XV-51 Southeast U.S. Continental Shelf: LME #6

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The Southeast U.S. Continental Shelf LME extends from the Straits of Florida to Cape Hatteras, North Carolina in the Atlantic Ocean. It is characterised by its temperate climate. The LME has a surface area of about 300,000 km², of which 2.44% is protected, and contains 0.27% of the world's coral reefs and 18 estuaries and river systems (Sea Around Us 2007). It also contains many bays including the Albemarle-Pamlico Sound, the second largest estuary in the nation, nearshore and barrier islands, freshwater and estuarine habitats and extensive coastal marshes that provide unique habitats for living marine resources. A book chapter pertaining explicitly to this LME is by Yoder (1991).

I. Productivity

The Southeast U.S. Continental Shelf LME is considered a Class II, moderately productive ecosystem (150-300 $gCm^{-2}yr^{-1}$). Additional information is provided by NOAA statistics in Our Living Oceans (NOAA 1999). A chapter on marine resources for the southeast region (with the Gulf of Mexico LME and Caribbean islands), including information on status and trends of the nation's biological resources, primary and secondary productivity, benthic resources, fisheries resources, marine birds and marine mammals can be found at the USGS biology website. The North Carolina Albemarle-Pamlico Sound is one of the largest and most productive aquatic systems in North America. Upwelling along the Gulf Stream front and intrusions from the Gulf Stream cause short-lived plankton blooms. The offshore upwelling regime is not as intense as in the higher latitude regions (see Yoder 1991).

Oceanic Fronts (after Belkin et al. 2009)*:* Adjacent to this LME, the warm, saline, northward flowing Gulf Stream is bounded by two fronts (Figure XV-51.1). The inshore Gulf Stream Front (IGSF) extends over the upper continental slope and shelf break, approximately aligned with the 50-m isobath (Atkinson & Menzel 1985), while the offshore Gulf Stream Front (OGSF) runs parallel to the IGSF, approximately 100 km offshore of the latter.

This LME is radically different from the Northeast U.S. Continental Shelf LME, where the Shelf-Slope/Shelf Break Front is associated with a cold, fresh southward Slope Current. The Gulf Stream forms a semi-permanent offshore deflection near a deepwater bank SE of Charleston, NC, called the 'Charleston Bump' (CB), at 31.5°N in the Southeast Shelf LME. The Mid-Shelf Front (MSF) is aligned approximately with the 35-to-40 meter isobaths. Other shelf fronts separate a mixture of water masses formed by wintertime cold air outbreaks, river discharge, tidal mixing and wind-induced coastal upwelling (Pietrafesa *et al*. 1985, Belkin *et al*. 2009).

U.S. Southeast Shelf LME SST (after Belkin 2009)
Linear SST trend since 1957: -0.15°C.
Linear SST trend since 1982: 0.16°C.
The Southeast US Continental Shelf is one of a few LMEs that experienced long-term cooling since 1957. Like most LMEs, the Southeast US Continental Shelf first went through a cooling phase before switching to a warming phase in 1976. Warming over the last 25 years was small, just 0.16°C. Given 1976 as a well-defined break point, this warming would amount to 0.5°C. The 1976 breakpoint could be tentatively associated with a similar break point in 1976 in the Gulf of Mexico LME, however the latter breaking

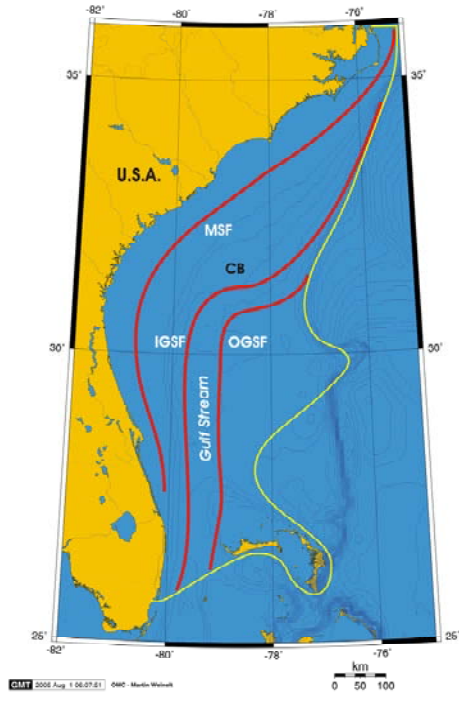

Figure XV-51.1. Fronts of the Southeast U.S. Continental Shelf LME. CB, Charleston Bump; IGSF, Inshore Gulf Stream Front; MSF, Mid-Shelf Front; OGSF, Offshore Gulf Stream Front. Yellow line, LME boundary. After Belkin et al. 2009.

point is not well defined. Nonetheless, the possible link between these LMEs cannot be dismissed since they are connected by the Gulf Stream flowing from the Gulf of Mexico past the Southeast US Shelf. Therefore, advection of SST anomalies from the Gulf of Mexico to the Southeast US Shelf is expected to play a key role in the thermal regime of the Southeast US Shelf. The two major SST peaks of 1961 and 1975 did not have immediate upstream precursors in the Gulf of Mexico. The 3-year time lag between the Gulf of Mexico SST peak of 1972 and the Southeast US Shelf SST peak of 1975 makes this connection tenuous. On the other hand, the 3-year time lag between the Gulf of Mexico and the Southeast US Shelf is consistent with the 3-year time lag between the Caribbean LME and the Gulf of Mexico.

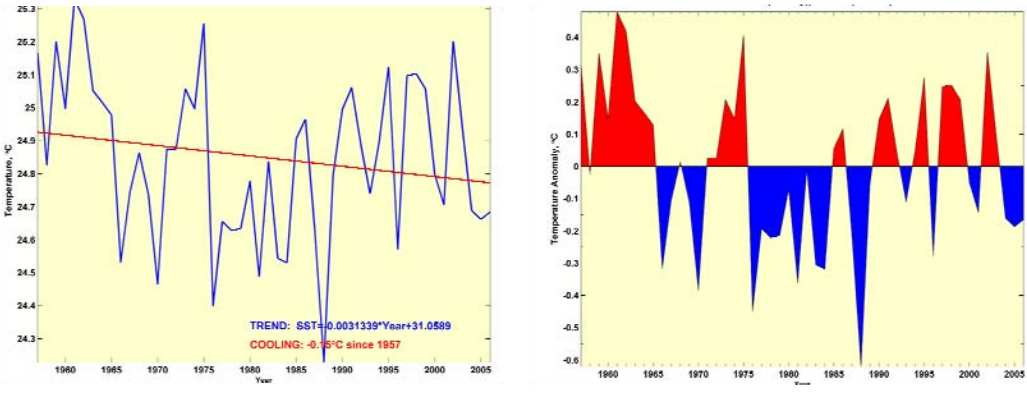

Figure XV-51.2. Southeast US Shelf LME annual mean SST and annual SST anomalies, 1957-2006, based on Hadley climatology. After Belkin 2009.

U.S. Southeast Shelf LME Chlorophyll and Primary Productivity: The Southeast U.S. Continental Shelf LME is considered a Class II, moderately productive ecosystem (150-300 $gCm^{-2}yr^{-1}$).

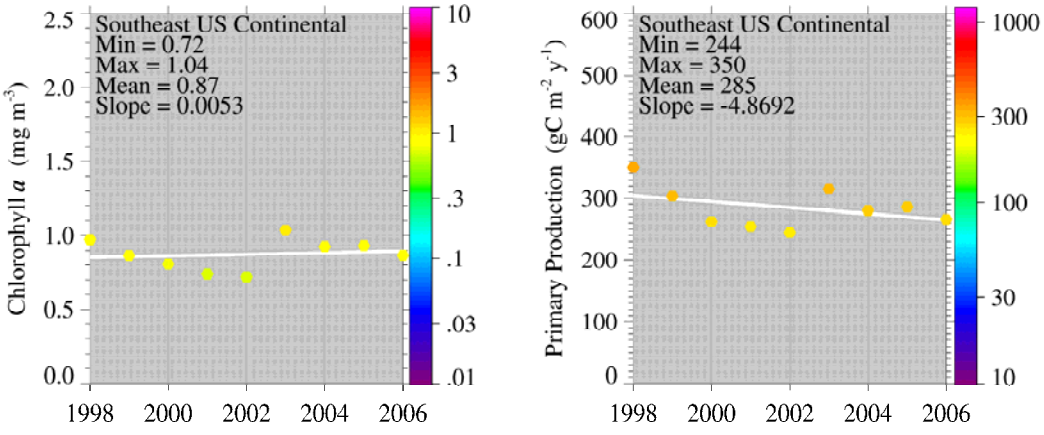

Figure XV-51.3. U.S. Southeast shelf LME trends in chlorophyll *a* and primary productivity, 1998-2006. Values are colour coded to the right hand ordinate. Figure courtesy of J. O'Reilly and K. Hyde. Sources discussed p. 15 this volume.

II. Fish and Fisheries

The estuaries support diverse aquatic organisms and complex food webs in a nursery system that promotes the recruitment and development of juvenile fish and invertebrate species important to recreational, commercial, and ecological interests (EPA 2004). The major species are coastal pelagics (mackerel, dolphinfish, and cobia), highly migratory pelagics (swordfish, tuna, albacore, marlin, sailfish, spearfish and sharks), Atlantic menhaden, invertebrates (shrimp, lobster, crab and conch), reef fish, drum and croaker, and Atlantic sharks. Major species landed include the coastal pelagic species, highly valued and sought after as game fish, the Atlantic highly migratory pelagic fish (especially yellowfin tuna), menhaden, and white and northern brown shrimps, centered off Georgia and the Carolinas. Shrimp stocks are affected by environmental conditions and by increased fishing pressure (NMFS 2009). Total reported landings increased from 1950, recording over 150,000 tonnes in 1981 and 1984, but have since declined to 62,000 tonnes in 2004 (Figure XV-51.4). There are major fluctuations in the landings of Atlantic menhaden, with peaks in the 1950s, drops in the late 1960s, another peak in 1983, followed by less than 2,000 tonnes landed in 1984 and 1997. Combined commercial and recreational landings of reef fishes have fluctuated since the 1970s, showing a slightly decreasing trend over time (EPA 2004). The value of the reported landings for the Southeast US Continental Shelf LME reached almost 400 million US$ (measured in year 2000 US$) in 1979, two-thirds of which was from the landings of crustaceans (Figure XV-51.5).

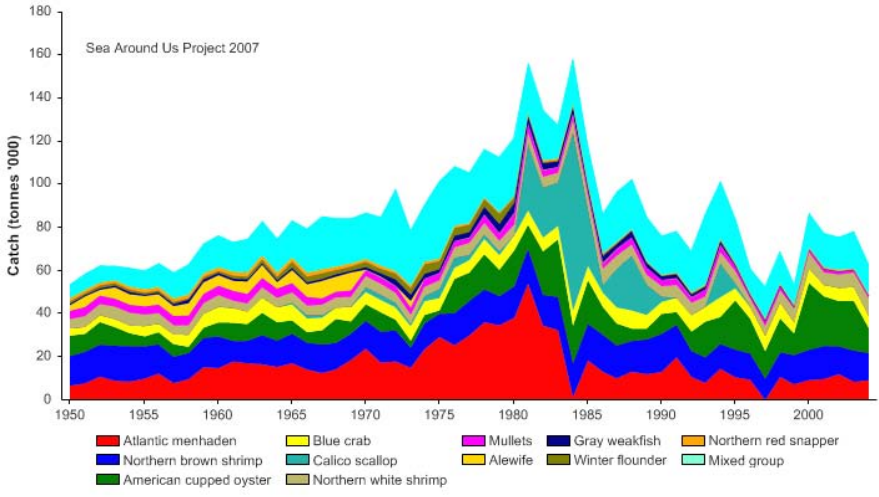

Figure XV-51.4. Total reported landings in the Southeast U.S. Continental Shelf LME by species (Sea Around Us 2007).

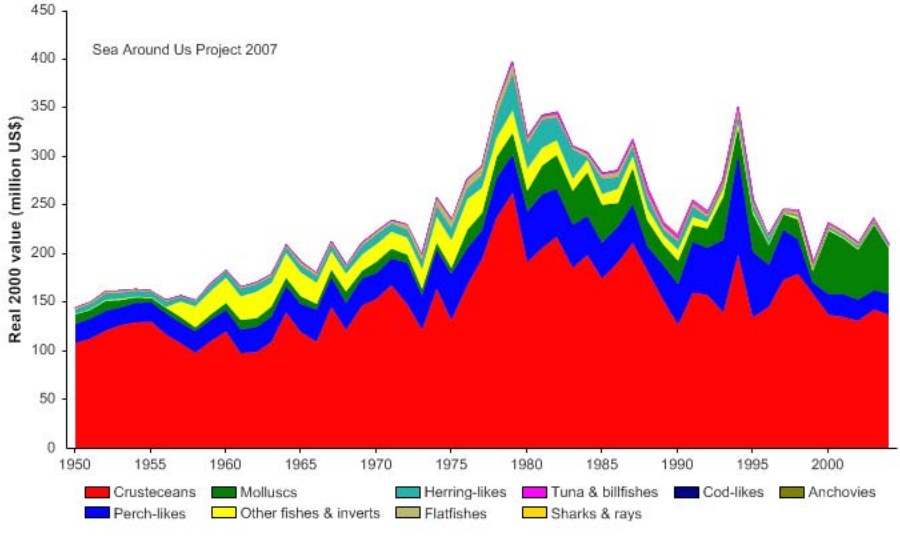

Figure XV-51.5. Value of reported landings in the Southeast U.S. Continental Shelf LME by commercial groups (Sea Around Us 2007).

The primary production required (PPR) (Pauly & Christensen 1995) to sustain the reported landings in the LME reached 6.5% of the observed primary production in 1980 but has not reached this level since (Figure XV-51.6. The US accounts for the largest share in this LME of the ecological footprint measured as the primary production required to support reported landings by countries.

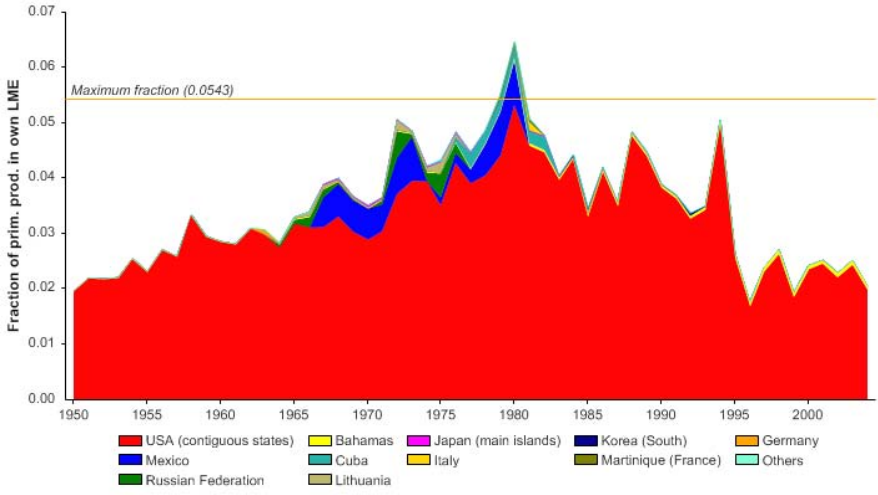

Figure XV-51.6. Primary production required to support reported landings (i.e., ecological footprint) as fraction of the observed primary production in the Southeast U.S. Continental Shelf LME (Sea Around Us 2007). The 'Maximum fraction' denotes the mean of the 5 highest values.

The mean trophic index (MTI) of the reported landings (Pauly & Watson 2005) shows a decreasing mean trophic level, though with some fluctuations (Figure XV-51.7 top). The trend becomes more pronounced when tuna landings are excluded and examined at a local level (see Figure 4 in Chuenpagdee *et al.* 2006). With the FiB index also declining sharply since the mid 1970s (Figure XV-51.7 bottom), the state of the LME can be diagnosed as undergoing a 'fishing down' of the food web (Pauly *et al.* 1998) with no increase in the landings to compensate for the decline in the mean trophic level of the catch.

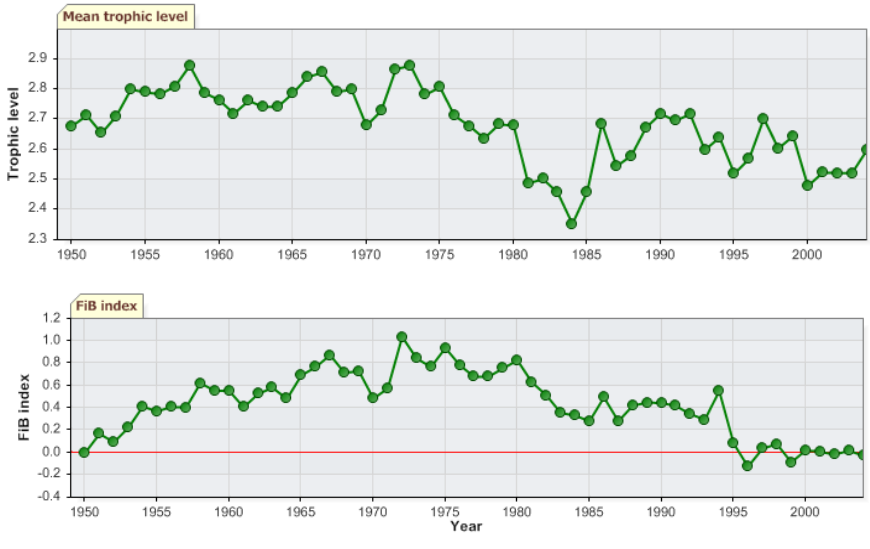

Figure XV-51.7. Mean trophic level (i.e., Marine Trophic Index) (top) and Fishing-in-Balance Index (bottom) in the Southeast U.S. Continental Shelf LME (Sea Around Us 2007).

The Stock-Catch Status Plots indicate that collapsed and overexploited stocks now account for over 80% of all commercially exploited stocks in the LME (Figure XV-51.8, top), with fully exploited stocks contributing more than half of the catch (Figure XV-51.8, bottom). The US National Marine Fisheries Service (NMFS) includes "overfished" but not "collapsed" in its stock status categories. Currently overfished are reef fishes (grouper, black sea bass, red porgy), highly migratory pelagic fisheries (albacore, blue marlin, bluefin tuna, yellowfin tuna, and sailfish,) and sciaenids such as red drum in some states. Bigeye tuna and swordfish are rebuilding (NMFS 2009). The populations of several species of sciaenids, most notably Atlantic croaker, appear to be closely linked to environmental conditions resulting in large annual fluctuations in population levels (EPA 2004). Removals of apex predators from the reef complex may result in shifts of species composition (i.e. trophic and ecological cascades) and increased variability in population dynamics of targeted species. Stock rebuilding plans are in effect for all reef fish species classified as overfished. The latest NMFS catch statistics indicate that commercial shrimp species are being harvested at maximum levels. Atlantic Spanish mackerel are considered to be at or near their full maximum fishery potential. Following declines in the abundance of large coastal sharks, new management measures to control catch levels were introduced in 1997.

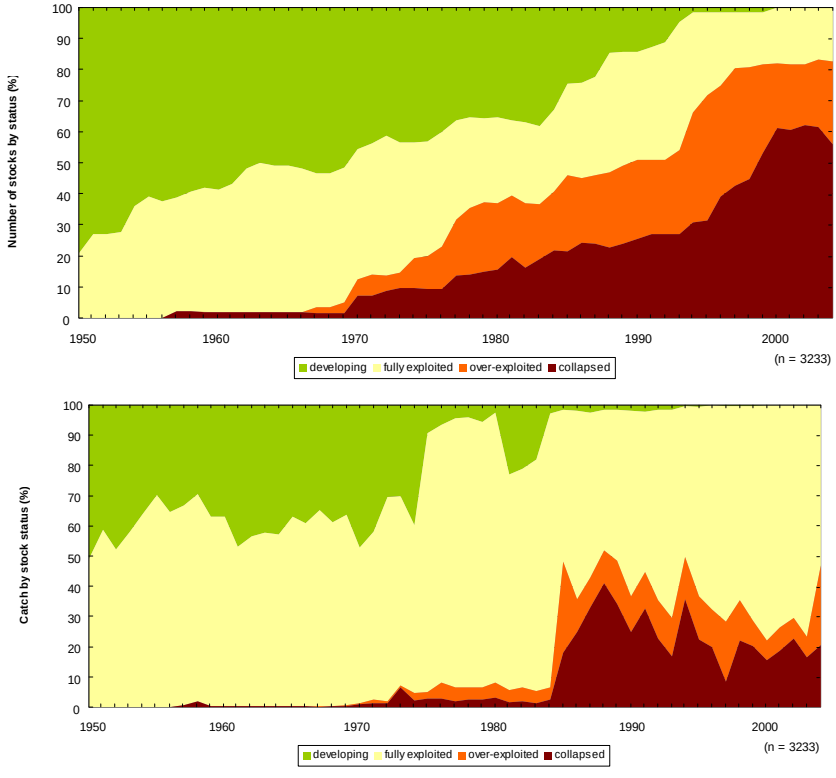

Figure XV-51.8. Stock-Catch Status Plots for the Southeast U.S. Continental Shelf LME, showing the proportion of developing (green), fully exploited (yellow), overexploited (orange) and collapsed (purple) fisheries by number of stocks (top) and by catch biomass (bottom) from 1950 to 2004. Note that (n), the number of 'stocks', i.e., individual landings time series, only include taxonomic entities at species, genus or family level. Higher and pooled groups have been excluded (see Pauly *et al*, this vol. for definitions).

Our Living Oceans (NOAA 1999) has statistics on landings of blue crab, sea urchin and oyster from the Atlantic coast, and landings and spawning biomass for menhaden from 1950 to 1997 (NOAA 1999, p. 141). The 2008 (quarterly) NOAA Status of U.S. Fisheries

Report to Congress (www.noaa.gov) contains the status (fished or overfished) of selected species. The annual report on fishery landings in the US provided by the NOAA-Fisheries Office of Science and Technology can be found at www.st.nmfs.noaa.gov. Information on large marine ecosystem fisheries is available in EPA 2004. This includes reef fish resources (see graph of coast reef fish landings, 1978-2000) as well as sciaenid, menhaden, mackerel and shrimp fisheries. The Georgia Department of Natural Resources Red Drum Project highlights the importance of habitat for all life stages of red drum (EPA 2004), an important fishery resource along the Atlantic coast since the late 1800s. Currently, these fish species support substantial harvests for both commercial and recreational fisheries and are captured in almost every type of gear used to fish the coastal waters of this LME.

III. Pollution and Ecosystem Health

The dynamic fringe of estuaries varies constantly with tidal fluctuations and levels of runoff, and it serves as an important habitat for waterfowl, reptiles, mammals, fish and invertebrates, as well as a diversity of plants. It also serves as a natural filter to remove pollutants and sediments from upland regions (EPA 2004). Species such as shrimps, crabs and menhaden, which account for much of the catch in this LME, are estuarine-dependant. There are habitat concerns impacting many of the Southeast invertebrate fishery resources. Additional studies are needed to further assess the impacts of human-induced changes in habitat availability, environmental conditions, predator abundance, and pollution in nursery areas. Florida spiny lobsters depend on reef habitat and shallow water algal flats for feeding and reproduction, but these habitat requirements can conflict with expanding coastal development in the region. The small mesh used in shrimp trawls can catch non-target species such as sea turtles, red snappers, croakers, seatrouts, and other species (NMFS 2009). All sea turtle species are listed as endangered or threatened under the Endangered Species Act. Shrimp vessels are required to use turtle excluder devices in their nets since 1988.

Of the regularly monitored U.S. Continental Shelf LMEs, the Southeast U.S. Continental Shelf LME has the best ecological condition. The U.S. EPA provides data on environmental stressors (water quality, sediment quality and tissue bioaccumulation) throughout the U.S. See EPA (2001, 2004) for the coastal condition of the Southeast region, which includes this LME. In 2001, the index for dissolved oxygen and fish tissue condition was good. Water clarity, coastal wetlands, eutrophic condition, sediment and benthos were fair (see EPA's 7 primary indicators in EPA 2001). The condition of the southeastern estuaries was fair. Approximately 54% of estuarine areas are in good ecological condition (EPA 2001, EPA 2004), based on five primary indicators: water quality (rated fair to good); sediment quality (rated fair to good); benthic index (fair); coastal habitat index (fair); and fish tissue index (good). The Albemarle-Pamlico Estuarine System's resources are threatened by increased pollution from urban and agricultural development in its watersheds (EPA 2004). For estimates of coastal wetland habitat loss from 1780 to 1980, see EPA (2001). By 1980, 40% of all wetlands existing in 1780 had disappeared.

The increasing population growth could contribute to increased water quality degradation in this region. A primary problem is sediment contamination by pesticides and metals. Municipal wastewater treatment plants and pesticides applied to agricultural lands are sources of coastal pollution. NOAA's National Status and Trends program provides data on toxic contaminants and their ecological effects. See EPA 2004 (www.epa.gov/) for information on South Carolina's Estuarine and Coastal Assessment Program which monitors the biological condition of 60 sites throughout the state's coastal zone (p.119), comparing and predicting PAH concentrations in urban and non-urban settings in South Carolina (p. 120), Clean Water Act assessments, and fish consumption and beach

advisories. In 2002, 15% of beached were affected by advisories or closures. The reasons were pre-emptive closure because of rainfall (24%), or elevated bacteria levels (75%).

IV. Socioeconomic Conditions

The Southeast U.S. Continental Shelf LME contains a wealth of resources including both commercial and recreational fisheries. Bycatch of Atlantic highly migratory species, and increasing numbers of recreational spiny lobster participants, cause conflicts between commercial and recreational fisheries and reduce the impact of conservation efforts. Other resources and economic activities in the LME include barrier islands such as North Carolina's outer banks, and busy shipping ports in Miami and Jacksonville, Florida, Savanna, Georgia, and Charleston, South Carolina. Non-consumptive uses of reef resources (e.g. ecotourism, sport diving, education, and scientific research) are economically important and may conflict with traditional commercial and recreational fisheries. Balancing the competing interests of these user groups is an important management issue.The Albemarle-Pamlico Sound is North Carolina's key resource base for commercial and recreational fishing and tourism. This resource and other coastal resources of the Southeast Coast states generate vast amounts of sales tax income for those states (EPA 2004).

Fishing pressure has increased over time in correlation with growing human populations, greater demands for sea food, and technological improvements in gear, electronic fish finders, and navigational aids. The coastal population has shown a growth rate of almost 2% per year (EPA 2004). The population increase amounted to 64% between 1970 and 1990 (U.S. Census Bureau 1996). In 1999, the southern region of the U.S. was the most populous area of the nation, accounting for 96 million residents. Florida was among the five most populous states in 1999 (U.S. Census Bureau 2001). The influx of people and businesses to this region, and added pressure on the coastal zone, will require additional programs and more environmental awareness in order to correct existing problems of ecosystem health.

V. Governance

The South Atlantic Fisheries Management Council (SAFMC) manages this LME's fish stocks in collaboration with the NMFS Southeast Fisheries Centre within the US Exclusive Economic Zone (EEZ), seaward of territorial waters out to 200 miles from the shore. Coastal pelagic fishes are jointly managed under the Coastal Migratory Pelagic Resources Fishery Management Plan and the regulations adopted by the SAFMC. Management regulations have included total allowable catches (TACs) and minimum size restrictions. Effective management of migratory coastal pelagic species will continue to require the coordination of Federal and state regulatory agencies in North Carolina, South Carolina, Georgia and Florida. US fleets for highly migratory pelagic fisheries operating in this LME are regulated under the Magnuson-Stevens Fishery Conservation and Management Act and the Atlantic Tunas Convention Act (ATCA). Management of Atlantic tunas and swordfish in US waters are based largely on recommendations by the International Commission for the Conservation of Atlantic Tunas (ICCAT). Some shark species are included in the International Union for the Conservation of Nature (IUCN) Red List of Threatened Species as vulnerable. Because Atlantic menhaden migrates long distances, interstate coordination of fishery management is required (NMFS 2009). Specific fishery management plans, including for the shrimp fishery, are available in Our Living Oceans (NOAA 1999). MPAs are used as management tools for deepwater species of reef fish. There is an increasing need for effective management of these resources given the predicted influx of people to the LME boundary coastal states (EPA 2001).

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