Florida Lagoon (Rank)	CLIMATE CHANGE	SLR Vulnerability (% area < 0.5 m)
Value	None	NA	.0000	NA		15
Region[2]	NA	NA	FAA	NA		A

[1] *Numeric rank by Coastal Shoreline Unit (CSU) Type and Subregion*

[2] *Regional Z-Score:*

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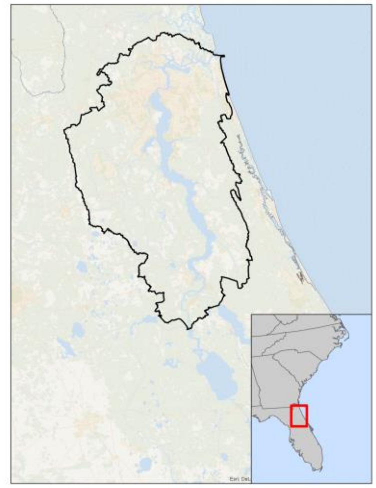
- AA = Above Average
- SAA = Slightly Above Average
- A = Average
- SBA = Slightly Below Average
- BA = Below Average
- FBA = Far Below Average
- NA = Not applicable

St. Johns River, Florida



- Subregion: Carolinian
- Type: Riverine (Coastal Plain Basin)
- Total area: 527,132 ha (477,702 land ha; 49,430 water ha)
- Cumulative Portfolio Score: 3, Below Average

HABITAT	Ocean Beach (ha)	Salt Marsh (ha)	Fresh Tidal Marsh (ha)	Tidal Forest (ha)	Mangrove (ha)	Tidal Flat (ha)	Seagrass (ha)	Intertidal Oysters (#)
Value	138	7711	161	50	NA	88	NA	0
Subregion[1]	9	9	9	10	NA	9	NA	NA
Region[2]	SBA	A	A	BA	NA	BA	NA	NA

SPECIES	Loggerhead Beach (nests/km)	Diadromous Fish (# Spp/km)	Manatee (Avg. wtd. persistence)	Estuarine Fish (Score)	CONDITION Shoreline/ Watershed (Score)
Value	0	4	1.12	15	13
Subregion[1]	NA	6	3	2	4
Region[2]	NA	SAA	SAA	SAA	A

RARE & EXEMPLARY FEATURES	Birds	Low Eutrophication	Low Pollution (sites/km^2)	Small Florida Lagoon (Rank)	CLIMATE CHANGE SLR Vulnerability (% area < 0.5 m)
Value	None	High	.0163	NA	10
Region[2]	NA	NA	SBA	NA	A

[1] *Numeric rank by Coastal Shoreline Unit (CSU) Type and Subregion*

[2] *Regional Z-Score:*

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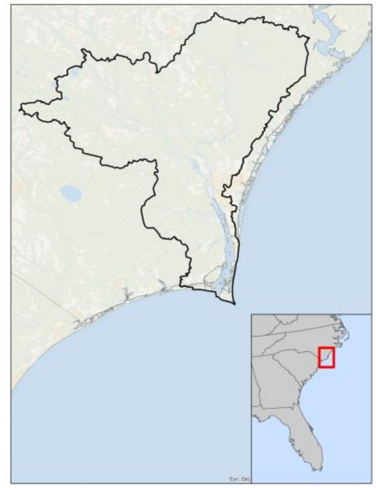
- AA = Above Average
- SAA = Slightly Above Average
- A = Average
- SBA = Slightly Below Average
- BA = Below Average
- FBA = Far Below Average
- NA = Not applicable

Cape Fear River, North Carolina



- Subregion: Carolinian
- Type: Riverine (Piedmont Basin)
- Total area: 466,586 ha (449,533 land ha; 17,053 water ha)
- Cumulative Portfolio Score: 8, Average

HABITAT	Ocean Beach (ha)	Salt Marsh (ha)	Fresh Tidal Marsh (ha)	Tidal Forest (ha)	Mangrove (ha)	Tidal Flat (ha)	Seagrass (ha)	Intertidal Oysters (#)
Value	346	3886	3641	575	NA	187	124	0
Subregion[1]	2	6	6	6	NA	3	1	NA
Region[2]	A	A	SAA	A	NA	SBA	A	NA

SPECIES	Loggerhead Beach (nests/km)	Diadromous Fish (# Spp/km)	Manatee (Avg. wtd. persistence)	Estuarine Fish (Score)	CONDITION Shoreline/ Watershed (Score)
Value	0	3	NA	12	29
Subregion[1]	NA	6	NA	1	4
Region[2]	NA	A	NA	A	SAA

RARE & EXEMPLARY FEATURES	Birds	Low Eutrophication	Low Pollution (sites/km^2)	Small Florida Lagoon (Rank)	CLIMATE CHANGE SLR Vulnerability (% area < 0.5 m)
Value	None	Moderate Low	.0090	NA	5
Region[2]	NA	NA	A	NA	BA

[1] *Numeric rank by Coastal Shoreline Unit (CSU) Type and Subregion*

[2] *Regional Z-Score:*

- FAA = Far Above Average
- AA = Above Average
- SAA = Slightly Above Average
- A = Average
- SBA = Slightly Below Average
- BA = Below Average
- FBA = Far Below Average
- NA = Not applicable

Winyah Bay, South Carolina

- Subregion: Carolinian
- Type: Riverine (Piedmont Basin)
- Total area: 842,705 ha (823,525 land ha; 19,180 water ha)
- Cumulative Portfolio Score: 13, Slightly Above Average

HABITAT	Ocean Beach (ha)	Salt Marsh (ha)	Fresh Tidal Marsh (ha)	Tidal Forest (ha)	Mangrove (ha)	Tidal Flat (ha)	Seagrass (ha)	Intertidal Oysters (#)
Value	192	5777	8841	28,095	NA	90	NA	17
Subregion[1]	3	5	1	1	NA	5	NA	3
Region[2]	A	A	AA	FAA	NA	SBA	NA	SAA

SPECIES	Loggerhead Beach (nests/km)	Diadromous Fish (# Spp/km)	Manatee (Avg. wtd. persistence)	Estuarine Fish (Score)	CONDITION	Shoreline/ Watershed (Score)
Value	23	4	NA	8		37
Subregion[1]	1	5	NA	4		3
Region[2]	AA	SAA	NA	SBA		AA

RARE & EXEMPLARY FEATURES	Birds	Low Eutrophication	Low Pollution (sites/km^2)	Small Florida Lagoon (Rank)	CLIMATE CHANGE	SLR Vulnerability (% area < 0.5 m)
Value	None	Moderate	.0173	NA		2
Region[2]	NA	NA	SBA	NA		BA

[1] *Numeric rank by Coastal Shoreline Unit (CSU) Type and Subregion*

[2] *Regional Z-Score:*

- FAA = Far Above Average
- AA = Above Average
- SAA = Slightly Above Average
- A = Average
- SBA = Slightly Below Average
- BA = Below Average
- FBA = Far Below Average
- NA = Not applicable

Santee Rivers, South Carolina

- Subregion: Carolinian
- Type: Riverine (Piedmont Basin)
- Total area: 182,398 ha (176,921 land ha; 5477 water ha)
- Cumulative Portfolio Score: 9, Average

HABITAT	Ocean Beach (ha)	Salt Marsh (ha)	Fresh Tidal Marsh (ha)	Tidal Forest (ha)	Mangrove (ha)	Tidal Flat (ha)	Seagrass (ha)	Intertidal Oysters (#)
Value	99	5829	6310	8932	NA	59	NA	0
Subregion[1]	6	4	2	3	NA	6	NA	NA
Region[2]	SBA	A	AA	AA	NA	BA	NA	NA

SPECIES	Loggerhead Beach (nests/km)	Diadromous Fish (# Spp/km)	Manatee (Avg. wtd. persistence)	Estuarine Fish (Score)	CONDITION	Shoreline/ Watershed (Score)
Value	2	6	NA	6		46
Subregion[1]	3	1	NA	6		2
Region[2]	A	FAA	NA	BA		AA

RARE & EXEMPLARY FEATURES	Birds	Low Eutrophication	Low Pollution (sites/km^2)	Small Florida Lagoon (Rank)	CLIMATE CHANGE	SLR Vulnerability (% area < 0.5 m)
Value	None	Moderate	.0320	NA		4
Region[2]	NA	NA	BA	NA		BA

[1] *Numeric rank by Coastal Shoreline Unit (CSU) Type and Subregion*

[2] *Regional Z-Score:*

- FAA = Far Above Average
- AA = Above Average
- SAA = Slightly Above Average
- A = Average
- SBA = Slightly Below Average
- BA = Below Average
- FBA = Far Below Average
- NA = Not applicable

Charleston Harbor, South Carolina

- Subregion: Carolinian
- Type: Riverine (Piedmont Basin)
- Total area: 293,728 ha (278,795 land ha; 14,933 water ha)
- Cumulative Portfolio Score: 8, Average

HABITAT	Ocean Beach (ha)	Salt Marsh (ha)	Fresh Tidal Marsh (ha)	Tidal Forest (ha)	Mangrove (ha)	Tidal Flat (ha)	Seagrass (ha)	Intertidal Oysters (#)
Value	101	11,759	5711	1341	NA	402	NA	21
Subregion[1]	5	3	4	5	NA	1	NA	2
Region[2]	SBA	A	AA	A	NA	A	NA	SAA

SPECIES	Loggerhead Beach (nests/km)	Diadromous Fish (# Spp/km)	Manatee (Avg. wtd. persistence)	Estuarine Fish (Score)	CONDITION: Shoreline/ Watershed (Score)
Value	0	5	NA	11	8
Subregion[1]	NA	2	NA	2	6
Region[2]	NA	AA	NA	A	A

RARE & EXEMPLARY FEATURES	Birds	Low Eutrophication	Low Pollution (sites/km^2)	Small Florida Lagoon (Rank)	CLIMATE CHANGE: SLR Vulnerability (% area < 0.5 m)
Value	None	Moderate Low	.0150	NA	6
Region[2]	NA	NA	SBA	NA	SBA

[1] *Numeric rank by Coastal Shoreline Unit (CSU) Type and Subregion*

[2] *Regional Z-Score:*

- FAA = Far Above Average
- AA = Above Average
- SAA = Slightly Above Average
- A = Average
- SBA = Slightly Below Average
- BA = Below Average
- FBA = Far Below Average
- NA = Not applicable

Savannah River, South Carolina and Georgia

- Subregion: Carolinian
- Type: Riverine (Piedmont Basin)
- Total area: 383,871 ha (366,005 land ha; 17,866 water ha)
- Cumulative Portfolio Score: 9, Average

HABITAT	Ocean Beach (ha)	Salt Marsh (ha)	Fresh Tidal Marsh (ha)	Tidal Forest (ha)	Mangrove (ha)	Tidal Flat (ha)	Seagrass (ha)	Intertidal Oysters (#)
Value	132	18,359	6005	7475	NA	165	NA	97
Subregion[1]	4	2	3	4	NA	4	NA	1
Region[2]	SBA	SAA	AA	AA	NA	SBA	NA	AA

SPECIES	Loggerhead Beach (nests/km)	Diadromous Fish (# Spp/km)	Manatee (Avg. wtd. persistence)	Estuarine Fish (Score)	CONDITION	Shoreline/ Watershed (Score)
Value	0	4.78	NA	9		17
Subregion[1]	NA	4	NA	3		5
Region[2]	NA	SAA	NA	A		A

RARE & EXEMPLARY FEATURES	Birds	Low Eutrophication	Low Pollution (sites/km²)	Small Florida Lagoon (Rank)	CLIMATE CHANGE	SLR Vulnerability (% area < 0.5 m)
Value	Regional	Moderate	.0116	NA		6
Region[2]	NA	NA	A	NA		SBA

[1] *Numeric rank by Coastal Shoreline Unit (CSU) Type and Subregion*

[2] *Regional Z-Score:*

- FAA = Far Above Average
- AA = Above Average
- SAA = Slightly Above Average
- A = Average
- SBA = Slightly Below Average
- BA = Below Average
- FBA = Far Below Average
- NA = Not applicable

Altamaha River, Georgia

- Subregion: Carolinian
- Type: Riverine (Piedmont Basin)
- Total area: 322,990 ha (307,330 land ha; 15,660 water ha)
- Cumulative Portfolio Score: 14, Slightly Above Average

HABITAT	Ocean Beach (ha)	Salt Marsh (ha)	Fresh Tidal Marsh (ha)	Tidal Forest (ha)	Mangrove (ha)	Tidal Flat (ha)	Seagrass (ha)	Intertidal Oysters (#)
Value	375	20,684	3800	10,231	NA	395	NA	8
Subregion[1]	1	1	5	2	NA	2	NA	4
Region[2]	SAA	SAA	SAA	AA	NA	A	NA	A

SPECIES	Loggerhead Beach (nests/km)	Diadromous Fish (# Spp/km)	Manatee (Avg. wtd. persistence)	Estuarine Fish (Score)	CONDITION Shoreline/ Watershed (Score)
Value	5	5	NA	7	54
Subregion[1]	2	3	NA	5	1
Region[2]	A	AA	NA	BA	AA

RARE & EXEMPLARY FEATURES	Birds	Low Eutrophication	Low Pollution (sites/km^2)	Small Florida Lagoon (Rank)	CLIMATE CHANGE SLR Vulnerability (% area < 0.5 m)
Value	Regional	Low[3]	.0091	NA	7
Region[2]	NA	NA	A	NA	SBA

[1] *Numeric rank by Coastal Shoreline Unit (CSU) Type and Subregion*

[3] *No data for St. Catherine's portion*

[2]*Regional Z-Score:*

- FAA = Far Above Average
- AA = Above Average
- SAA = Slightly Above Average
- A = Average
- SBA = Slightly Below Average
- BA = Below Average
- FBA = Far Below Average
- NA = Not applicable

Middle Keys, Florida

- Subregion: Floridian
- Type: Island Archipelago
- Total area: 60,542 ha (3052 land ha; 57,490 water ha)
- Cumulative Portfolio Score: 6, Slightly Below Average

HABITAT	Ocean Beach (ha)	Salt Marsh (ha)	Fresh Tidal Marsh (ha)	Tidal Forest (ha)	Mangrove (ha)	Tidal Flat (ha)	Seagrass (ha)	Intertidal Oysters (#)
Value	28	10	0	20	1045	1137	61,002	0
Subregion[1]	2	2	NA	2	2	2	2	NA
Region[2]	BA	BA	NA	BA	SAA	A	AA	NA

SPECIES	Loggerhead Beach (nests/km)	Diadromous Fish (# Spp/km)	Manatee (Avg. wtd. persistence)	Estuarine Fish (Score)	CONDITION Shoreline/ Watershed (Score)
Value	0	0	2	23	5
Subregion[1]	NA	NA	1	1	2
Region[2]	NA	NA	SAA	AA	SBA

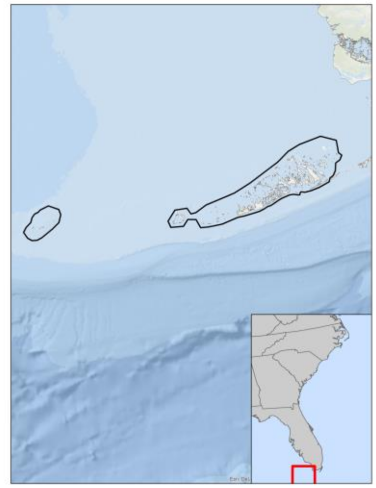
RARE & EXEMPLARY FEATURES	Birds	Low Eutrophication	Low Pollution (sites/km^2)	Small Florida Lagoon (Rank)	CLIMATE CHANGE SLR Vulnerability (% area < 0.5 m)
Value	None	NA	.0016	NA	34
Region[2]	NA	NA	AA	NA	AA

[1] *Numeric rank by Coastal Shoreline Unit (CSU) Type and Subregion*

[2] *Regional Z-Score:*

- FAA = Far Above Average
- AA = Above Average
- SAA = Slightly Above Average
- A = Average
- SBA = Slightly Below Average
- BA = Below Average
- FBA = Far Below Average
- NA = Not applicable

Lower Keys, Florida



- Subregion: Floridian
- Type: Island Archipelago
- Total area: 191,047 ha (18,097 land ha; 172,950 water ha)
- Cumulative Portfolio Score: 18, Above Average

HABITAT	Ocean Beach (ha)	Salt Marsh (ha)	Fresh Tidal Marsh (ha)	Tidal Forest (ha)	Mangrove (ha)	Tidal Flat (ha)	Seagrass (ha)	Intertidal Oysters (#)
Value	71	22	0	2604	8959	20,635	144,996	0
Subregion[1]	1	1	NA	1	1	1	1	NA
Region[2]	BA	BA	NA	A	AA	AA	AA	NA

SPECIES	Loggerhead Beach (nests/km)	Diadromous Fish (# Spp/km)	Manatee (Avg. wtd. persistence)	Estuarine Fish (Score)	CONDITION	Shoreline/ Watershed (Score)
Value	4	0	0	16		31
Subregion[1]	1	NA	NA	2		1
Region[2]	A	NA	NA	SAA		SAA

RARE & EXEMPLARY FEATURES	Birds	Low Eutrophication	Low Pollution (sites/km^2)	Small Florida Lagoon (Rank)	CLIMATE CHANGE	SLR Vulnerability (% area < 0.5 m)
Value	None	NA	NA	NA		28
Region[2]	NA	NA	NA	NA		SAA

[1] *Numeric rank by Coastal Shoreline Unit (CSU) Type and Subregion*

[2] *Regional Z-Score:*

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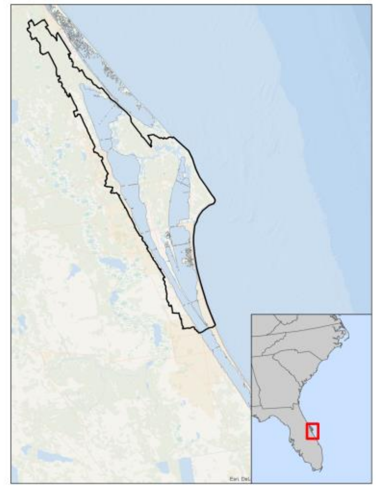
- AA = Above Average
- SAA = Slightly Above Average
- A = Average
- SBA = Slightly Below Average
- BA = Below Average
- FBA = Far Below Average
- NA = Not applicable

Cape Canaveral, Florida



- Subregion: Floridian
- Type: Lagoonal
- Total area: 122,880 ha (69,633 land ha; 53,247 water ha)
- Cumulative Portfolio Score: 13, Slightly Above Average

HABITAT	Ocean Beach (ha)	Salt Marsh (ha)	Fresh Tidal Marsh (ha)	Tidal Forest (ha)	Mangrove (ha)	Tidal Flat (ha)	Seagrass (ha)	Intertidal Oysters (#)
Value	468	4672	55	508	1842	1478	17,814	0
Subregion[1]	1	1	2	2	4	3	3	NA
Region[2]	SAA	A	A	A	AA	SAA	AA	NA

SPECIES	Loggerhead Beach (nests/km)	Diadromous Fish (# Spp/km)	Manatee (Avg. wtd. persistence)	Estuarine Fish (Score)	CONDITION Shoreline/ Watershed (Score)
Value	15	0	1.69	9	0
Subregion[1]	5	NA	8	6	NA
Region[2]	SAA	NA	SAA	A	NA

RARE & EXEMPLARY FEATURES	Birds	Low Eutrophication	Low Pollution (sites/km^2)	Small Florida Lagoon (Rank)	CLIMATE CHANGE SLR Vulnerability (% area < 0.5 m)
Value	None	Moderate	.0100	NA	51
Region[2]	NA	NA	A	NA	AA

[1] *Numeric rank by Coastal Shoreline Unit (CSU) Type and Subregion*

[2] *Regional Z-Score:*

- FAA = Far Above Average
- AA = Above Average
- SAA = Slightly Above Average
- A = Average
- SBA = Slightly Below Average
- BA = Below Average
- FBA = Far Below Average
- NA = Not applicable

Sebastian Inlet, Florida

- Subregion: Floridian
- Type: Lagoonal
- Total area: 94,604 ha (76,434 land ha; 18,170 water ha)
- Cumulative Portfolio Score: 8, Average

HABITAT	Ocean Beach (ha)	Salt Marsh (ha)	Fresh Tidal Marsh (ha)	Tidal Forest (ha)	Mangrove (ha)	Tidal Flat (ha)	Seagrass (ha)	Intertidal Oysters (#)
Value	263	42	1	247	1513	89	3079	1
Subregion[1]	4	4	5	3	5	7	5	2
Region[2]	A	SBA	SBA	SBA	SAA	SBA	SAA	A

SPECIES	Loggerhead Beach (nests/km)	Diadromous Fish (# Spp/km)	Manatee (Avg. wtd. persistence)	Estuarine Fish (Score)	CONDITION	Shoreline/ Watershed (Score)
Value	46	0	2.11	14		0
Subregion[1]	1	NA	6	3		NA
Region[2]	FAA	NA	AA	SAA		NA

RARE & EXEMPLARY FEATURES	Birds	Low Eutrophication	Low Pollution (sites/km^2)	Small Florida Lagoon (Rank)	CLIMATE CHANGE	SLR Vulnerability (% area < 0.5 m)
Value	None	Moderate	.0100	1		20
Region[2]	NA	NA	A	NA		A

[1] *Numeric rank by Coastal Shoreline Unit (CSU) Type and Subregion*

[2] *Regional Z-Score:*

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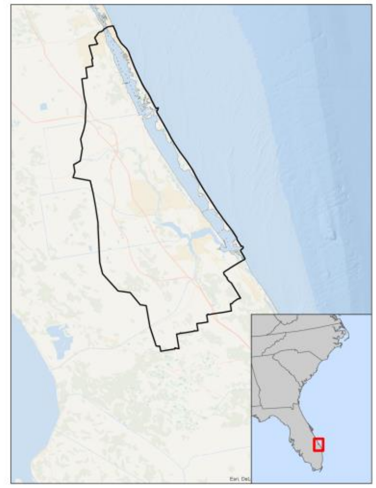
- AA = Above Average
- SAA = Slightly Above Average
- A = Average
- SBA = Slightly Below Average
- BA = Below Average
- FBA = Far Below Average
- NA = Not applicable

St. Lucie River, Florida



- Subregion: Floridian
- Type: Lagoonal
- Total area: 139,896 ha (118,439 land ha; 21,457 water ha)
- Cumulative Portfolio Score: 13, Slightly Above Average

HABITAT	Ocean Beach (ha)	Salt Marsh (ha)	Fresh Tidal Marsh (ha)	Tidal Forest (ha)	Mangrove (ha)	Tidal Flat (ha)	Seagrass (ha)	Intertidal Oysters (#)
Value	309	22	1	535	3114	228	4557	16
Subregion[1]	3	5	4	1	3	5	4	1
Region[2]	A	BA	SBA	A	AA	A	SAA	A

SPECIES	Loggerhead Beach (nests/km)	Diadromous Fish (# Spp/km)	Manatee (Avg. wtd. persistence)	Estuarine Fish (Score)	CONDITION Shoreline/ Watershed (Score)
Value	25	0	2.05	13	21
Subregion[1]	3	NA	7	4	2
Region[2]	AA	NA	SAA	A	SAA

RARE & EXEMPLARY FEATURES	Birds	Low Eutrophication	Low Pollution (sites/km^2)	Small Florida Lagoon (Rank)	CLIMATE CHANGE SLR Vulnerability (% area < 0.5 m)
Value	None	Moderate	.0100	NA	16
Region[2]	NA	NA	A	NA	A

[1] *Numeric rank by Coastal Shoreline Unit (CSU) Type and Subregion*

[2] *Regional Z-Score:*
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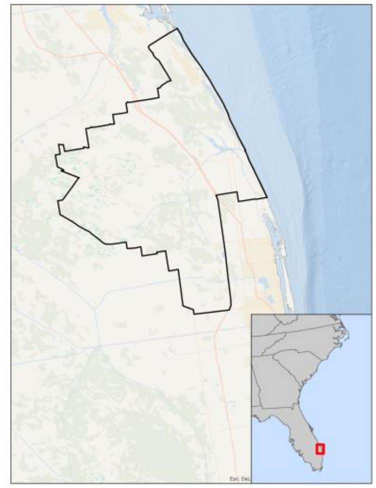
- SAA = Slightly Above Average
- A = Average
- SBA = Slightly Below Average
- BA = Below Average
- FBA = Far Below Average
- NA = Not applicable

Loxahatchee River, Florida



- Subregion: Floridian
- Type: Lagoonal
- Total area: 80,816 ha (73,887 land ha; 6,929 water ha)
- Cumulative Portfolio Score: 5, Slightly Below Average

HABITAT	Ocean Beach (ha)	Salt Marsh (ha)	Fresh Tidal Marsh (ha)	Tidal Forest (ha)	Mangrove (ha)	Tidal Flat (ha)	Seagrass (ha)	Intertidal Oysters (#)
Value	163	0	0.4	181	548	112	241	1
Subregion[1]	6	NA	6	5	7	6	7	2
Region[2]	A	NA	BA	SBA	SAA	SBA	A	A

SPECIES	Loggerhead Beach (nests/km)	Diadromous Fish (# Spp/km)	Manatee (Avg. wtd. persistence)	Estuarine Fish (Score)	CONDITION Shoreline/ Watershed (Score)
Value	31	0	3.11	4	13
Subregion[1]	2	NA	2	7	4
Region[2]	AA	NA	AA	BA	A

RARE & EXEMPLARY FEATURES	Birds	Low Eutrophication	Low Pollution (sites/km^2)	Small Florida Lagoon (Rank)	CLIMATE CHANGE SLR Vulnerability (% area < 0.5 m)
Value	None	NA	NA	NA	3
Region[2]	NA	NA	NA	NA	BA

[1] *Numeric rank by Coastal Shoreline Unit (CSU) Type and Subregion*

[2] *Regional Z-Score:*

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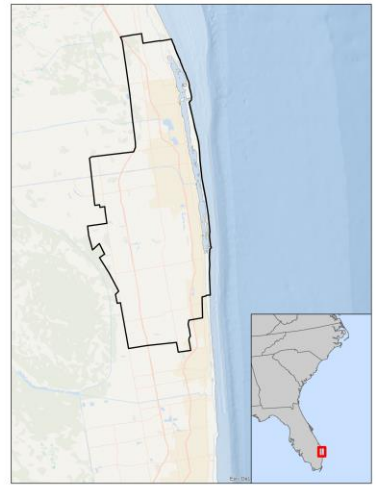
- AA = Above Average
- SAA = Slightly Above Average
- A = Average
- SBA = Slightly Below Average
- BA = Below Average
- FBA = Far Below Average
- NA = Not applicable

Lake Worth Lagoon, Florida



- Subregion: Floridian
- Type: Lagoonal
- Total area: 72,284 ha (64,907 land ha; 7377 water ha)
- Cumulative Portfolio Score: 6, Slightly Below Average

HABITAT	Ocean Beach (ha)	Salt Marsh (ha)	Fresh Tidal Marsh (ha)	Tidal Forest (ha)	Mangrove (ha)	Tidal Flat (ha)	Seagrass (ha)	Intertidal Oysters (#)
Value	155	8	0	1	109	516	687	1
Subregion[1]	7	6	NA	8	8	4	6	2
Region[2]	SBA	BA	NA	FBA	A	A	A	A

SPECIES	Loggerhead Beach (nests/km)	Diadromous Fish (# Spp/km)	Manatee (Avg. wtd. persistence)	Estuarine Fish (Score)	CONDITION Shoreline/ Watershed (Score)
Value	17	0	3.38	21	0
Subregion[1]	4	NA	1	2	NA
Region[2]	SAA	NA	FAA	AA	NA

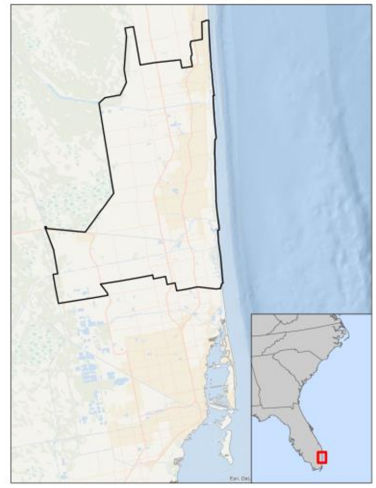
RARE & EXEMPLARY FEATURES	Birds	Low Eutrophication	Low Pollution (sites/km^2)	Small Florida Lagoon (Rank)	CLIMATE CHANGE SLR Vulnerability (% area < 0.5 m)
Value	None	NA	.0272	3	5
Region[2]	NA	NA	BA	NA	BA

[1] *Numeric rank by Coastal Shoreline Unit (CSU) Type and Subregion*

[2] *Regional Z-Score:*

- FAA = Far Above Average
- AA = Above Average
- SAA = Slightly Above Average
- A = Average
- SBA = Slightly Below Average
- BA = Below Average
- FBA = Far Below Average
- NA = Not applicable

Port Everglades, Florida



- Subregion: Floridian
- Type: Lagoonal
- Total area: 113,950 ha (104,196 land ha; 9754 water ha)
- Cumulative Portfolio Score: 3, Below Average

HABITAT	Ocean Beach (ha)	Salt Marsh (ha)	Fresh Tidal Marsh (ha)	Tidal Forest (ha)	Mangrove (ha)	Tidal Flat (ha)	Seagrass (ha)	Intertidal Oysters (#)
Value	243	0	0	57	636	12	121	0
Subregion[1]	5	NA	NA	6	6	8	8	NA
Region[2]	A	NA	NA	SBA	SAA	BA	A	NA

SPECIES	Loggerhead Beach (nests/km)	Diadromous Fish (# Spp/km)	Manatee (Avg. wtd. persistence)	Estuarine Fish (Score)	CONDITION Shoreline/ Watershed (Score)
Value	0	0	2.82	11	0
Subregion[1]	NA	NA	3	5	NA
Region[2]	NA	NA	AA	A	NA

RARE & EXEMPLARY FEATURES	Birds	Low Eutrophication	Low Pollution (sites/km^2)	Small Florida Lagoon (Rank)	CLIMATE CHANGE SLR Vulnerability (% area < 0.5 m)
Value	None	NA	.0272	NA	5
Region[2]	NA	NA	BA	NA	BA

[1] *Numeric rank by Coastal Shoreline Unit (CSU) Type and Subregion*

[2] *Regional Z-Score:*
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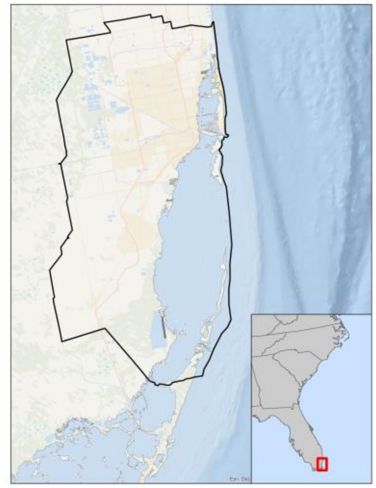
- SAA = Slightly Above Average
- A = Average
- SBA = Slightly Below Average
- BA = Below Average
- FBA = Far Below Average
- NA = Not applicable



Biscayne Bay, Florida

- Subregion: Floridian
- Type: Lagoonal
- Total area: 269,166 ha (187,761 land ha; 81,405 water ha)
- Cumulative Portfolio Score: 15, Above Average

HABITAT	Ocean Beach (ha)	Salt Marsh (ha)	Fresh Tidal Marsh (ha)	Tidal Forest (ha)	Mangrove (ha)	Tidal Flat (ha)	Seagrass (ha)	Intertidal Oysters (#)
Value	314	1068	2	34	6026	6297	83,279	0
Subregion[1]	2	3	3	7	2	2	2	NA
Region[2]	A	SBA	SBA	BA	AA	AA	AA	NA

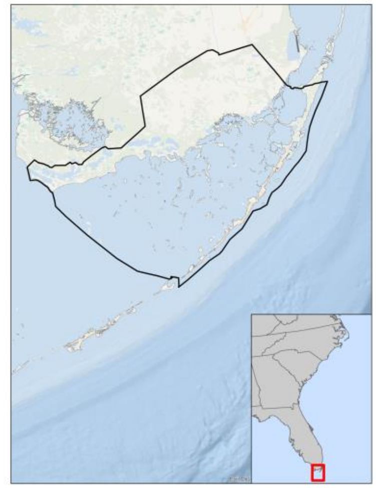
SPECIES	Loggerhead Beach (nests/km)	Diadromous Fish (# Spp/km)	Manatee (Avg. wtd. persistence)	Estuarine Fish (Score)	CONDITION	Shoreline/ Watershed (Score)
Value	0	1	2.70	29		18
Subregion[1]	NA	1	4	1		3
Region[2]	NA	A	AA	FAA		SAA

RARE & EXEMPLARY FEATURES	Birds	Low Eutrophication	Low Pollution (sites/km^2)	Small Florida Lagoon (Rank)	CLIMATE CHANGE	SLR Vulnerability (% area < 0.5 m)
Value	None	Moderate Low	.0533	NA		20
Region[2]	NA	NA	FBA	NA		A

[1] *Numeric rank by Coastal Shoreline Unit (CSU) Type and Subregion*

[2] *Regional Z-Score:*

- FAA = Far Above Average
- AA = Above Average
- SAA = Slightly Above Average
- A = Average
- SBA = Slightly Below Average
- BA = Below Average
- FBA = Far Below Average
- NA = Not applicable



Florida Bay, Florida

- Subregion: Floridian
- Type: Lagoonal
- Total area: 308,332 ha (106,853 land ha; 201,479 water ha)
- Cumulative Portfolio Score: 17, Above Average

HABITAT	Ocean Beach (ha)	Salt Marsh (ha)	Fresh Tidal Marsh (ha)	Tidal Forest (ha)	Mangrove (ha)	Tidal Flat (ha)	Seagrass (ha)	Intertidal Oysters (#)
Value	37	4628	179	231	37,504	46,418	186,667	0
Subregion[1]	8	2	1	4	1	1	1	NA
Region[2]	BA	A	A	SBA	FAA	FAA	FAA	NA

SPECIES	Loggerhead Beach (nests/km)	Diadromous Fish (# Spp/km)	Manatee (Avg. wtd. persistence)	Estuarine Fish (Score)	CONDITION	Shoreline/ Watershed (Score)
Value	0	0	2.47	0		36
Subregion[1]	NA	NA	5	NA		1
Region[2]	NA	NA	AA	NA		AA

RARE & EXEMPLARY FEATURES	Birds	Low Eutrophication	Low Pollution (sites/km^2)	Small Florida Lagoon (Rank)	CLIMATE CHANGE	SLR Vulnerability (% area < 0.5 m)
Value	None	Moderate Low	.0274	NA		50
Region[2]	NA	NA	BA	NA		AA

[1] *Numeric rank by Coastal Shoreline Unit (CSU) Type and Subregion*

[2] *Regional Z-Score:*

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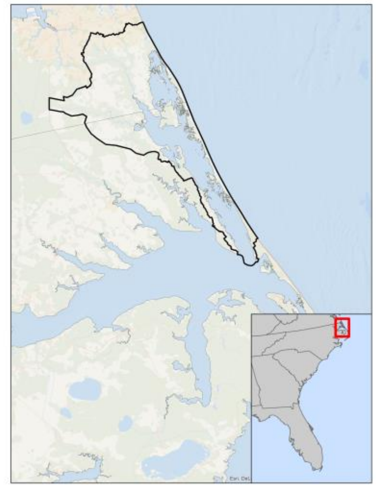
- SAA = Slightly Above Average
- A = Average
- SBA = Slightly Below Average
- BA = Below Average
- FBA = Far Below Average
- NA = Not applicable

Currituck Sound, North Carolina



- Subregion: Mid-Atlantic
- Type: Lagoonal
- Total area: 170,719 ha (113,524 land ha; 57,195 water ha)
- Cumulative Portfolio Score: 9, Average

HABITAT	Ocean Beach (ha)	Salt Marsh (ha)	Fresh Tidal Marsh (ha)	Tidal Forest (ha)	Mangrove (ha)	Tidal Flat (ha)	Seagrass (ha)	Intertidal Oysters (#)
Value	369	6236	6904	10,821	NA	339	8059	0
Subregion[1]	2	3	1	1	NA	2	2	NA
Region[2]	SAA	A	AA	AA	NA	A	SAA	NA

SPECIES	Loggerhead Beach (nests/km)	Diadromous Fish (# Spp/km)	Manatee (Avg. wtd. persistence)	Estuarine Fish (Score)	**CONDITION** Shoreline/ Watershed (Score)
Value	0	2.51	NA	8	19
Subregion[1]	NA	2	NA	3	3
Region[2]	NA	A	NA	SBA	SAA

RARE & EXEMPLARY FEATURES	Birds	Low Eutrophication	Low Pollution (sites/km^2)	Small Florida Lagoon (Rank)	**CLIMATE CHANGE** SLR Vulnerability (% area < 0.5 m)
Value	None	NA	.0108	NA	37
Region[2]	NA	NA	A	NA	AA

[1] *Numeric rank by Coastal Shoreline Unit (CSU) Type and Subregion*

[2] *Regional Z-Score:*

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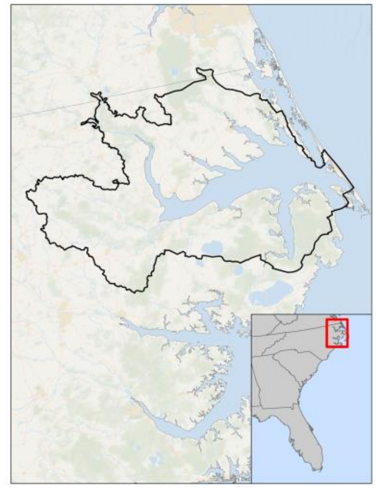
- AA = Above Average
- SAA = Slightly Above Average
- A = Average
- SBA = Slightly Below Average
- BA = Below Average
- FBA = Far Below Average
- NA = Not applicable

Albemarle Sound, North Carolina



- Subregion: Mid-Atlantic
- Type: Lagoonal
- Total area: 1,059,988 ha (842,761 land ha; 217,227 water ha)
- Cumulative Portfolio Score: 7, Average

HABITAT	Ocean Beach (ha)	Salt Marsh (ha)	Fresh Tidal Marsh (ha)	Tidal Forest (ha)	Mangrove (ha)	Tidal Flat (ha)	Seagrass (ha)	Intertidal Oysters (#)
Value	110	6256	724	4453	NA	211	3660	0
Subregion[1]	3	2	3	3	NA	3	3	NA
Region[2]	SBA	A	A	SAA	NA	SBA	SAA	NA

SPECIES	Loggerhead Beach (nests/km)	Diadromous Fish (# Spp/km)	Manatee (Avg. wtd. persistence)	Estuarine Fish (Score)	CONDITION	Shoreline/ Watershed (Score)
Value	0	3	NA	13		41
Subregion[1]	NA	1	NA	2		2
Region[2]	NA	A	NA	A		AA

RARE & EXEMPLARY FEATURES	Birds	Low Eutrophication	Low Pollution (sites/km^2)	Small Florida Lagoon (Rank)	CLIMATE CHANGE	SLR Vulnerability (% area < 0.5 m)
Value	None	NA	.0134	NA		27
Region[2]	NA	NA	A	NA		SAA

[1] *Numeric rank by Coastal Shoreline Unit (CSU) Type and Subregion*

[2] *Regional Z-Score:*

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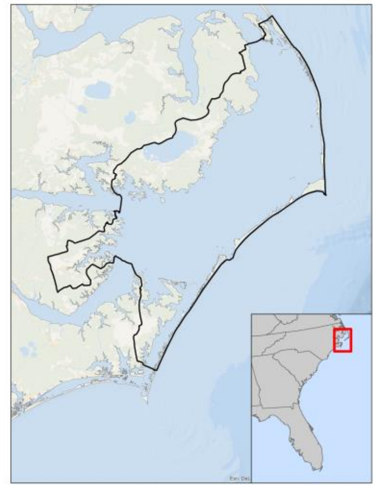
- AA = Above Average
- SAA = Slightly Above Average
- A = Average
- SBA = Slightly Below Average
- BA = Below Average
- FBA = Far Below Average
- NA = Not applicable

Pamlico Sound, North Carolina



- Subregion: Mid-Atlantic
- Type: Lagoonal
- Total area: 670,196 ha (179,298 land ha; 490,898 water ha)
- Cumulative Portfolio Score: 21, Far Above Average

HABITAT	Ocean Beach (ha)	Salt Marsh (ha)	Fresh Tidal Marsh (ha)	Tidal Forest (ha)	Mangrove (ha)	Tidal Flat (ha)	Seagrass (ha)	Intertidal Oysters (#)
Value	1513	36,536	1685	9697	NA	9828	42,358	0
Subregion[1]	1	1	2	2	NA	1	1	NA
Region[2]	FAA	AA	SAA	AA	NA	AA	AA	NA

SPECIES	Loggerhead Beach (nests/km)	Diadromous Fish (# Spp/km)	Manatee (Avg. wtd. persistence)	Estuarine Fish (Score)	CONDITION Shoreline/ Watershed (Score)
Value	0	2	NA	19	97
Subregion[1]	NA	3	NA	1	1
Region[2]	NA	A	NA	AA	FAA

RARE & EXEMPLARY FEATURES	Birds	Low Eutrophication	Low Pollution (sites/km^2)	Small Florida Lagoon (Rank)	CLIMATE CHANGE SLR Vulnerability (% area < 0.5 m)
Value	None	NA	.0090	NA	31
Region[2]	NA	NA	SAA	NA	AA

[1] *Numeric rank by Coastal Shoreline Unit (CSU) Type and Subregion*

[2] *Regional Z-Score:*

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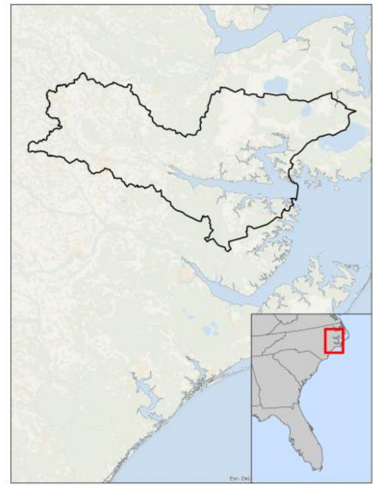
- AA = Above Average
- SAA = Slightly Above Average
- A = Average
- SBA = Slightly Below Average
- BA = Below Average
- FBA = Far Below Average
- NA = Not applicable

Tar River, North Carolina



- Subregion: Mid-Atlantic
- Type: Riverine (Piedmont Basin)
- Total area: 537,022 ha (483,464 land ha; 53,558 water ha)
- Cumulative Portfolio Score: 12, Slightly Above Average

HABITAT	Ocean Beach (ha)	Salt Marsh (ha)	Fresh Tidal Marsh (ha)	Tidal Forest (ha)	Mangrove (ha)	Tidal Flat (ha)	Seagrass (ha)	Intertidal Oysters (#)
Value	0	7478	936	4215	NA	24	770	0
Subregion[1]	NA	1	1	1	NA	2	1	NA
Region[2]	NA	A	SAA	SAA	NA	BA	A	NA

SPECIES	Loggerhead Beach (nests/km)	Diadromous Fish (# Spp/km)	Manatee (Avg. wtd. persistence)	Estuarine Fish (Score)	CONDITION Shoreline/ Watershed (Score)
Value	0	2.82	NA	11	9
Subregion[1]	NA	2	NA	2	2
Region[2]	NA	A	NA	A	A

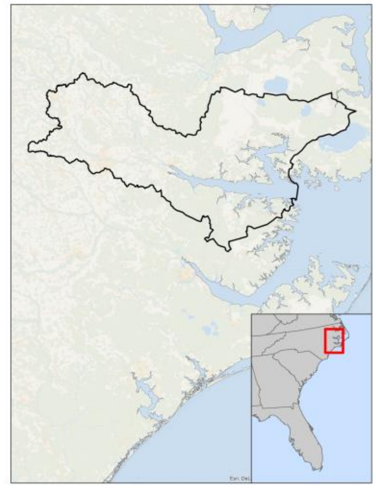
RARE & EXEMPLARY FEATURES	Birds	Low Eutrophication	Low Pollution (sites/km^2)	Small Florida Lagoon (Rank)	CLIMATE CHANGE SLR Vulnerability (% area < 0.5 m)
Value	None	NA	.0142	NA	14
Region[2]	NA	NA	A	NA	A

[1] *Numeric rank by Coastal Shoreline Unit (CSU) Type and Subregion*

[2] *Regional Z-Score:*

- FAA = Far Above Average
- AA = Above Average
- SAA = Slightly Above Average
- A = Average
- SBA = Slightly Below Average
- BA = Below Average
- FBA = Far Below Average
- NA = Not applicable

Neuse River, North Carolina



- Subregion: Mid-Atlantic
- Type: Riverine (Piedmont Basin)
- Total area: 478,649 ha (427,566 land ha; 51,083 water ha)
- Cumulative Portfolio Score: 9, Average

HABITAT	Ocean Beach (ha)	Salt Marsh (ha)	Fresh Tidal Marsh (ha)	Tidal Forest (ha)	Mangrove (ha)	Tidal Flat (ha)	Seagrass (ha)	Intertidal Oysters (#)
Value	0	5805	378	1069	NA	68	253	0
Subregion[1]	NA	2	2	2	NA	1	2	NA
Region[2]	NA	A	A	A	NA	BA	A	NA

SPECIES	Loggerhead Beach (nests/km)	Diadromous Fish (# Spp/km)	Manatee (Avg. wtd. persistence)	Estuarine Fish (Score)	**CONDITION** Shoreline/ Watershed (Score)
Value	0	3	NA	11	16
Subregion[1]	NA	1	NA	1	1
Region[2]	NA	A	NA	A	A

RARE & EXEMPLARY FEATURES	Birds	Low Eutrophication	Low Pollution (sites/km^2)	Small Florida Lagoon (Rank)	**CLIMATE CHANGE** SLR Vulnerability (% area < 0.5 m)
Value	None	High	.0072	NA	10
Region[2]	NA	NA	AA	NA	A

[1] *Numeric rank by Coastal Shoreline Unit (CSU) Type and Subregion*

[2] *Regional Z-Score:*
- FAA = Far Above Average
- AA = Above Average
- SAA = Slightly Above Average
- A = Average
- SBA = Slightly Below Average
- BA = Below Average
- FBA = Far Below Average
- NA = Not applicable