5.0 LIFE HISTORY ACCOUNTS AND EFH DESCRIPTIONS AND MAPS

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5.0 ESSENTIAL FISH HABITAT

This section fulfills the requirements for the EFH identification and designation component of FMPs, as described in 50 CFR 600.759. Since this document serves as an integrated document for purposes of both the Magnuson-Stevens Act and the National Environmental Policy Act, it should be noted that this chapter describes EFH in accordance with Alternative 3 of the FEIS, which is identified as the agency's preferred alternative.

5.1 Life History Accounts and Essential Fish Habitat Descriptions

5.1.1 Tuna

5.1.1.1 Atlantic Albacore Tuna

Atlantic Albacore Tuna (*Thunnus alalunga*) Albacore tuna is a circumglobal species. Its life cycle is poorly known (Santiago and Arrizabalaga, 2005). In the western, Atlantic albacore tuna range from 40° to 45°N, to 40°S. It is an epipelagic, oceanic species generally found in surface waters with temperatures between 15.6° and 19.4°C, although larger individuals have a wider depth and temperature range (13.5° to 25.2°C). Albacore may dive into cold water (9.5°C) for short periods. However, they do not tolerate oxygen levels lower than two milliliter/liter (ml/l). Albacore tuna undergo extensive horizontal movements. Aggregations are composed of similarly sized individuals with groups comprised of the largest individuals making the longest journeys. Aggregations of albacore tuna may include other tuna species such as skipjack, yellowfin and bluefin tuna. North Atlantic and South Atlantic stocks are considered separate, with no evidence of mixing between the two (ICCAT, 1997; Collette and Nauen, 1983).

Predator-prey relationships: Albacore tuna forage from epipelagic to upper mesopelagic waters, down to a depth of 500 m (Consoli *et al*., 2008). A wide variety of fishes and invertebrates have been found in the few stomachs of albacore tuna that have been examined. As with other tuna, albacore probably exhibit opportunistic feeding behavior, with little reliance on specific prey items (Dragovich, 1969; Matthews *et al*., 1977). Consoli *et al.* (2008) assessed feeding habits in Mediterranean albacore tuna where the results showed that the species is a top pelagic predator that consumes primarily medium sized fish and secondarily cephalopods. The diet consisted of a limited number of taxa and a constant size prey that did not vary over the course of the study, indicating a limited trophic niche width.

Life history: Albacore tuna spawn in the spring and summer in the western tropical Atlantic (ICCAT, 1997). They are assumed to spawn in waters around the Sargasso Sea and adjacent waters (Santiago and Arrizabalaga, 2005). Larvae have also been collected in the Mediterranean Sea and historically in the Black Sea (Vodyanitsky and Kazanova, 1954). The central Atlantic is the wintering area for albacore tuna, and the feeding migration of juveniles (up to age 5) to the productive waters in the northeastern Atlantic occurs in the summer while adults make the spawning migration. However, adults are also caught in feeding areas of the northeastern Atlantic, especially in September and October, and some juveniles are also caught in the western Atlantic (Santiago and Arrizabalaga, 2005).

Fisheries: For assessment purposes, three stocks of albacore tuna are assumed: North and South Atlantic stocks (separated at 5°N) and a Mediterranean stock (SCRS, 1997). In the North Atlantic albacore are taken by surface and longline fisheries. Surface fisheries target juveniles at 50 to 90 cm fork length (FL), and longlines catch sub-adult and adult fish at 60 to120 cm FL.

U.S. Fishery Status: North Atlantic albacore tuna is overfished with overfishing occurring; South Atlantic albacore tuna is not overfished and overfishing is not occurring.

Growth and mortality: The maximum size of albacore tuna has been reported at 127 cm FL (Collette and Nauen, 1983). For both sexes sexual maturity is reached at five years at 90 to 94 cm FL (Collette and Nauen, 1983; ICCAT, 1997). Mortality is higher for females (Collette and Nauen, 1983).

Essential Fish Habitat for Albacore Tuna:

- **Spawning, eggs, and larvae:** At this time, available information is insufficient for the identification of EFH for this life stage within the U.S. EEZ

- **Juveniles (<90 cm FL):** Offshore the U.S. east coast from north of Cape Hatteras to Cape Cod. Mid-east coast of Florida. Please refer to Figure 5.1 for detailed EFH map.

- **Adults (≥90 cm FL):** Central Gulf of Mexico, mid-east coast of Florida, and Puerto Rico. Atlantic east coast from North Carolina, south of Cape Hatteras to Cape Cod. Please refer to Figure 5.2 for detailed EFH map.

5.1.1.2 Atlantic Bigeye Tuna

Atlantic Bigeye Tuna (*Thunnus obesus*) Scientific knowledge of Atlantic bigeye tuna is limited. Its range is almost the entire Atlantic Ocean from 50°N to 45°S. It is rarely taken in the Gulf of Mexico, and some of the points currently included in the EFH maps may require further validation (J. Lamkin, pers. comm.). Although its distribution with depth in the water column varies, it is regularly found in deeper waters than are other tuna, descending to 300 to 500 m and then returning regularly to the surface layer (Musyl *et al*., 2003). Bigeye tuna can tolerate water with temperatures as low as 5°C and dissolved oxygen levels of less than 3.5 ml/l (Brill *et al*., 2005). Smaller fish are probably restricted to the tropics, while larger individuals migrate to temperate waters. There is probably one population in the Atlantic Ocean (ICCAT, 1997). Young bigeye tuna form schools near the sea surface, mixing with other tuna such as yellowfin and skipjack tuna (Collette and Nauen, 1983).

Predator-prey relationships: The diet of bigeye tuna includes fishes, cephalopods and crustaceans (Dragovich, 1969; Matthews *et al.*, 1977). Predators include large billfishes and toothed whales (Collette and Nauen, 1983).

Life history: Bigeye tuna probably spawn between 15°N and 15°S. A nursery area is known to exist in the Gulf of Guinea (Richards, 1969) off the coast of Africa where larvae have been collected below the 25°C isotherm (Richards and Simmons, 1971). Peak spawning here occurs in January and February, whereas in the northwestern tropical Atlantic spawning occurs in June and July (SCRS, 1978, 1979). The collection of larvae in U.S. waters has not been confirmed.

Fisheries: The bigeye tuna stock has been exploited using three major gear types - longline, baitboat, and purse seine - and by many countries throughout its range of distribution. ICCAT currently recognizes one stock for management purposes, based on time/area distribution of fish and movements of tagged fish. However, other possibilities such as distinct northern and southern stocks should not be disregarded (SCRS, 1997).

U.S. Fishery Status: Overfished and overfishing is occurring.

Growth and mortality: Growth rate for bigeye tuna is believed to be rapid. Sexual maturity is attained around three and a half years old, at approximately 115 cm FL (Fromentin and Fonteneau, 2001).

Habitat associations: Juvenile bigeye tuna form schools near the surface, mostly mixed with other tuna such as yellowfin and skipjack. These schools often associate with floating objects, whale sharks and sea mounts. These associations weaken as bigeye tuna mature (ICCAT, 2008a).

Essential Fish Habitat for Bigeye Tuna:

- **Spawning, eggs and larvae:** Information is insufficient for the identification of EFH for this life stage within the U.S. EEZ; although it cannot be identified as EFH under the Magnuson-Stevens Act because it is located outside the U.S. EEZ, the Gulf of Guinea, off the coast of Africa, is identified as important habitat for spawning adults, eggs and larvae. Matsumoto and Miyabe (2001) identified spawning sites offshore Dakar, Africa in the Atlantic Ocean just south of the Cape Verde islands.

- **Juveniles (<100 cm FL):** In the Gulf of Mexico south of Louisania and Mississippi, off the southern west coast of Florida, and south of the Florida Keys; as well as in the Atlantic off the Florida east coast through South Carolina, and from North Carolina, south of Cape Hatteras, to Cape Cod. Puerto Rico and the Virgin Islands. Please refer to Figure 5.3 for detailed EFH map.

- **Adults (≥100 cm FL):** In the central Gulf of Mexcio and the mid-east coast of Florida. Atlantic east coast from Cape Hatteras to Cape Cod. Please refer to Figure 5.4 for detailed EFH map.

5.1.1.3 Atlantic Bluefin Tuna

Atlantic Bluefin Tuna (*Thunnus thynnus*) Atlantic bluefin tuna are managed as distinct western and eastern stocks separated by a management boundary at the 45°W meridian. In the western North Atlantic, bluefin tuna range from 45°N to 0° (Collette and Nauen, 1983).

However, they have recently been found up to 55°N in the western Atlantic (Vinnichenko, 1996). Bluefin tuna move seasonally from spring (April to June) spawning grounds in the Gulf of Mexico through the Straits of Florida to feeding grounds off the northeast U.S. coast (Mather *et al.*, 1995; Block *et al.*, 2005). It is believed that there is a single stock which ranges from Labrador and Newfoundland south into the Gulf of Mexico and the Caribbean, and also off Venezuela and Brazil. The Labrador Current may separate this western stock from that found in the eastern Atlantic (Tiews, 1963; Mather *et al.*, 1995; ICCAT, 1997).

The prevailing assumption is that mature western bluefin tuna follow an annual cycle of foraging in June through March off the eastern United States and Canadian coasts, followed by migration to the Gulf of Mexico to spawn in April, May, and June (Mather *et al.*, 1995; Block *et al.*, 2005). Recent electronic tagging has confirmed two populations of Atlantic bluefin tuna that overlap on North Atlantic Ocean foraging grounds and sort to independent spawning areas located primarily in the Gulf of Mexico and Mediterranean Sea (Block *et al.*, 2005). After leaving the western spawning areas, bluefin tuna move to waters overlying the North American continental shelf, slope, and Gulf Stream waters, the South and Mid-Atlantic Bight, the Gulf of Maine, and the Nova Scotia Shelf (Block *et al.*, 2005). Bluefin tuna were also documented moving to the central North Atlantic in the vicinity of 40°W, east of the Flemish Cap (Block *et al.*, 2005). Fish identified as western spawners can move to the eastern Atlantic and back, crossing the 45°W meridian several times over the course of one or more years. The overlap areas identified in the central and eastern Atlantic seem to be foraging areas for these western spawners (Block *et al.*, 2005). However, bluefin tuna smaller than 200 cm curved fork length (CFL) did not enter identified spawning areas, and most of these fish remained west of 45°W throughout the year (Block *et al.*, 2005).

Additionally, electronically tagged fish in the western Atlantic showed transatlantic migrations to the Mediterranean Sea (Block *et al.*, 2005). These fish resided in the western Atlantic foraging grounds for 0.5 to 3 years before migrating to the Balearic Islands or the Tyrrhenian and/or Ionian seas (Block *et al.*, 2005). Western-tagged fish recaptured in the Mediterranean Sea seem to be returning to natal spawning areas in the Mediterranean after sharing feeding grounds in U.S. coastal waters (Rooker and Secor, 2004; Block *et al.*, 2005).

Bluefin tuna distributions are probably constrained by the 12° C isotherm, although individuals can dive to 6° to 8°C waters to feed (Tiews, 1963). Year-to-year variations in movements have been noted (Mather *et al.*, 1995). While bluefin tuna are epipelagic and usually oceanic, they do come close to shore seasonally (Collette and Nauen, 1983). They often occur over the continental shelf and in embayments, especially during the summer months when they feed actively on herring, mackerel, and squids in the north Atlantic. Larger individuals move into higher latitudes than do smaller fish. Bluefin tuna are often found in mixed schools with skipjack tuna, these schools consisting of similarly sized individuals (Tiews, 1963).

Predator-prey relationships: Bluefin tuna larvae initially feed on zooplankton but switch to a piscivorous diet at a relatively small size. Small bluefin tuna larvae prey on other larval fishes and are subject to the same predators as these larvae, primarily larger fishes and gelatinous zooplankton (McGowan and Richards, 1989). Adults are opportunistic feeders, preying on a variety of schooling fish, cephalopods, and benthic invertebrates, including silver hake, Atlantic mackerel, Atlantic herring, krill, sandlance, and squid (Dragovich, 1969, 1970a;

Mathews *et al.*, 1977; Estrada et. al., 2005). Predators of adult bluefin tuna include toothed whales, swordfish, and sharks (Tiews, 1963; Chase, 2002).

Life history: Western North Atlantic bluefin tuna spawn from April to June in the Gulf of Mexico, Bahamas, and in the Florida Straits (Baglin, 1982; Richards, 1976, 1990; McGowan and Richards, 1989; Block *et. al*., 2005). Although individuals may spawn more than once a year, it had been assumed that there is a single annual spawning period. However, recent tagging data and the presence of small (<235 cm CFL) sexually mature females in the Gulf of Maine in June and July suggests that either individual bluefin tuna do not spawn on an annual cycle (Lutcavage *et al*., 1999; Block *et al*., 2005; Fromentin and Powers, 2005; Goldstein *et al*., 2007), or a component of the western stock is spawning somewhere other than the Gulf of Mexico (*e.g.*, in the central North Atlantic or Gulf Stream edge) (Mather *et al*., 1995; Lutcavage *et al*., 1999; Goldstein *et al*., 2007). Larvae have been confirmed from the Gulf of Mexico (Richards, 1991) and have been found as far north as the Carolinas, although their presence was associated with advection from the Florida Straits and not from offshore spawning (McGowan and Richards, 1989). Most of the larvae found were located around the 1,000 fathom curve in the northern Gulf of Mexico, with some sporadic collections off Texas. In the Florida Straits they are primarily collected along the western edge of the Florida Current, suggesting active transport from the Gulf of Mexico. This would also explain their occasional collection off the southeast United States.

Atlantic bluefin tuna have not been observed spawning (Richards, 1991); however recent work has identified putative breeding behaviors by bluefin tuna while in the Gulf of Mexico (Teo *et al*., 2007a; 2007b). Presumed Atlantic bluefin tuna breeding behaviors were associated with bathymetry, sea surface temperature, eddy kinetic energy, surface chlorophyll, and surface wind speed (Teo *et al*., 2007b). Presumed breeding bluefin tuna preferred continental slope waters with moderate sea surface temperatures, moderate eddy kinetic energy, low surface chlorophyll concentrations, and moderate wind speeds (Teo *et al*., 2007b).

It appears that larvae are generally retained in the Gulf of Mexico until they grow into juveniles; in June, young-of-the-year begin movements in schools to juvenile habitats (McGowan and Richards, 1989) thought to be located over the continental shelf around 34°N and 41°W in the summer and further offshore in the winter. Also, they have been identified from the Dry Tortugas area in June and July (Richards, 1991; ICCAT, 1997). Juveniles migrate to nursery areas located between Cape Hatteras, North Caroliona and Cape Cod, Massachusetts (Mather *et al*., 1995). Mixed-stock analysis indicated that approximately 60 percent of the adolescent bluefin tuna collected from foraging areas in the Atlantic Ocean off the United States originated from the eastern nursery, suggesting that substantial trans-Atlantic movement of adolescents from east to west occurred (Rooker *et al*., 2008). In addition, natal homing was well developed, with 94 percent of the adult bluefin tuna collected in the Mediterranean Sea derived from the eastern nursery (Rooker *et al*., 2008). Rooker *et al*. (2008) suggest that the U. S. fisheries depend upon migrants of Mediterranean origin and that mixing across the 45°W management boundary is substantially higher than previously assumed.

Fisheries: Atlantic bluefin tuna are caught using a wide variety of gear types, including longlines, purse seines, traps, and various handgears. ICCAT recognizes two management units of Atlantic bluefin, one in the eastern and one in the western Atlantic; however, some mixing is probably occurring, as fish tagged in one location have been retrieved in the other (Block *et. al*., 2005). These management units are divided as follows: North of 10° N they are separated at 45°W; below the equator they are separated at 25° W, with an eastward shift between those parallels (SCRS, 1997). The effects of reduced stock size on distribution and habitat use is unknown at this time.

U.S. Fishery Status: Overfished, and overfishing is occurring.

Growth and mortality: Bluefin tuna can grow to more than 650 kg in weight and 300 cm in length, with no apparent difference between the growth rates of males and females (Mather *et al.*, 1995); however recent work by Neilson and Campana (2007) suggest that the growth curve most commonly used to assign ages for the western Atlantic stock may have shifted, which could result in growth curves needing to be adjusted for this species (Restrepo *et al*., 2007). Maximum age is estimated to be more than 20 years, with sexual maturity reached at approximately 196 cm (77 inches) FL and a weight of approximately 145 kg (320 lb). However, smaller mature females (185 cm CFL) have been observed in the Gulf of Maine in June and July (Goldstein *et al*., 2007). The length at age are similar between the western Atlantic and Mediterranean Sea bluefin tuna, but age at maturity is believed to be different (A. Boustany, Pers. Comm.) It is believed that the western Atlantic stock matures at age 8 to10 (Turner *et al*., 1991). The mean age of electronically tagged bluefin tuna in the spawning grounds of the Gulf of Mexico are ages 11 and above (≥ 241 cm CFL) (Block *et al*., 2005). In addition, recent analyses on longline data in the Gulf of Mexico estimate the age of 50 percent maturity to be 12 years (Diaz and Turner, 2007). However, the sizes of fish in the Gulf of Mexico in April and May may not accurately represent the spawning size range of the population as a whole (Goldstein *et al*., 2007). In addition, bluefin tuna in the western Atlantic mature more slowly than those in the eastern Atlantic and are believed to grow more slowly and reach a larger maximum size (SCRS, 1997). The rapid larval growth rate is estimated as one mm/day up to 15 mm, the size at transformation (McGowan and Richards, 1989).

Habitat associations: It is believed that there are probably certain features of the bluefin tuna larval habitat in the Gulf of Mexico which determine growth and survival rates, and that these features show variability from year to year, perhaps accounting for a significant portion of the fluctuation in yearly recruitment success (McGowan and Richards, 1989). The habitat requirements for larval success are not known, but larvae are collected within narrow ranges of temperature and salinity - approximately 26°C and 36 ppt. Along the coast of the southeastern United States onshore meanders of the Gulf Stream can produce upwelling of nutrient rich water along the shelf edge. In addition, compression of the isotherms on the edge of the Gulf Stream can form a stable region which, together with upwelling nutrients, provides an area favorable to maximum growth and retention of food for the larvae (McGowan and Richards, 1989). Size classes used for habitat analysis for bluefin tuna are based on the sizes at which they shift from a schooling behavior to a more solitary existence. Bluefin tuna have traditionally been grouped by small schooling, large schooling, and giant size classes. Future analyses should more fully evaluate habitat differences between the traditional size classes, if the data are available.

Essential Fish Habitat for Atlantic Bluefin Tuna:

- **Spawning, eggs, and larvae:** In the Gulf of Mexico from the 100 meter depth contour to the EEZ , continuing to the mid-east coast of Florida as shown in Figure 5.5.

- **Juveniles (<231 cm FL):** In waters off North Carolina, south of Cape Hatteras, to Cape Cod. Please refer to Figure 5.6 for detailed EFH map.

- **Adults (≥231 cm FL):** In pelagic waters of the central Gulf of Mexcio and the mid-east coast of Florida. North Carolina from Cape Lookout to Cape Hatteras, and New England from Connecticut to the mid-coast of Maine. Please refer to Figure 5.7 for detailed EFH map.

5.1.1.4 Atlantic Skipjack Tuna

Atlantic Skipjack Tuna (*Katsuwonus pelamis*) Skipjack tuna are circumglobal in tropical and warm-temperate waters, generally limited by the 15°C isotherm. In the western Atlantic skipjack range as far north as Newfoundland (Vinnichenko, 1996) and as far south as Brazil (Collette and Nauen, 1983). Skipjack tuna are an epipelagic and oceanic species and may dive to a depth of 260 m during the day. Skipjack tuna is also a schooling species, forming aggregations associated with hydrographic fronts (Collette and Nauen, 1983). There has been no trans-Atlantic recovery of tags; eastern and western stocks are considered separate (ICCAT, 1997).

Predator-prey relationships: Skipjack tuna is an opportunistic species which preys upon fishes, cephalopods and crustaceans (Dragovich, 1969, 1970b; Dragovich and Potthoff, 1972; Collette and Nauen, 1983; ICCAT, 1997). Predators include other tuna and billfishes (Collette and Nauen, 1983). Skipjack tuna are believed to feed in surface waters, however they are caught as bycatch on longlines at greater depths. Stomach contents often include *Sargassum* or *Sargassum* associated species (Morgan *et al.*, 1985).

Life history: Skipjack tuna spawn opportunistically in equatorial waters throughout the year and in subtropical waters from spring to early fall (Collette and Nauen, 1983). Larvae have been collected off the east coast of Florida from October to December (Far Seas Fisheries Research Lab, 1978) and in the Gulf of Mexico and Florida Straits from June to October. However, most spawning takes place during summer months in the Caribbean, off Brazil (with the peak in January through March), in the Gulf of Mexico (April to May), and in the Gulf of Guinea (throughout the year) (Richards, 1969; SCRS, 1978/79).

Fisheries: This fishery is almost exclusively a surface gear fishery, although some skipjack tuna are taken as longline bycatch. Most skipjack tuna are taken in the eastern Atlantic and off the coast of Brazil, most recently with the use of floating objects to attract them. These floating objects have been identified to possibly affect migration patters and cause poor growth rates (ICCAT, 2008b). ICCAT assumes two management units for this species (eastern and western) due to the development of fisheries on both sides of the Atlantic and to the lack of transatlantic tag recoveries.

U.S. Fishery Status: Unknown.

Growth and mortality: Maximum size of skipjack tuna is reported at 108 cm FL and a weight of 34.5 kg. Size at sexual maturity is 45 cm (18 inches) for males and 42 cm for females. This size is believed to correspond to about 1 to 1.5 years of age, although significant variability in interannual growth rates makes size-to-age relationships difficult to estimate (Collette and Nauen, 1983; ICCAT, 1997). Growth rate is variable and seasonal, with individuals from the tropical zone having a higher growth rate than those from the equatorial zone (SCRS, 1997). Life span is estimated to be eight to 12 years (Collette and Nauen, 1983).

Habitat associations: Aggregations of skipjack tuna are associated with convergences and other hydrographic discontinuities. Also, skipjack tuna associate with birds, drifting objects, whales, sharks and other tuna species (Colette and Nauen, 1983). The optimum temperature for the species is 27°C, with a range from 20° to 31°C (ICCAT, 1995).

Essential Fish Habitat for Skipjack Tuna:

- **Spawning, eggs, and larvae:** In offshore waters in the Gulf of Mexico to the EEZ and portions of the Florida Straits as shown in Figure 5.8.

- **Juveniles/subadults (<45 cm FL):** Localized areas in the central Gulf of Mexico from Louisiania through the Florida Panhandle. Localized areas in the Atlantic off of Georgia, South Carolina, and North Carolina to Maryland, and from Delaware to Cape Cod and the southern east coast of Florida through the Florida Keys. Please refer to Figure 5.9 for detailed EFH map.

- **Adults (≥45 cm FL):** In the central Gulf of Mexico, off of Texas through Florida. Localized areas in the Atlantic off of South Carolina and the northern east coast of Florida, and from Cape Hatteras to Cape Cod and the southern east coast of Florida through the Florida Keys. Please refer to Figure 5.10 for detailed EFH map.

5.1.1.5 Atlantic Yellowfin Tuna

Atlantic Yellowfin Tuna (*Thunnus albacres*) Atlantic yellowfin tuna are circumglobal in tropical and temperate waters. In the western Atlantic they range from 45°N to 40°S. Yellowfin tuna is an epipelagic, oceanic species, found in water temperatures between 18° and 31°C. It is a schooling species, with juveniles found in schools at the surface, mixing with skipjack and bigeye tuna. Larger fish are found in deeper water and also extend their ranges into higher latitudes. All individuals in the Atlantic probably comprise a single population, although movement patterns are not well known (Collette and Nauen, 1983; SCRS, 1997). There are possible movements of fish spawned in the Gulf of Guinea to more coastal waters off Africa, followed by movements toward the U.S. coast, at which time they reach a length of 60 to 80 cm (ICCAT, 1997). In the Gulf of Mexico yellowfin tuna occur beyond the 500-fathom isobath (Idyll and de Sylva, 1963).

Predator-prey relationships: Atlantic yellowfin tuna are opportunistic feeders. Stomachs have been found to contain a wide variety of fish and invertebrates (Dragovich, 1969, 1970b;

Dragovich and Potthoff, 1972; Matthews *et al.*, 1977). Stomach contents of yellowfin from St. Lucia and the Caribbean contained squid and the larvae of stomatopods, crabs and squirrelfish (Idyll and de Sylva, 1963). Stomach contents often contain *Sargassum* or *Sargassum* associated fauna. Yellowfin tuna are believed to feed primarily in surface waters down to a depth of 100 m (Morgan *et al.*, 1985).

Life history: Spawning occurs throughout the year in the core areas of the species= distribution - between 15°N and 15°S - and also in the Gulf of Mexico and the Caribbean, occurring from May through November (ICCAT, 2008c). Spawning adults are typically significantly larger in body size in the Caribbean compaired to the Gulf of Mexico (Arocha *et al.*, 2001). Yellowfin tuna are believed to be serial spawners, and larval distribution appears to be limited to water temperatures above 24°C and salinity greater than 33 ppt (Richards and Simmons, 1971). Larvae have been collected near the Yucatan peninsula and during September in the northern Gulf of Mexico along the Mississippi Delta (ICCAT, 1994).

Fisheries: Yellowfin tuna are caught by surface gears (purse seine, baitboat, troll, and handline) and with sub-surface gears (longline). A single stock is assumed for the Atlantic, based on transatlantic tag recaptures, time/area size frequency distribution, etc. (SCRS, 1997).

U.S. Fishery Status: Approaching an overfished condition.

Growth and mortality: The maximum size of yellowfin tuna is over 200 cm FL (Collette and Nauen, 1983). Sexual maturity is reached at about three years of age, at 110 cm FL, and a weight of 25 kg. Although it is not known if there is a differential growth rate between males and females (ICCAT, 1994), males are predominant in catches of larger sized fish (SCRS, 1997). Natural mortality is 0.8 for fish less than 65 cm in length, and 0.6 for fish greater than 65 cm. Mortality is higher for females of this size (ICCAT, 1994).

Habitat associations: Adult yellowfin tuna are confined to the upper 100 m of the water column due to their intolerance of oxygen concentrations of less than 2 ml/l (Collette and Nauen, 1983). In northern latitudes yellowfin can be further restricted to the surface depending on thermocline depth (Block *et al.*, 1997). Association with floating objects has been observed, and in the Pacific larger individuals often school with porpoises (Collette and Nauen, 1983). Juveniles are found nearer to shore than are adults (SCRS, 1994). In the Gulf of Mexico adults usually occur 75 km or more offshore, while in the Caribbean they are found closer to shore. Although there appears to be a year-round population in the southern part of the Gulf of Mexico (Idyll and de Sylva, 1963), in June there appears to be some movement from the southern to the northern part of the Gulf of Mexico, resulting in greater catches in the northern part of the Gulf of Mexico from July to December.

Essential Fish Habitat for Yellowfin Tuna:

- **Spawning, eggs, and larvae:** In offshore waters in the Gulf of Mexico to the EEZ and portions of the Florida Straits as shown in Figure 5.11. No changes to the 1999 boundary are proposed.

- **Juveniles/subadults (<110 cm FL):** In the central Gulf of Mexico from Florida Panhandle to southern Texas. Mid-east coast of Florida and Georgia to Cape Cod. South of Puerto Rico. Please refer to Figure 5.12 for detailed EFH map.

- **Adults (≥110 cm FL):** In the central Gulf of Mexico from the Florida Panhandle to southern Texas. Mid-east coast of Florida and Georgia to Cape Cod. South of the Virgin Islands. Please refer to Figure 5.13 for detailed EFH map.

5.1.2 Swordfish

Swordfish (*Xiphias gladius*) Swordfish are circumglobal, ranging through tropical, temperate and sometimes cold water regions. Their latitudinal range is from 50° to 40°N, to 45°S in the western Atlantic, and 60° to 45°N, to 50°S in the eastern Atlantic (Nakamura, 1985). The swordfish population in the Atlantic is distinctly structured into North Atlantic and South Atlantic components. An investigation by Chow *et al*. (2007) indicated that not only gene flow but also individual migrations between the North and Mid-south Atlantic populations is consistently restricted, and that the swordfish are much less migratory than previously believed. ICCAT has managed the North and South Atlantic stocks on the basis of a separation at 5° N. However, Chow *et al*. (2007) also report that results of their genetic investigations suggest that the boundary between the populations may be located in the range of 10° to 20°N. The species moves from spawning grounds in warm waters to feeding grounds in colder waters. In the western north Atlantic two movement patterns are apparent: some fish move northeastward along the edge of the U.S. continental shelf in summer and return southwestward in autumn; another group moves from deep water westward toward the continental shelf in summer and back into deep water in autumn (Palko *et al.*, 1981).

Swordfish are epipelagic to meso-pelagic, and are usually found in waters warmer than 13°C. Their optimum temperature range is believed to be 18° to 22°C but they will dive into 5° to10°C waters at depths of up to 650 m (Nakamura, 1985). Swordfish migrate diurnally, coming to the surface at night (Palko *et al.*, 1981). The species tolerates rapid temperature changes and dives into deep, cold waters, probably to search for prey, due to a specialized heating system to warm the eyes and brain, suggesting that the species is less likely to be restricted in its habitat by thermoclines (Chow *et al*., 2007). Carey (1990) observed different diel migrations in two groups of fish: swordfish in neritic (shallow, near-coastal) waters of the northwestern Atlantic were found in bottom waters during the day and moved to offshore surface waters at night. Swordfish in oceanic waters migrated vertically from a daytime depth of 500 m to 90 m at night.

Predator-prey relationships: Adult swordfish are opportunistic feeders, having no specific prey requirements. They feed at the bottom as well as at the surface, in both shallow and deep waters. In waters greater than 200 m deep they feed primarily on pelagic fishes, including small tunas, dolphinfishes, lancetfish (*Alepisaurus*), snake mackerel (*Gempylus*), flyingfishes, barracudas and squids such as *Ommastrephes*, *Loligo*, and *Illex*. In shallow water they prey upon neritic fishes, including mackerels, herrings, anchovies, sardines, sauries, and needlefishes. In deep water, swordfish may also take demersal fishes such as hakes, pomfrets (Bromidae), snake mackerels, cutlass fish (trichiurids), lightfishes (Gonostomatidae), hatchet fishes (Sternoptychidae), redfish, lanternfishes, and cuttlefishes (Nakamura, 1985).

In the Gulf of Mexico swordfish were found to feed primarily on cephalopods - 90 percent of stomach contents consisted of 13 species of teuthoid squids, most of which were *Illex*, and two species of octopus (Toll and Hess, 1981). Stillwell and Kohler (1985) found that 80 percent of the stomach contents of swordfish taken off the northeast coast of the United States consisted of cephalopods, of which short-finned squid (*Illex illecebrosus*) made up 26.4 percent. Adult swordfish in neritic waters will feed inshore near the bottom during the daytime and head seaward to feed on cephalopods at night. The movement of larger individuals into higher latitudes in the summer and fall may be in part to allow those individuals access to high concentrations of *Illex* (Arocha, 1997). Predators of adult swordfish are probably restricted to sperm whales (*Physeter catodon*), killer whales (*Orcinus orca*) and large sharks such as mako (*Isurus* spp).

Typically, swordfish larvae less than 9.0 mm in length consume small zooplankton, those 9.0 to 14.0 mm feed on mysids, phyllopods and amphipods, and at sizes greater than 21 mm they begin to feed on the larvae of other fishes. Govoni *et al.* (2003) report that the diet of larval swordfish is indicative of their vertical distribution in the water column: larvae <11 mm PSL eat primarily near-surface copepods, while larvae >11 mm PSL eat exclusively neustonic fish larvae. Juveniles feed on squids, fishes and some pelagic crustaceans (Palko *et al.*, 1981). Larvae are preyed upon by other fishes, and juveniles fall prey to predatory fishes, including sharks, tunas, billfishes, and adult swordfish (Palko *et al.*, 1981).

Life history: First spawning for North Atlantic swordfish occurs at four to five years of age (74 kg) in females. Fifty percent maturity in females is reached at 179 to 182 cm lower jaw fork length (LJFL), and in males at 112 to 129 cm LJFL (21 kg) at approximately 1.4 years of age (Arocha, 1997; Nakamura, 1985; Palko *et al.*, 1981). Most spawning takes place in waters with surface temperatures above 20° to 22°C, between 15°N and 35°N (Arocha, 1997; Palko *et al.*, 1981). In the western North Atlantic spawning occurs in distinct locations at different times of the year: south of the Sargasso Sea and in the upper Caribbean spawning occurs from December to March, while off the southeast coast of the United States it occurs from April through August (Arocha, 1997). Major spawning grounds are probably located in the Straits of Yucatan and the Straits of Florida (Grall *et al.*, 1983; Govoni *et al.*, 2003). Larvae have been found in largest abundance from the Straits of Florida to Cape Hatteras, North Carolina and around the Virgin Islands.

Larvae are associated with surface temperatures between 24° and 29°C. The Gulf of Mexico is believed to serve as a nursery area (Palko *et al.*, 1981). Govoni *et al.* (2003) report that spawning in the Gulf of Mexico seems to be focused in the vicinity of the northernmost arc of the Gulf Loop Current. Grall *et al.,* (1983) found larvae 10 mm and larger to be abundant in the Caribbean, the Straits of Florida, and the Gulf Stream north of Florida from December to February. In the areas off the southeast coast of the United States spawning is focused in the western Gulf Stream frontal zone (Govoni *et al.*, 2003). In the western Gulf of Mexico, large larvae were found from March to May and from September to November; many larvae of all sizes were collected in the Caribbean and were also present year-round in the eastern Gulf of Mexico, the Straits of Florida and the Gulf Stream. Juvenile fish are frequently caught in the pelagic longline fishery in the Gulf of Mexico, the Atlantic coast of Florida, and near the Charleston Bump, regions that may serve as nurseries for North Atlantic swordfish (Cramer and Scott, 1998).

Fisheries: Swordfish in the Atlantic are taken by a directed longline fishery and as bycatch of the tuna longline fishery. There are also seasonal harpooning and driftnetting efforts off Nova Scotia (harpooning), off the northeast U.S. coast, and on the Grand Banks (driftnetting) (Arocha, 1997). The effect of this reduction in stock size on habitat use and species distributions is unknown. In January 1999, NMFS prohibited the use of driftnets for the swordfish fishery. In March 1999, NMFS instituted a program requiring all swordfish imported into the United States to have a certificate of eligibility specifying the origin of the fish. If the swordfish is from the Atlantic it must meet the 33-lb dw minimum size requirement of ICCAT.

U.S. Fishery Status: North Atlantic swordfish is not overfished, overfishing is not occurring, and the stock is in recovery (B/Bmsy = 0.99). South Atlantic swordfish is fully fished, overfishing may be occurring.

Growth and mortality: Swordfish reach a maximum length of 445 cm total length (TL) and a maximum weight of 540 kg. Males and females have different growth rates, with females longer and heavier at any given age (Nakamura, 1985). Natural mortality rate was estimated at 0.21 to 0.43 by Palko *et al.,* (1981), but ICCAT presently uses an estimate of 0.2 (Arocha, 1997). Berkeley and Houde (1981) found a higher growth rate for females than males over two years of age, and also found males to have a higher mortality rate than females.

Habitat associations: In the winter in the North Atlantic, swordfish are restricted to the warmer waters of the Gulf Stream, while in the summer their distribution covers a larger area. Distribution is size and temperature related, with few fish under 90 kg found in waters with temperatures less than 18°C. Larvae are restricted to a narrow surface temperature range, and are distributed throughout the Gulf of Mexico, in areas of the Caribbean, and in the Gulf Stream along the U.S. coast as far north as Cape Hatteras, North Carolina. Concentrations of adult swordfish seem to occur at ocean fronts between water masses associated with boundary currents, including the Gulf Stream and Loop Current of the Gulf of Mexico (Arocha, 1997; Govoni *et al.*, 2003).

***Essential Fish Habitat for Atlantic Swordfish*:**

- **Spawning, eggs, and larvae:** From off Cape Hatteras, North Carolina extending south around peninsular Florida through the Gulf of Mexico to the U.S./Mexico border from the 200 m isobath to the EEZ boundary; associated with the Loop Current boundaries in the Gulf and the western edge of the Gulf Stream in the Atlantic; also, all U.S. waters of the Caribbean from the 200 m isobath to the EEZ boundary (Figure 5.14). No changes to the 1999 boundary are proposed.

- **Juveniles/subadults (<180 cm LJFL):** In the central Gulf of Mexico from southern Texas through the Florida Keys and Atlantic east coast from south Florida to Cape Cod. Puerto Rico and the Virgin Islands. Please refer to Figure 5.15 for detailed EFH map.

- **Adults (≥180 cm LJFL):** In the central Gulf of Mexico from southern Texas to the Florida Panhandle and western Florida Keys. Atlantic east coast from southern

Florida to the mid-east coast of Florida, and Georgia to Cape Cod. Puerto Rico and the Virgin Islands. Please refer to Figure 5.16 for detailed EFH map.

5.1.3 Billfish

5.1.3.2 Blue Marlin

Blue Marlin (*Makaira nigricans*) Blue marlin inhabit the tropical and subtropical waters of the Atlantic, Pacific and Indian Oceans. Their geographic range is from 45°N to 35°S. In the Atlantic two seasonal concentrations occur: January to April in the southwest Atlantic from 5° to 30°S, and from June to October in the northwest Atlantic between 10° and 35° N. May, November and December are transitional months (Rivas, 1975). Blue marlin are generally solitary and do not occur in schools or in coastal waters (Nakamura, 1985). Since 2000, the ICCAT SCRS has considered a single, Atlantic-wide stock of blue marlin in stock assessments which is consistent with recent genetic stock structure analysis (ICCAT, 2001; Graves and McDowell, 2001; and Graves and McDowell 2003).

This species is epipelagic and oceanic, generally found in blue water with a temperature range of 22° to 31°C. Goodyear (2003) found that spatio-temporal heterogeneity in pelagic longline catch rates may be partly explained by seasonal changes in sea surface temperatures. Prince and Goodyear (2006) reported evidence of habitat compression in areas where there is a distinct band of cold, hypoxic water close to the surface in the eastern Atlantic and Pacific Oceans. This phenomenon restricts the acceptable habitat of billfish to shallower water in these areas, making them more vulnerable to surface gear, but also increases their access to prey items, possibly increasing growth rates. Research presented by the SCRS (2006) described data from a pop-up tagging study of eight blue marlin that were released in several locations in the tropical Atlantic Ocean, from off Dakar (shallow mixed layer) to off Brazil (deep mixed layer), that agreed with this hypothesis. They found that the diving depth was correlated with the depth of the mixed layer, so that as the depth of the mixed layer increased, the maximum depth of the dives also increased. The data indicated that blue marlin spent the majority of their time within the surface mixed layer and occasionally make short term dives to 800 m (Orbesen, Pers. Comm.).

Most of the blue marlin tagging and recovery efforts have been restricted to the western North Atlantic Ocean, with particularly intense activities off the U.S. Caribbean (including Puerto Rico and U.S. Virgin Islands) and the north-eastern coast of South America near La Guaira, Venezuela (Ortiz *et al*. 2003). Plots of minimum travel distance versus years-at large revealed no clear patterns that might indicate site fidelity and/or cyclic annual movements. Global plots of release-recovery vectors indicate that blue marlin are capable of trans-oceanic and trans-equatorial movements in the Atlantic and Pacific Oceans, as well as inter-oceanic movements (*i.e.*, from the Atlantic to the Indian Ocean and from the Pacific to the Indian Ocean). Strong seasonal movement patterns were evident in the Atlantic Ocean, from the U.S. Mid-Atlantic coast and Mexican Caribbean to Venezuela.

Orbesen *et al*. (in press) investigated blue marlin movements relative to the ICCAT management areas, as well as U.S. domestic data collection areas within the western North Atlantic basin, with mark-recapture data from 769 blue marlin. Linear displacement between release and recapture locations ranged from zero to 15,744 km (mean 575, median 119, SE 44) for blue marlin with the proportions of visits highest in the Caribbean area.

Predator-prey relationships: Blue marlin feed near the surface but also are known to feed in deeper waters than the other istiophorids. They feed primarily on tuna-like fishes, squid, and on a wide size range of other organisms, from 38 mm postlarval surgeonfish to 50 lb. bigeye tuna. Stomach contents have also included deep-sea fishes, such as chiasmodontids. Other important prey species vary by location and include dolphinfishes, especially bullet tuna (*Auxis* sp.) around the Bahamas, Puerto Rico, and Jamaica, and dolphinfishes and scombrids in the Gulf of Mexico. Octopods are also prey items (Rivas, 1975; Davies and Bortone, 1976; Nakamura, 1985). Predators of blue marlin are relatively unknown; although, evidence of shark predation on white marlin has been described (Kerstetter *et al*., 2004).

Reproduction and Early Life History: Blue marlin are sexually mature by 2 to 4 years of age (SCRS, 1997). Female blue marlin begin to mature at approximately 104 to 134 lb, while males mature at smaller weights, generally from 77 to 97 lb. Analysis of egg (ova) diameter frequency suggests that blue marlin, white marlin, and sailfish spawn more than once each spawning season (de Sylva and Breder, 1997). During the spawning season blue marlin release from one million to ten million small (1 to 2 mm), transparent pelagic planktonic eggs (Yeo, 1978). Martins *et al*. (2007) calculated batch fecundities for five mature females and found values ranging from 3,600,960 to 6,769,060 oocytes for five mature females ranging in size from 277 to 290 cm LJFL. Ovaries from a 324 lb female blue marlin from the northwestern Atlantic were estimated to contain 10.9 million eggs, while ovaries of a 275 lb female were estimated to contain approximately 7 million eggs. Luckhurst *et al*. (2006) found that the largest female specimen (over 1,000 lbs) in their sample was in spawning condition, indicating that the largest females are still capable of reproducing and may not have reached senescence as had been proposed previously.

Although evidence indicates genetic mixing between the two geographic areas, de Sylva and Breder (1997) hypothesized that there may be two separate blue marlin spawning seasons; one in the North Atlantic with spawning from July to September (July to October according to de Sylva and Breder, 1997; May to November, according to Prince *et al.*, 1991) and one in the South Atlantic from February to March. May and June are peak spawning months for fish off Florida and the Bahamas, and there is a protracted spawning period off northwest Puerto Rico from May to November. Females taken off Cape Hatteras, North Carolina in June were found to have recently spawned (Rivas, 1975). Prince *et al*. (2005) found evidence of spawning blue marlin resulting from the presence of larvae off Punta Cana, Dominican Republic. One larval blue marlin (5.2 mm SL) was collected in pelagic waters off Miami, FL (Serafy *et al*., 2006). As reported by the SCRS (2006), Luckhurst *et al*. (2006) described evidence of spawning in blue marlin during July (from gonad index analyses and the ageing of a juvenile specimen) in the waters of Bermuda. This represents a northern extension (32°N) of the known spawning area in the northwest Atlantic for blue marlin. Preliminary information on blue marlin reproduction from between 7°N and 20°S presented in Martins *et al*. (2007) using gonad index showed higher values during June and August which corresponded seasonally with Luckhurst *et al*. (2006) above. Serafy *et al*. (2003) showed evidence of blue marlin spawning near Exuma Sound, Bahamas with highest larvae densities found especially where exchange with the Atlantic is greatest. Given age estimates and assuming passive surface transport, the larvae were likely spawned in waters that include Exuma Sound and may extend some 200 km southeast of its mouth. Blue marlin larvae were found in pelagic waters across the northern Gulf of Mexico in June and July of 2005 and 2006 (J. Rooker, Texas A&M University, Pers. Comm.). Blue marlin larvae were found in the north-central Gulf of Mexico in 2005 and 2006 (N. Brown-Peterson, University of Southern Mississippi, Pers. Comm.). A few larvae have been collected in the western Atlantic off Georgia, off Cat Cay, Bahamas, and in the Mid to North Atlantic (Ueyanagi *et al.*, 1970; Nakamura, 1985).

Fisheries: Blue marlin are targeted as a recreational fishery in the United States and Caribbean, and are also caught as bycatch of tropical tuna longline fisheries, which use shallow gear deployment. They are also caught by offshore longline fisheries which target swordfish, especially in the western Atlantic, as well as by directed artisanal fisheries in the Caribbean.

U.S. Fishery Status: Overfished, and overfishing is occurring.

Growth and mortality: Blue marlin are believed to be one of the fastest growing of all teleosts in the early stages of development, and weigh between 66 and 99 lb by age one (SCRS, 1997). Based on analyses of daily otolith ring counts, they reach 24 cm LJFL in about 40 days, and about 190 cm LJFL in 500 days, with a maximum growth rate of approximately 1.66 cm/day occurring at 39 cm LJFL (Prince *et al.*, 1991). Fish larger than 190 cm LJFL tend to add weight more than length, making the application of traditional growth curve models, in which length or weight are predicted as a function of age, difficult for fish in these larger size categories. Sponaugle *et al*. (2005) found differing early growth rates between locations after the first 5-6 days of life for fish from Exuma Sound, Bahamas and the Straits of Florida, which resulted in a 4-6 mm difference in standard length by day 15. The differences in growth appeared to be unrelated to water temperature. Females grow faster and reach much larger maximum sizes than males. Examination of sagitta (otolith) weight, body weight, and length/age characteristics indicate that sex-related size differences are related to differential growth between the sexes and not to differential mortality (Wilson *et al.*, 1991). Sexually dimorphic growth variation (weight only) in blue marlin appears to begin at 140 cm LJFL (Prince *et al.*, 1991). Somatic growth of male blue marlin slows significantly at about 220 lb, while females continue substantial growth throughout their lifetime (Wilson *et al.*, 1991). Male blue marlin usually do not exceed 350 lb, while females can exceed 1,200 lb.

Blue marlin are estimated to reach ages of at least 20 to 30 years, based on analysis of dorsal spines (Hill *et al.*, 1990). Although spine ageing techniques for blue marlin have not been validated and vascularization of the spine core causes problems with accurate ring counts (SCRS 2006), longevity estimates are supported by tagging data. The maximum time at liberty recorded of a tagged individual was 4,591 days (12.6 years) for a blue marlin (Orbesen *et al*, in press). Sagitta otolith weight is suggested to be proportional to age, indicating that both sexes are equally long-lived, based on the maximum otolith weight observed for each sex (Wilson *et al.*, 1991). Data about the age and growth of marlin are still lacking, hindering the ability to incorporate age-structure based on observations into Atlantic marlin stock assessments (SCRS 2006).

Habitat associations: Adults are found primarily in the tropics within the 24EC isotherm, and make seasonal movements related to changes in sea surface temperatures. In the northern Gulf of Mexico they are associated with the Loop Current and are found in blue waters of low productivity rather than in more productive green waters. Off Puerto Rico the largest numbers of blue marlin are caught during August, September and October. Equal numbers of both sexes occur off northwest Puerto Rico in July and August, with larger males found there in May and smaller males in September (Rivas, 1975). Very large individuals, probably females, are found off the southern coast of Jamaica in the summer and off the northern coast in winter, where males are caught in December and January.

Essential Fish Habitat for Blue Marlin:

- **Spawning, eggs, and larvae:** Mid-east coast of Florida through the Florida Keys. Please refer to Figure 5.17 for detailed EFH map.
- **Juveniles/Subadults (20-189 cm LJFL):** In the central Gulf of Mexico from southern Texas to the Florida Panhandle through the Florida Keys to southern Cape Cod. Puerto Rico and the Virgin Islands. Please refer to Figure 5.18 for detailed EFH map.
- **Adults (≥190 cm LJFL):** In the central Gulf of Mexcio, from southern Texas to the Florida Panhandle, through the Florida Keys to southern Cape Cod. Puerto Rico and the Virgin Islands. Please refer to Figure 5.19 for detailed EFH map.

5.1.3.3 White Marlin

White Marlin (*Tetrapturus albidus*) White marlin is an oceanic, epipelagic species that occurs in the Atlantic Ocean, Gulf of Mexico, and Caribbean waters. It inhabits almost the entire Atlantic from 45ºN to 45°S in the western Atlantic and 45EN to 35ES in the eastern Atlantic. The geographical range for white marlin is restricted to the tropical and temperate waters of the Atlantic Ocean and adjacent seas. This differs from the blue marlin (*Makaira nigricans*) and sailfish (*Istiophorus platypterus*), that range throughout both the Atlantic and Indo-Pacific regions. In higher latitudes, such as between New Jersey and Virginia, they are found commonly in shallow coastal waters (de Sylva and Davis, 1963). White marlin are found at the higher latitudes of their range only in the warmer months. Large post-spawning aggregations of white marlin are reported off the Mid-Atlantic States during the summer period (Earle, 1940; deSylva and Davis, 1963; Baglin, 1977). Although they are generally solitary, they sometimes are found in small, usually same-age groups.

Portions of the following description are excerpted from White Marlin Biological Review Team (2007). Taxonomic investigations have occurred recently for white marlin and its congeners. Collette *et al*. (2006) presented genetic evidence to propose a taxonomic reclassification of white marlin and Indo-Pacific striped marlin, *Tetrapturus audux* into a separate genus, *Kajikia*. Validity of the roundscale spearfish (*T. georgii*) has recently been reported by Shivji *et al*. (2006) using genetic and morphometric analyses. Roundscale spearfish are not hybrids, but rather a clearly different genetic lineage to sympatric billfish species. To an untrained observer, the roundscale spearfish and white marlin are morphologically similar. Characteristics that differentiate the roundscale spearfish from the white marlin include: mid-lateral scales that are rounded anteriorly; a greater distance between the anus and insertion of the first anal fin; branchiostegal rays extending to posterior edge of the operculum; and, unique mitochondrial ND4L-ND4 nucleotide sequences. It is likely that most roundscale spearfish captures have been classified as white marlin. The proportion of roundscale spearfish in the white marlin population is unknown. Further, it is unknown whether the proportion has changed over time. It took >100 years to observe sufficient specimens to clearly identify the species, so it is not likely to be abundant. No information is available describing interspecific competition, and potential geographic overlap, between the roundscale spearfish and white marlin; although, a genetic re-analysis of specimens identified as "white marlin," landed in New Jersey recreational fishing tournaments over the last few years, confirmed 17.5 percent were actually roundscale spearfish (J. Graves, VIMS, unpubl. data). This has raised the possibility that the abundance of white marlin may be overestimated. The Pelagic Observer Program (POP) data suggests the roundscale spearfish is widely distributed in the western North Atlantic, and abundant in the Sargasso Sea area during the winter period (Beerkircher *et al*., in press). Further, POP observers have reported roundscale spearfish in mid-July off the Grand Banks at 43°42´N, 47°37´W (L. Beerkircher, SEFSC, Pers. Comm.).

The so-called "hatchet marlin" (*Tetrapturus* sp.), another putative congener, exhibits truncated dorsal and anal fins. Genetic analysis reveals this condition can occur in both roundscale spearfish and white marlin; thus, the shortened fins suggest a phenotype variable only, not a separate species (J. Graves, VIMS, pers. com).

Conventional mark-recapture data collected by the Cooperative Tagging Center (CTC) constituent-based tagging program (NOAA/NMFS/SEFSC) has revealed spatial and temporal characteristics of white marlin movement (Ortiz *et al*., 2003). From 1954 through 2005, a total of 47,662 white marlin were marked and released in the Atlantic basin, resulting in 961 recaptures (2.01 percent; Orbesen *et al*., In Review]). The majority of releases took place in the months of July through September, in the western North Atlantic off the eastern coast of the United States; and, to a lesser extent, off Venezuela, the Gulf of Mexico, and the western central Atlantic. The longest distance traveled was 6,523 km (4,053 miles), while the maximum number of days at-liberty was 5,488 (15 yrs). Trans-Atlantic crossings have been recorded for several individuals. However, only two reports of trans-equatorial crossings have been documented (Orbesen *et al*., In Review). Recaptures indicate a substantial number of individuals moving between the Mid-Atlantic coast of the United States and the northeast coast of South America.

Horodysky *et al*. (2007) examined vertical movement and habitat use with 47 PSATs that monitored white marlin released from recreational and commercial vessels (Horodysky and Graves, 2005; Kerstetter and Graves, 2006). During periods at-liberty, ranging from five to seven days, these white marlin spent nearly half their time near the surface (< 10 m). All made frequent short duration dives to depths averaging 51 m, suggesting that a great deal of foraging effort takes place well below the surface waters. Horodysky *et al*. (2007) go on to suggest this behavior may explain the relatively high catch rates of white marlin on some deep-set pelagic longline gears. In a study supporting this suggestion, Junior *et al*. (2004) reported no obvious depth layer preference for white marlin captured with pelagic longline gear off northeastern Brazil in depths ranging from 50 to 230 m (164-754 feet). An analysis of high resolution (≤ 60 seconds) archival data from two white marlin PSATs showed time engaged in vertical movement ranged from 29.4 percent to 54.4 percent, with most of this activity taking place during daylight hours (Hoolihan *et al*., unpubl. data). Maximum depths recorded for these individuals were 188 m and 260 m. While dive events were frequent, the majority of time (55.9 and 86.1 perccent) was spent at depths less than 75 m. Prince and Goodyear (2006) used PSAT data from sailfish and blue marlin to show how vertical movement could be restricted by a hypoxic barrier formed during upwelling. One implication of this condition is that billfish movements are constrained to near-surface depths where adequate levels of dissolved oxygen are available. Another is that their susceptibility to capture by surface fishing gears would increase. Given the same conditions, white marlin could be expected to behave similarly.

Predator–prey relationships: The most important prey items of adult white marlin, at least in the Gulf of Mexico, are squid, dolphinfishes (*Coryphaena*) and hardtail jack (*Caranx crysos*), followed by mackerels, flyingfishes, and bonitos. Other food items found inconsistently and to a lesser degree include cutlassfishes, puffers, herrings, barracudas, moonfishes, triggerfishes, remoras, hammerhead sharks, and crabs. Along the central Atlantic coast food items include round herring (*Etrumerus teres*) and squid *(Loligo pealei*). Carangids and other fishes are consumed as well (Nakamura, 1985). Davies and Bortone (1976) found the most frequent stomach contents in 53 specimens from the northeastern Gulf of Mexico, off Florida, and off Mississippi to include little tunny (*Euthynnus* sp.), bullet tuna (*Auxis* sp.), squid, and moonfish (*Vomer setapinnis*). They also found white marlin to feed on barracuda and puffer fish. Atlantic pomfret (*Brama brama*) and squid (*Ornithoteuthis antillarum*) were the most abundant food items sampled from stomachs of white marlin collected off the coast of Brazil in the southwestern Atlantic Ocean (Junior *et al*., 2004). The only predators of adult white marlin may be sharks and possibly killer whales (Mather *et al.*, 1975).

Reproduction and Early Life History: Female white marlin are about 20 kg (44 lb) in weight and 130 cm (51.2 inches) in length at sexual maturity. Spawning activity occurs during the spring (March through June) in northwestern Atlantic tropical and sub-tropical waters marked by relatively high surface temperatures (20° to 29°C) and salinities (> 35 ppt). White marlin move to higher latitudes during summer, when waters warm. White marlin sampled during the summer at these higher latitudes (Mid-Atlantic States) were in a post-spawning state (deSylva and Davis, 1963). Arocha *et al*. (2006) reported females exhibiting high gonad index values (associated with mature gonads) present in the western North Atlantic from April to July between 18°N and 22°N. Spawning seems to take place further offshore than sailfish, although white marlin larvae are not found as far offshore as blue marlin. Females may spawn up to four times per spawning season (deSylva and Breder, 1997). It is believed there are at least five spawning areas in the western North Atlantic: northeast of Little Bahama Bank off the Abaco Islands; northwest of Grand Bahama Island; southwest of Bermuda; the Mona Passage, east of the Dominican Republic; and the Gulf of Mexico. Prince *et al*. (2005) collected eight white marlin larvae in neuston tows in April/May off the coast of Punta Cana, Dominican Republic indicating that there had been recent spawning activity in this general area. More recently, nine white marlin larvae were collected during May-June near the Bahamas in the Florida Straits (D. Richardson, RSMAS, unpubl. data). Lastly, white marlin larvae (n = 15) have been genetically identified from the Gulf of Mexico, confirming spawning activity in that region (J. Rooker, Texas A&M University, Unpubl. Data).

Fisheries: White marlin are targeted as a recreational fishery in the United States and Caribbean, and are also caught as bycatch of tropical tuna longline fisheries which use shallow gear deployment. They are also caught by offshore longline fisheries which target swordfish, especially in the western Atlantic, as well as by directed artisanal fisheries in the Caribbean.

U.S. Fishery Status: Overfished, overfishing is occurring. White marlin underwent a status review under the Endangered Species Act (ESA) in 2002 that found that listing the species as threatened or endangered was "not warranted" (September 9, 2002; 67 FR 57204). Subsequent to the 2002 finding, a settlement agreement was reached between NMFS, the Center for Biological Diversity (CBD), and the Turtle Island Restoration Network (TIRN) wherein it was agreed that NMFS would revisit the status of the white marlin following the 2006 stock assessment by ICCAT. In December 2006, NMFS announced that a status review of the Atlantic white marlin was initiated (December 21, 2006; 71 FR 76639). NMFS conducted a white marlin status review in 2007 and found that listing the species as threatened or endangered was "not warranted" (January 4, 2008; 73 FR 843).

Growth and mortality: Adult white marlin grow to over 280 cm TL and 82 kg (184 lbs). Size at harvest generally ranges from 20 to 30 kg (44-66 lb). White marlin exhibit sexually dimorphic growth patterns; females grow larger than males (Mather *et al.*, 1975; Nakamura, 1985). They grow quickly and can reach an age of at least 18 years, based on tag recapture data (SCRS, 2004).

Habitat associations: The world's largest sport fishery for the species occurs in the summer from Cape Hatteras, North Carolina to Cape Cod, Massachusetts especially between Oregon Inlet, North Carolina and Atlantic City, New Jersey. Successful fishing occurs up to 80 miles offshore at submarine canyons, Carolina extending from Norfolk Canyon in the Mid-Atlantic to Block Canyon off eastern Long Island (Mather, *et al.*, 1975). Concentrations are associated with rip currents and weed lines (fronts), and with bottom features such as steep dropoffs, submarine canyons and shoals (Nakamura, 1985). The spring peak season for white marlin sport fishing occurs in the Straits of Florida, southeast Florida, the Bahamas, and off the north coasts of Puerto Rico and the Virgin Islands. In the Gulf of Mexico summer concentrations are found off the Mississippi River Delta, at DeSoto Canyon, and at the edge of the continental shelf off Port Aransas, Texas, with a peak off the Delta in July, and in the vicinity of DeSoto Canyon in August. In the Gulf of Mexico adults appear to be associated with blue waters of low productivity, being found with less frequency in more productive green waters. While this is also true of the blue marlin, there appears to be a contrast in the factors controlling blue and white marlin abundances, as higher numbers of blue marlin are caught when catches of white marlin are low and vice versa (Rivas, 1975; Nakamura, 1985). It is believed that white marlin prefer slightly cooler temperatures than blue marlin. Spawning occurs in early summer, in subtropical, deep oceanic waters with high surface temperatures and salinities (20° to 29EC and over 35 ppt). Spawning concentrations occur off the Bahamas, Cuba, and the Greater Antilles, probably beyond the U.S. EEZ, although the locations are unconfirmed. Concentrations of white marlin in the northern Gulf of Mexico and from Cape Hatteras to Cape Cod are probably related to feeding rather than spawning (Mather *et al.*, 1975).

Essential Fish Habitat for White Marlin:

- **Spawning, eggs, and larvae:** At this time the available information is insufficient to identify EFH for this life stage.

- **Juvenile (20-158 cm LJFL):** In the central Gulf of Mexico from southern Texas to the Florida Panhandle. Florida Keys to mid-east coast of Florida, and Georgia to Cape Cod. Please refer to Figure 5.20 for detailed EFH map.

- **Adults (≥159 cm LJFL):** In the central Gulf of Mexico from southern Texas to the Florida Panhandle. Florida Keys to the mid-east coast of Florida, and South Carolina to Cape Cod. Puerto Rico and the Virgin Islands. Please refer to Figure 5.21 for detailed EFH map.

5.1.3.4 Sailfish

Sailfish (*Istiophorus platypterus*) Sailfish have a circumtropical distribution (Post, 1998). They range from 40EN to 40ES in the western Atlantic and 50EN to 32ES in the eastern Atlantic. Sailfish are epipelagic and coastal to oceanic, and are usually found above the thermocline at a temperature range of 21° to 28EC, but may dive into deeper, colder water. Taxonomic investigations have occurred recently for sailfish and its congeners. Collette *et al*. (2006) presented genetic evidence to propose a taxonomic reclassification of some genera and recommended continued placement of sailfish in its own genus, Istiophorus.

During the winter sailfish are restricted to the warmer parts of their range and move farther from the tropics during the summer (Beardsley *et al.*, 1975; Nakamura, 1985). The summer distribution of sailfish does not extend as far north as for marlins. Tag-and-recapture efforts have recovered specimens only as far north as Cape Hatteras, North Carolina, but there have been reported interactions further north than Cape Hattaras. No transatlantic or transequatorial movements have been documented using tag-recapture methods (Bayley and Prince, 1993).

Predator-prey relationships: Early larvae feed on copepods, but shift to eating fish when they reach 6.0 mm in size. The diet of adult sailfish caught around Florida consists mainly of pelagic fishes such as little thunny (*Euthynnus alletteratus*), halfbeaks (*Hemiramphus* spp.), cutlassfish (*Trichiurus lepturus*), rudderfish (*Strongylura notatus*), jacks (*Caranx ruber*), pinfish (*Lagodon rhomboides*), and squids, including *Argonauta argo* and *Ommastrephes bartrami* (Nakamura, 1985). Sailfish are opportunistic feeders, and there is unexpected evidence that they may feed on demersal species such as sea robin (Triglidae), cephalopods, and gastropods found in deep water. Sailfish in the western Gulf of Mexico have been found to contain a large proportion of shrimp in their stomachs (Beardsley *et al.*, 1975; Nakamura, 1985). Davies and Bortone (1976) report that the stomach contents of 11 sailfish from the Gulf of Mexico most frequently contained little thunny, bullet tuna (*Auxis* sp.), squid, and Atlantic moonfish (*Vomer setapinnis*). Adult sailfish are probably not preyed upon often, but predators include killer whales (*Orcinus orca*), bottlenose dolphin (*Tursiops turncatus*), and sharks (Beardsley *et al.*, 1975).

Reproduction and Early Life History: Spawning has been reported to occur in shallow waters (30 to 40 ft) around Florida, from the Keys to the region off Palm Beach on the east coast. Spawning also occurs in the Gulf of Mexico as shown by the presence of hydrated eggs in ovaries of fish collected off Texas (Bumguardner *et al*., 2007). Additionally, spawning is assumed to occur, based on the presence of larvae, in the northern Gulf of Mexico from May to

September (Jay Rooker, Texas A&M University at Galveston, Pers. Comm.). Spawning is also assumed to occur, based on presence of larvae, offshore beyond the 100 m isobath from Cuba to the Carolinas, from April to September. Sailfish larvae have been found in Exuma Sound in the Bahamas during summer months, suggesting that spawning may occur in the Sound and/or up to 200 km southeast of the mouth of the Sound (Serafy *et al*., 2003). Sailfish larvae (3.5 to12mm SL) have been found in pelagic waters off Miami, Florida in August (Serafy *et al*., 2006). Sexual maturity occurs in the third year, with females at a weight of 13 to18 kg and males at 10 kg (de Sylva and Breder, 1997). Sailfish are multiple spawners, with spawning activity moving northward in the western Atlantic as the summer progresses. Larvae are found in Gulf Stream waters in the western Atlantic, and in offshore waters throughout the Gulf of Mexico from March to October (Beardsley *et al.*, 1975; Nakamura, 1985; de Sylva and Breder, 1997).

Fisheries: Sailfish are primarily caught in directed sport fisheries and as bycatch of the commercial longline fisheries for tunas and swordfish. Historically, nearly all sailfish and longbill spearfish from commercial catches have been reported as Atlantic sailfish; however, nearly all of these represent longbill spearfish (and perhaps other spearfish), and it is probable that very few sailfish are taken commercially in offshore waters of the Atlantic. Thus, it is impossible to determine historical trends in sailfish catches since at least two species have been combined.

U.S. Fishery Status: Unknown.

Growth and mortality: Analysis of daily growth rings in Atlantic sailfish sagittae otoliths estimated ages at 3 to18 days for fish that were 2.8 to15.2 mm SL (Luthy *et al*., 2005). Most sailfish examined that have been caught off Florida are under three years of age. Mortality is estimated to be high in this area, as most of the population consists of only two year classes (Beardsley *et al.*, 1975). Sailfish are probably the slowest growing of the Atlantic istiophorids. Sexual dimorphic growth is found in sailfish, but it is not as extreme as with blue marlin (SCRS, 1997). An individual sailfish was recaptured after 6,568 days (17.9 years) at liberty. The maximum age can be 13 to15 or more years. Growth rate in older individuals is very slow - 0.59 kg/yr (Prince *et al.*, 1986).

Habitat associations: In the winter, sailfish can be found in small schools around the Florida Keys and off eastern Florida, in the Caribbean, and in offshore waters throughout the Gulf of Mexico. In the summer they appear to diffuse along the U.S. coast as far north as the coast of Maine, although there is a population off the east coast of Florida all year long. During the summer some of these fish move north along the inside edge of the Gulf Stream. After the arrival of northerlies in the winter they regroup off the east coast of Florida. Sailfish appear to spend most of their time above the thermocline, which occurs at depths of 10 to 20 m to 200 to 250 m, depending on location. The 28EC isotherm appears to be the optimal temperature for this species. Sailfish are mainly oceanic but migrate into shallow coastal waters. Larvae are associated with the warm waters of the Gulf Stream (Beardsley *et al.*, 1975; Nakamura, 1985; Post, 1998).

Essential Fish Habitat for Sailfish:

- **Spawning, eggs, and larvae:** Off the southeast coast of Florida to Key West, FL, associated with waters of the Gulf Stream and Florida Straits from 5 mi offshore out to the EEZ boundary (Figure 5.22). .

- **Juveniles/Subadults (20-142 cm LJFL):** In the central Gulf of Mexico, and off southern Texas, Louisiania, and the Florida Panhandle. Atlantic east coast from the Florida Keys to mid-coast of South Carolina, the Outer Banks of North Carolina and Maryland. Eastern Puerto Rico and Virgin Islands. Please refer to Figure 5.23 for detailed EFH map.

- **Adults (≥143 cm LJFL):** In the central Gulf of Mexico, and off southern Texas, Louisiania, and the Florida Panhandle. Atlantic east coast from the Florida Keys to northern Florida, off of Georgia, and Cape Hatteras. Also around the Virgin Islands. Please refer to Figure 5.24 for detailed EFH map.

5.1.3.5 Longbill Spearfish

Longbill Spearfish (*Tetrapturus pfluegeri*) Only relatively recently (1963) has the longbill spearfish been reported as a new (distinct) species. It is known, but rare, from off the east coast of Florida, the Bahamas and the Gulf of Mexico, and from Georges Bank to Puerto Rico. More recently it has been observed to be more widely distributed, mostly in the western Atlantic. The range for this species is from 40EN to 35ES. It is an epipelagic, oceanic species, usually inhabiting waters above the thermocline (Robins, 1975; Nakamura, 1985). The species is generally found in offshore waters.

Taxonomic investigations have occurred recently for billfishes. Collette *et al*. (2006) presented genetic evidence to propose a taxonomic reclassification of some billfishes; however, in their suggestions, longbill spearfish remain in the genus *Tetrapturus*.

Validity of the roundscale spearfish (*Tetrapturus georgii*) has recently been reported by Shivji *et al*. (2006) using genetic and morphometric analyses. Roundscale spearfish are not hybrids, but rather a clearly different genetic lineage to sympatric billfish species. Due to its similar morphometric characteristics, it is likely that most roundscale spearfish captures have been classified as white marlin and more information on roundscale spearfish may be found in the white marlin discussion elsewhere in this section.

Predator-prey relationships: The diet of the longbill spearfish consists of pelagic fishes and squids. However, little data for diet specific to fish in the north Atlantic is available.

Life history: Spawning is thought to occur in widespread areas in the tropical and subtropical Atlantic (Nakamura, 1985) in the winter from November to May (de Sylva and Breder, 1997). There are a few records of larvae caught near the Mid-Atlantic Ridge from December to February, and in the Caribbean (Ueyanagi *et al.*, 1970; de Sylva and Breder, 1997)

Fisheries: Longbill spearfish is not a target species, and retention is prohibited in the U.S. EEZ. It is taken as bycatch of the tuna and swordfish longline fisheries; however, retention is prohibited.

U.S. Fishery Status: Unknown.

Growth and mortality: The maximum weight of females at first maturity is approximately 45 kg (de Sylva and Breder, 1997).

Habitat associations: The species ranges farther offshore than sailfish. Nothing is known about its habitat associations.

Essential Fish Habitat for Longbill Spearfish:

- **Spawning, eggs, and larvae:** At this time available information is insufficient to describe and identify EFH for this life stage.

- **Juvenile/Subadult and Adult:** EFH designation for juveniles and adults have been combined and are considered the same. In the central Gulf of Mexico through eastern Louisiana to the Florida Panhandle. In the Atlantic from Flordia Keys to the mid-east coast of Florida and localized areas from northern Florida to Cape Cod, with concentrations from North Carolina to Delaware, and Pureto Rico and the U.S. Virgin Islands. Please refer to Figure 5.25 for detailed EFH map, and Table 5.1 for life stage size information.

5.1.4 Large Coastal Sharks

5.1.4.2 Basking Sharks

Basking shark (*Cetorhinus maximus*) The basking shark is the second largest fish in the world, its size exceeded only by the whale shark. Like the whale shark, it is a filter-feeding plankton eater. Basking sharks feed by swimming forward with a widely opened mouth to filter particulate prey from the water column. As water passes across the gills, it is filtered by long bristle-like rakers on the gill arches, a strategy known as ram filter-feeding. *Cetorhinus maximus* is considered to be the only shark species that is an obligate ram filter-feeder (Diamond, 1985). It is a migratory species of the subpolar and cold temperate seas throughout the world, spending the summer in high latitudes and moving into warmer water in winter (Castro, 1983). In spite of its size and local abundance in summer, its habits are very poorly known. Basking sharks are thought to actively select areas along thermal fronts containing high densities of zooplankton, mainly large calanoid copepods. It is believed that they track seasonal zooplankton aggregations closely (Sims and Quayle, 1998; Sims, 1999; Sims *et al*., 2003) and follow annual changes in zooplankton distribution (Sims and Reid, 2002). These shifts may explain the disappearance of basking sharks from areas where they were formerly abundant; alternatively, local basking shark declines have been thought to be due to excessive fishing pressure (Southall *et al*., 2005).

In the northwestern and eastern Atlantic basking sharks occur in coastal regions from April to October, usually with a peak in sightings from May until August (Kenney *et al*., 1985;

Southall *et al*., 2005). The temporal and spatial distribution of basking sharks in both the northwestern and eastern Atlantic are thought to be influenced by seasonal water stratifications, temperature, and prey abundance (Owen, 1984, Sims and Merrett, 1997; Sims and Quayle, 1998; Sims, 1999; Sims *et al*., 2003; Skomal *et al*., 2004; Cotton *et al*., 2005). Recent tagging and metabolic studies have shown that basking sharks do not hibernate during the winter; rather they make extensive migrations, often to deeper waters, utilizing productive continental-shelf and shelf-edge habitats. In addition, animals did not exhibit long migrations into open-ocean regions away from coastal waters (Sims, 1999; Sims *et al*., 2003; Skomal *et al*., 2004).

Distribution data for the basking shark is incomplete largely because the species is not commonly taken by fisheries. In addition, to date, a stock assessment has not been conducted on basking sharks; however, tagging data suggest separate eastern and western stocks (Kohler *et al*., 1998). Aerial surveys of the U.S. continental shelf waters off New England in the northwest Atlantic (Hudson Canyon to the Gulf of Maine) estimated the abundance of basking sharks to be between 6,671 to 14,295 individuals in these waters (Owen, 1984; Kenney *et al*., 1985). Recent genetic work suggests comparatively low genetic diversity and no significant differentiation among ocean basins with a low effective population size (N_e) for a globally distributed species (Hoelzel *et al*., 2006).

While feeding, individual basking sharks are usually observed at the surface from spring to autumn, although some individuals form loose aggregations as they feed in the same discrete patch of zooplankton (Sims *et al*., 2000). In the northwest Atlantic, aggregations of basking sharks were observed from the south and southeast of Long Island, east of Cape Cod, and along the coast of Maine (Kenney *et al*., 1985). In particular, large aggregations were observed approximately 75 km south of Martha's Vineyard and 90 km south of Moriche's Inlet, Long Island (Kenney *et al*., 1985).

Reproductive potential: Little is known about basking shark reproductive processes. Males are believed to reach maturity between 460 and 610 cm (Bigelow and Schroeder, 1948); however, the age at maturation is not known at this time. Female length at maturity has been suggested as 700 cm by Matthews (1950) and Parker and Scott (1965), and 810-980 cm by Compagno (1984). Aggregations of basking sharks thought to exhibit group courtship behaviors have been observed. These aggregations tend to be associated with persistent thermal fronts within areas of high prey density, which have been hypothesized to be important areas for courtship and breeding of basking sharks (Sims *et al*., 2000). Wilson (2004) noted courtship behaviors in aggregations of basking sharks in the southern Gulf of Maine and near the Great South Channel, approximately 95 km southeast of Cape Cod, Massachusetts. Harvey-Clark *et al*. (1999) found aggregations exhibiting similar behaviors off the coast of Nova Scotia, Canada. Similarly, Sims *et al*. (2000) observed putative annual courtship behaviors from 1996–1999 off southwest England. However, no mating has been observed and is presumed to occur at depth (Sims *et al*., 2000; Wilson, 2004). It is believed that female basking sharks give birth to young measuring about 180 cm total length (TL), probably in high latitudes. There are no modern reports on the size of litters or data on reproductive cycles, however, Matthews (1950) observed basking sharks in breeding condition in late spring and early summer off the west coast of Scotland. Sampling was not conducted later in the summer to verify the extent of the breeding season.

Impact of fisheries: Fishing for the basking shark is prohibited in U.S. waters, although basking sharks are common off the east coast in winter. The basking shark is listed as 'Vulnerable' in the International Union for the Conservation of Nature Red List of Threatened Species (IUCN, 2002) and in Appendix II of CITES (UNEP-WCMC, 2003).

***Essential Fish Habitat for Basking Shark*:**

Note: At this time, insufficient data is available to differentiate EFH between the juvenile and adult size classes; therefore, EFH is the same for those life stages.

- **Neonate/YOY (≤182 cm TL):** At this time, available information is insufficient for the identification of EFH for this life stage.

- **Juveniles and Adults:** EFH designation for juveniles and adults have been combined and are considered the same. Atlantic east coast from the northern Outer Banks of North Carolina to the Gulf of Maine. Please refer to Figure 5.26 for detailed EFH map and Table 5.1 for life stage size information.

5.1.4.3 Hammerhead Sharks

5.1.4.3.1 Great Hammerhead Shark

Great hammerhead (*Sphyrna mokarran*) This shark is found both in open oceans and shallow coastal waters. One of the largest sharks, the great hammerhead is circumtropical in warm waters (Castro, 1983). It is usually a solitary fish, unlike the more common scalloped hammerhead, which often forms very large schools. Great hammerhead sharks have been observed using their laterally expanded head in prey-handling (Strong *et al*., 1990; Chapman and Gruber, 2002). Hammerheads are known for their unique head morphology. This morphology is thought to aid in a greater lateral search area, which may increase the probability of encountering prey, and enhanced maneuverability, which may aid in prey capture (Kajiura and Holland, 2002).

Reproductive potential: In Australian waters males mature at about 210 to 258 cm TL and females mature usually at 210 to 220 cm TL (Stevens and Lyle, 1989). Pups measure about 67 cm TL at birth (Stevens and Lyle, 1989), and litters consist of 20 to 40 pups (Castro, 1983). The gestation period lasts about 11 months (Stevens and Lyle, 1989). The reproductive cycle is biennial (Stevens and Lyle, 1989). In U.S. waters, the great hammerhead utilizes shallow inshore waters along Florida's Gulf coast as nursery areas throughout the warm months (Hueter and Tyminski, 2007). The location of their pupping grounds in this area is uncertain, as no neonates have been documented by the Mote Center for Shark Research (Hueter and Tyminski, 2007). The presence of young-of-the-year great hammerheads (N = 25, TL = 64–89 cm) in June and July indicates that pupping occurs in late spring and early summer, perhaps off the beaches in areas not sampled by the Mote CSR or farther offshore along Florida's Gulf coast (Hueter and Tyminski, 2007). Young-of-the-year great hammerheads can been found in the Yankeetown, Tampa Bay, and Charlotte Harbor areas throughout the summer at temperatures of 23.9 to 31.5°C, salinities of 20.8 to 34.2 ppt, dissolved oxygen of 5.3 to 7.6 mg/l, and depths of 1.8 to 5.5 m, but are seldom seen after October (Hueter and Tyminski, 2007). The first-year animals return to the nursery grounds the following March and April (Hueter and Tyminski, 2007).

Older juvenile great hammerheads (TL = 92–279 cm) often are found close to shore along Florida's Gulf coast in the Florida Keys and the bays and estuaries of the Yankeetown, Tampa Bay, Charlotte Harbor, and Ten Thousand Islands areas (Hueter and Tyminski, 2007). Longline surveys of Texas coastal waters also have revealed offshore secondary nurseries for this species (Hueter and Tyminski, 2007).

Impact of fisheries: Great hammerheads are caught in coastal longline shark fisheries as well as in pelagic tuna and swordfish longline fisheries. Its fins bring the highest prices in the shark fin market. The great hammerhead is vulnerable to overfishing because of its biennial reproductive cycle and because it is caught both in directed fisheries and as bycatch in tuna and swordfish fisheries.

***Essential Fish Habitat for Great Hammerhead*:**

Note: At this time, insufficient data is available to differentiate EFH by size classes, therefore, EFH is the same for all life stages.

- **Neonate/YOY, Juveniles, and Adults:** EFH designation for all life stages have been combined and are considered the same. Coastal areas throughout the west coast of Florida and scattered in the Gulf of Mexico from Alabama to Texas. Atlantic east coast from the Florida Keys to New Jersey. Eastern Puerto Rico. Please refer to Figure 5.27 for detailed EFH map and Table 5.1 for life stage size information.

5.1.4.3.2 Scalloped Hammerhead Shark

Scalloped hammerhead (*Sphyrna lewini*) This is a very common, large, schooling hammerhead of warm waters. It is the most common hammerhead in the tropics and is readily available in abundance to inshore artisanal and small commercial fisheries as well as offshore operations (Compagno, 1984). It migrates seasonally north-south along the eastern United States. Scalloped hammerhead sharks are widely distributed, but they are also dependent on discrete coastal nursery areas (Duncan *et al*., 2006). Tagging data indicate that scalloped hammerhead sharks use offshore oceanic habitat, but do not regularly roam across large distances (Kohler and Turner, 2001). Rather, individuals appear to disperse readily across continuous habitat (continental shelves) (Duncan *et al*., 2006). Hammerheads are known for their unique head morphology. This morphology is thought to aid in a greater lateral search area, which may increase the probability of prey encounter, and enhanced maneuverability, which may aid in prey capture (Kajiura and Holland, 2002). In addition, recent morphological and genetic research suggests a cryptic species of scalloped hammerhead shark found in the northwestern Atlantic from coastal North Carolina to Florida (Abercrombie *et al*., 2005; Quattro *et al*., 2006); a recent phylogeny for hammerhead sharks was done by Cavalcanti (2007).

Reproductive potential: There is sexual segregation of males and females with females found more often in deeper water and a tendency to move into offshore waters at a smaller size than males (Klimley 1987; Branstetter, 1987b; Stevens and Lyle, 1989). Males in the Atlantic and Gulf of Mexico mature at about 180 to 234 cm FL or 9 to10 years of age (Branstetter, 1987b; Hazin *et al*., 2001; Piercy *et al*., 2007), while those in the Indian Ocean mature at 140 to 165 cm

TL (Bass *et al.*, 1973). Branstetter (1987b) found that males grow to a maximum size of 272 to 300 cm, corresponding to 22 to 30 years of age. Females mature around 241 cm FL or 15 years of age (Branstetter, 1987b; Hazin *et al*., 2001; Piercy *et al*., 2007), with a maximum size of 305 to 310 cm, corresponding to 35 yrs of age (Branstetter, 1987b). Peircy *et al*. (2007) found that the northwestern Atlantic Ocean and Gulf of Mexico populations grow more slowly and have smaller asymptotic sizes than previously reported studies for this species in the Pacific Ocean. Branstetter (1987b) reported growth through the first winter around 15 cm, and an annual growth rate of 10 to15cm for the next few years for scalloped hammerhead in the Gulf of Mexico; however, Piercy *et al*. (2007) found faster growth for this species in the Gulf of Mexico. Scalloped hammerheads can have large litters (>30 pups) with pups ranging in size from 38 and 56.2 cm TL (Clarke 1971; Castro, 1983; Compagno 1984; Branstetter, 1987b; Chen *et al*., 1988). However, there is variation in liter size based on geographic region (Lessa *et al*, 1998). In the northwestern Gulf of Mexico, back-calculated size at parturition for this species ranged from 45 to 60 cm TL with a mean of 50.3 cm TL (Branstetter, 1987b). Clarke (1971) reported a 39.5 cm TL scalloped hammerhead from Hawaiian waters. Castro (1993b) recorded a 34.7 cm TL neonate from Bulls Bay, South Carolina. During this study, three free swimming individuals were collected measuring less than 40 cm TL, with the smallest measuring 38.5 cm TL.

The reproductive cycle is annual (Castro, 1993b), and the gestation period is nine to ten months (Stevens and Lyle, 1989) but may be as long as 12 months (Branstetter, 1987b). Castro (1993b) found nurseries in the shallow coastal waters of South Carolina. Subsequent studies have identified the importance of coastal South Carolina waters as primary and secondary nursery areas for scalloped hammerheads (Abel *et al*., 2007; Ulrich *et al*., 2007). Abel *et al*. (2007) collected juvenile scalloped hammerhead sharks (47 to 58 cm TL) in Winyah Bay, South Carolina, and suggested that this area may be an important secondary nursery area for this species. Ulrich *et al*. (2007) collected neonate and juvenile scalloped hammerhead sharks in both estuarine and nearshore waters off South Carolina. Sizes ranged from 27.4 to 101.4 cm FL, and scalloped hammerheads occurred over a temperature range of 18 to 31°C and a salinity range of 20 to 37 ppt (Ulrich *et al*., 2007). Scalloped hammerheads were present in South Carolina coastal waters from mid-April, when water temperatures had increased to approximately 18°C, through mid-November, when water temperatures decreased to 18°C (Ulrich *et al*., 2007). They were observed in estuarine waters from mid-May through early September in a narrow temperature range from 25° to 26°C (Ulrich *et al*., 2007). Scalloped hammerheads were collected in nearshore waters in November as they were presumably migrating out of South Carolina waters (Ulrich *et al*., 2007). Neonates dominated the catch (67.31 percent), with the majority occurring from mid-May through the beginning of November (Ulrich *et al*., 2007). Of the 173 neonates caught, only three were captured in nearshore waters, two of these being in October and November when these sharks were likely migrating out of South Carolina waters (Ulrich *et al*., 2007). The mean size of neonates with an open or partially healed umbilicus was 33.1 cm FL, which is in agreement with Castro's (1993b) estimates of size at parturition.

Adams and Paperno (2007) also collected neonates from late May to early June in an area identified as nursery habitat in waters adjacent to Cape Canaveral and directly southwest of Canaveral Bight off the east coast of Florida. Water temperatures ranged from 26.1° to 28.8°C and water depths ranged from 3.8 to 9.7 m during the sampling period. The stomach contents of neonates examined in this area included fresh, partially digested, and well-digested small fishes (*e.g*., menhaden *Brevoortia* spp.) and shrimp (Adams and Paperno, 2007). The presence of fresh and partially digested prey items in stomachs of scalloped hammerheads examined during this study indicated that individuals from this population were actively feeding in nearshore Cape Canaveral waters (Adams and Paperno, 2007). The extensive sand-shell plain of Southeast Shoal, the deeper waters of Canaveral Bight, and the shelf transition zone directly south of Canaveral Bight may provide important feeding areas for this species (Adams and Paperno, 2007). The shallow waters and unique habitat of Southeast Shoal also may afford neonates an increased level of protection from large predators compared to adjacent deepwater habitats (Adams and Paperno, 2007).

Young scalloped hammerheads are relatively uncommon in Gulf nearshore waters of peninsular Florida. Neonates of this species (TL = 46 to 53 cm) are observed along the beaches of the lower Texas coast in late spring and early summer and also are occasionally seen in the Yankeetown, Tampa Bay, and Charlotte Harbor areas at that time in temperatures of 23.2° to 30.2°C, salinities of 27.6 to 36.3 ppt, and DO of 5.1 to 5.5 ml/l (Hueter and Tyminski, 2007). Young-of-the-year scalloped hammerheads are present in bays and nearshore nurseries during the summer months in the Florida areas of Yankeetown, Tampa Bay, and Charlotte Harbor as well as along the beaches of the lower Texas coast (Hueter and Tyminski, 2007). These first-year sharks typically move out of these areas by late October (Hueter and Tyminski, 2007). Older juvenile scalloped hammerheads (TL = 102–120 cm) occasionally are seen in the Tampa Bay area (Hueter and Tyminski, 2007). Nursery habitat for scalloped hammerhead sharks has also been identified in Mississippi Sound and Mobile Bay off the coasts of Mississippi and Alabama (Parsons and Hoffmayer, 2007). Secondary nurseries for this species extend into deeper coastal waters particularly off Texas, where they have been captured during longline surveys and on rod-and-reel around offshore oil rigs at depths of at least 53 m (Hueter and Tyminski, 2007).

Juvenile scalloped hammerhead sharks reside within nursery habitats for extended periods of time (at least on year post parturition) (Duncan and Holland, 2006). In addition, juveniles of the cryptic species of scalloped hammerheads were found in relative high abundance in South Carolina estuaries, and its rarity in other areas (*i.e.*, Gulf of Mexico) suggests that South Carolina bays are among the more important nursery grounds for the cryptic species (Quattro *et al*., 2006).

Impact of fisheries: Because the scalloped hammerhead forms very large schools in coastal areas, it is targeted by many fisheries for its high priced fins. Scalloped hammerhead and silky sharks make up >80 percent of the shark bycatch in the winter swordfish/tuna longline fishery of the northwestern Gulf of Mexico. Neonate scalloped hammerheads are also taken in shrimp trawls in coastal waters of the Gulf of Mexico (Branstetter, 1987b). The scalloped hammerhead is considered vulnerable to overfishing because its schooling habit makes it extremely vulnerable to gillnet fisheries and because scalloped hammerheads are actively pursued in many fisheries throughout the world. Fishery-dependent data from 1986 to 2000 from the U.S. pelagic longline fleet shows a decreasing trend in the abundance of hammerhead sharks, most of which are comprised of scalloped hammerhead sharks (Baum *et al*., 2003); however, critical evaluation of these results indicate that this estimate may be exaggerated based on incomplete analyses and dataset limitations (Burgess *et al*., 2005). Due to limited dispersal by this species, it is suggested that depleted populations will not recover quickly through immigration; rather, recovery would be slow through reproduction (Duncan *et al*., 2006).

Essential Fish Habitat for Scalloped Hammerhead:

- **Neonate/YOY (≤60 cm TL):** Coastal areas in the Gulf of Mexico from Texas to the southern west coast of Florida. Atlantic east coast from the mid-east coast of Florida to southern North Carolina. Please refer to Figure 5.28 for detailed EFH map.

- **Juveniles (61 to 179 cm TL):** Coastal areas in the Gulf of Mexico from the southern to mid-coast of Texas, eastern Lousainia to the southern west coast of Florida, and the Florida Keys. Offshore from the mid-coast of Texas to eastern Louisiania. Atlantic east coast of Florida through New Jersey. Please refer to Figure 5.29 for detailed EFH map.

- **Adults (≥180 cm TL):** Coastal areas in the Gulf of Mexico along the southern Texas coast, and eastern Lousainia through the Florida Keys. Offshore from southern Texas to eastern Louisiania. Atlantic east coast of Florida to Long Island, NY. Please refer to Figure 5.30 for detailed EFH map.

5.1.4.3.3 Smooth Hammerhead Shark

Smooth hammerhead (*Sphyrna zygaena*) This is an uncommon hammerhead of temperate waters. Fisheries data for hammerheads includes this species and the scalloped and great hammerheads; however, there is little data specific to the species.

Essential Fish Habitat for Smooth Hammerhead:

- Note: At this time, there is insufficient data available to designate EFH.

5.1.4.4 Mackerel Sharks

5.1.4.4.1 White Shark

White shark (*Carcharodon carcharias*) The white shark is the largest of the lamnid, or mackerel, sharks. It is a poorly known apex predator that occurs in coastal and offshore waters and is most common in cold and warm temperate seas (Compagno, 1984). Its presence is usually sporadic throughout its range, although there are a few localities (*e.g.*, off California, Australia, South Africa, and New England) where it is seasonally common. In the western North Atlantic, it is found from Newfoundland to the Gulf of Mexico (Casey and Pratt, 1985). The number of white sharks reported along the east coast of the United States was lowest in the most northern and southern parts of the range, *i.e.*, the Gulf of St. Lawrence region and the Gulf of Mexico-southeast U.S. regions, respectively. The highest number of occurrences were recorded from the region the authors identify as the "Mid-Atlantic Bight" (Casey and Pratt, 1985). Seasonally, white sharks were reported from January through September in the Gulf of Mexico; in every month but August off the southeastern United States; from April through December in the Mid-Atlantic Bight; from June through November in the Gulf of Maine; and during July and August in the Gulf of St. Lawrence-Newfoundland region (Casey and Pratt, 1985). White shark sightings are common off New England during the summer (Casey and Pratt, 1985). The seasonal occurrence of the white shark is at least partly influenced by surface temperature. Miles (1971) suggests that the world distribution of white sharks is restricted to water temperatures between 12° and 25°C. Squire (1967) reported white sharks during all months of the year in Monterey Bay, where mean monthly temperatures ranged from 10.2° to 14.4°C. Water temperatures reported in 73 cases of white shark occurrence in Casey and Pratt's study, ranged from 11° to 24°C with 75 percent of the occurrences where surface temperatures were between 15°C and 22°C (Casey and Pratt, 1985). They suggest that the 15°C isotherm is the limit in the northern latitudes (Casey and Pratt, 1985).

If temperature is a major factor influencing the distribution of the white shark, it appears that larger individuals tolerate a wider range of temperatures and occupy a broader geographical range than smaller individuals (Casey and Pratt, 1985). Although white sharks over 300 cm TL have been reported in every region, individuals less than 200 cm TL are common only in the Mid-Atlantic Bight (Casey and Pratt, 1985). From all available evidence, the white shark is more abundant on the continental shelf between Cape Hatteras and Cape Cod (35°00'N, 43°00'N) than in any other region in the western North Atlantic (Casey and Pratt, 1985). More young white sharks have been caught there than in any area of comparable size in the world (Casey and Pratt, 1985), with the smallest specimen measuring 109 cm fork length caught in Vineyard Sound off Massachusetts (Skomal, 2007). The occurrence of small and intermediate size white sharks in continental shelf waters of the Mid-Atlantic Bight up through coastal waters of Massachusetts suggests this area serves as a nursery area for juveniles (Casey and Pratt, 1985; Skomal, 2007). In addition, on eight occasions pairs of large white sharks have been observed swimming close together (Casey and Pratt, 1985). Although adult white sharks of both sexes occur in the Mid-Atlantic Bight, sexes of these pairs were not determined (Casey and Pratt, 1985). The occurrence of adults of both sexes in the same region and the presence of large individuals swimming together may be evidence of mating activity in the Mid-Atlantic Bight (Casey and Pratt, 1985).

White sharks are born between 108 and 136 cm FL (120-150 cm TL; Francis 1996) and are known to reach 599 cm FL (640 cm TL; Castro 1983, Compagno 1984). The size at maturity is estimated to be about 340 cm for females (Castro, In Press) and 470 for males (Uchida *et al.*, 1996). Casey and Pratt (1985) provided a length-weight curve indicating the white shark is very robust, with its weight increasing an average of 456 kg (207 lb) for every 30 cm (1 ft) of length between 415-549 cm (15 and 18 ft).

Off the California coast, large adults prey on seals and sea lions and are sometimes found around seal and sea lion rookeries. The white shark is also a scavenger of large dead whales. Recent isotopic analysis showed an isotopic signature based on diet that changed with increasing size, indicating a change in diet over time; one shift was from yolk to fish after white sharks were born and another switch occurred at a total length of 341 cm, representing a known diet shift from fish to marine mammals (Estrada *et al.*, 2006). This is consistent with other work that has shown that after birth, juvenile white sharks are known to be piscivorous, and white sharks > 300 cm long shift from a diet principally of fish to marine mammals (Klimley 1985, McCosker 1985). Morphological work on white sharks has shown special adaptations in their caudal fins and liver size that allow small individuals to effectively hunt fast-swimming fish, whereas larger white sharks have increased buoyancy to patrol wide-ranging areas while minimizing energy costs in search of preferred large mammalian prey (Lingham-Soliar, 2005b). White sharks also have a highly stiffened dorsal fin and a highly modified caudal peduncle and caudal fin that allows for fast swimming (Lingham-Soliar, 2005a; 2005c).

Recent PSAT tagging of white sharks off of South Africa have shown that both male and female white sharks make coastal migrations as well as transoceanic return migrations. Based on this tagging data and genetic data, it is believed that while female white sharks may exhibit natal homing behavior, they also can make long, transoceanic migrations (Bonfil *et al*., 2005). However, previous genetic work by Pardini *et al*. (2001) suggested that male sharks show transoceanic dispersal, while females exhibit more non-roving behaviors. Tagging work by Boustany *et al*. (2002) also indicate that adult white sharks' ranges are more pelagic than was previously thought, comprising of an inshore continental-shelf phase as well as extensive oceanic travel that includes extensive dives. Juvenile white sharks use the entire water column when the animal is over the continental shelf (Dewar *et al*., 2004). In addition, foraging juveniles may occur in the mixed layer and near the surface at night, however, daytime dive patterns suggest that diurnal feeding occurs at or near the bottom (Dewar *et al*., 2004). These tagging data have also indicated that juvenile white sharks may be able to tolerate colder waters than previously thought; however, vertical movement patterns may indicate some thermal constraints on the behavior of juveniles (Dewar *et al*., 2004). Adult white sharks, however, do not seem to be constrained to the mixed layer and spend large portions of time below the thermocline when offshore (Boustany *et al*., 2002).

Reproductive potential: Very little is known of its reproductive processes because few gravid females have been examined by biologists in modern times. Two specimens contained seven embryos. Recent observations show that white sharks carry seven to ten embryos that are born at 120 to 150 cm TL (Francis, 1996; Uchida *et al*., 1996). A pregnant female white shark captured by a tunny boat in the Gulf of Gabes (southern Tunisia, central Mediterranean) on February 26, 2004 (Saidi *et al*., 2005) had four developing embryos, three females and one male, ranging in size between 132 and 135 cm total length and weighed between 27.65 and 31.50 kg (Saidi *et al*., 2005). The embryos exhibited a distended abdomen due to yolk accumulation (Uchida *et al*., 1996; Saidi *et al*., 2005). This confirms that the species is known to be oophagous (Saidi *et al*., 2005). The types of habitats and locations of nursery areas are unknown. It is likely that the nurseries will be found in the warmer parts of the range in deep water.

The lengths of the reproductive and gestation cycles are unknown. White sharks are believed to mature between 370 and 430 cm at an estimated age of nine to ten years (Cailliet *et al.,* 1985). Cailliet *et al.* (1985) estimated growth rates of 25.0 to 30.0 cm/year for juveniles and 21.8 cm/year for older specimens, and gave the following von Bertalanffy parameters: n = 21, L4 = 763.7 cm, K = 0.058, to = -3.53. They estimated that a 610 cm TL specimen would be 13 to 14 years old. Mollet and Cailliet (2002) used a life history table model and the Leslie-matrix demographic model to predict annual population growth of white sharks. With population parameter estimates, as defined in their paper, they estimated the potential annual population growth as 8.2 percent, with a fishing mortality of 0.0787 $year^{-1}$ across all age classes producing a stationary population ($\lambda = 1.0$). Population growth was most affected by juvenile survival (Mollet and Cailliet, 2002), and mean generation time was estimated to be 23.1 years.

Impact of fisheries: The white shark is a prized game fish because of its size. It is occasionally caught in commercial longlines or in near-shore drift gillnets, but it must be released in a manner which maximizes its survival. Its jaws and teeth are often seen in specialized markets where they bring high prices. Preliminary observations (Strong *et al.,* 1992) show that populations may be small, highly localized, and very vulnerable to overexploitation. The white shark has been adopted as a symbol of a threatened species by some conservation organizations, and has received protected status in South Africa, Australia, and the State of California. In 1997, the Unites States implemented a catch-and-release only recreational fishery for the white shark, while prohibiting possession of the species. There are no published population assessments, or even anecdotal reports, indicating any population decreases of the white shark. However, Baum *et al*. (2003) reported an 80 percent decline in longline CPUE on white sharks in the North Atlantic, suggesting a decrease in population size over time. Burgess *et al*. (2005a) questioned the assumptions and data used in the Baum and Myers article and challenged the appropriateness of some of the analyses. Nevertheless, it is a scarce apex predator and a long-lived species of a limited reproductive potential that is vulnerable to longlines.

***Essential Fish Habitat for White Shark*:**

- **Neonate/YOY, Juveniles, and Adults:** EFH designation for all life stages have been combined and are considered the same. Along the mid- and southern west coast of Florida in the Gulf of Mexico, and along the mid- and northern east coast of Florida, South Carolina, and North Carolina in the Atlantic. Maryland to Cape Cod. Please refer to Figure 5.31 for detailed EFH map and Table 5.1 for life stage size information.

5.1.4.5 Nurse Sharks

Nurse shark (*Ginglymostoma cirratum*) The nurse shark inhabits littoral waters in both sides of the tropical and subtropical Atlantic, ranging from tropical West Africa and the Cape Verde Islands in the east, and from Cape Hatteras, North Carolina to Brazil in the west. It is also found in the eastern Pacific, ranging from the Gulf of California to Panama and Ecuador (Bigelow and Schroeder, 1948). It is a shallow water species, often found lying motionless on the bottom under coral reefs or rocks. It often congregates in large numbers in shallow water (Castro, 1983; Pratt and Carrier, 2001). Generally, nurse sharks are not usually far ranging in their movements and most individuals spend their entire life cycle within a few hundred square kilometers (Carrier and Luer, 1990; Kohler *et al*., 1998).

Reproductive potential: Males reach maturity at about 214 cm TL and females at about 214 cm TL (Castro, in press). Litters consist of 20 to 30 pups, the young measuring about 30 cm total length at birth. The gestation period is about five to six months and reproduction is biennial (Castro, 2000). The age at maturity is unknown, but the nurse shark is a long-lived species. Clark (1963) reported an aquarium specimen living up to 24 years in captivity.

Its nurseries are in shallow turtle grass (*Thalassia*) beds and shallow coral reefs (Castro, 2000; Pratt and Carrier 2001). Juveniles are also found around mangrove islands in south Florida. Primary nurseries for the nurse shark on the west coast of Florida have not been well documented, perhaps due in part to this species' small size at birth and ability to avoid entanglement in collection gear (Hueter and Tyminski, 2007). No neonates or young of the year have been captured in any Mote CSR-directed field collections (Hueter and Tyminski, 2007). Older juveniles (*N* = 314, TL = 49–212 cm), which have been caught on Mote CSR longline and drumline gear, are commonly observed from April to November in the areas of Tampa Bay, Charlotte Harbor, Ten Thousand Islands, and the Florida Keys in temperatures of 17.5° to 32.9°C, salinities of 21.8 to 38.9 ppt, DO of 1.7 to 11.5 mg/l, and depths of 0.3 to 12.2 m (Hueter and Tyminski, 2007). In addition, juvenile nurse sharks (62.0–121.9 cm TL) were collected in northern Cape Canaveral (latitude 28°40'N) to south of the Jupiter Island area (latitude 27°04'N) in water depths of 3 to 11 m (Adams and Paperno, 2007) and in Winyah Bay, South Carolina (Abel *et al*., 2007). Large numbers of nurse sharks often congregate in shallow waters off the Florida Keys and the Bahamas at mating time in June and July (Fowler, 1906; Gudger, 1912; Pratt and Carrier, 2001). A small area has been set up for protection of mating sharks at Fort Jefferson in the Dry Tortugas as nurse shark mating has been observed in this area (Pratt and Carrrier, 2001).

Work by Wiley and Simpendorfer (2007) caught juvenile and adult nurse sharks (10 to 215 cm) in the marine areas of the Everglades National Park. Here, nurse sharks seem to avoid salinities < 30 ppt and were found in salinities > 30 ppt. Most nurse sharks were caught in waters between 25° to 29°C and in depths greater than 2.25 m (Wiley and Simpendorfer, 2007).

Impact of fisheries: In North America and the Caribbean the nurse shark has often been pursued for its hide, which is said to be more valuable than that of any other shark (Springer, 1950a). The fins have no value, and the meat is of questionable value (Springer, 1979). The U.S. commercial bottom longline fleet catches few nurse sharks (Burgess and Morgan, 2005).

***Essential Fish Habitat for Nurse Shark*:**

- **Neonate/YOY (≤36 cm TL):** Insufficient data to determine EFH for this lifestage.
- **Juvenile (52 to 230 cm TL):** Coastal areas in the Gulf of Mexico from the Florida Panhandle to the Florida Keys. Atlantic east coast of Florida to southern Georgia. Virgin Islands. Please refer to Figure 5.32 for detailed EFH map.
- **Adults (≥231 cm TL):** Coastal areas in the Gulf of Mexico from the Florida Panhandle to the Florida Keys. Atlantic east coast of Florida. Please refer to Figure 5.33 for detailed EFH map.

5.1.4.6 Requiem Sharks

5.1.4.6.1 Bignose Shark

Bignose shark (*Carcharhinus altimus*) The bignose shark is a poorly known, bottom dwelling shark of the deeper waters of the continental shelves. It is found in tropical and subtropical waters throughout the world (Castro, 1983). There is evidence that bignose sharks undergo diurnal vertical migration. Bignose sharks have been documented near the bottom at depths of 90-500 m during the day. At night, at least some individuals move into shallower water or up into the pelagic zone (Anderson and Stevens, 1996).

Reproductive potential: The smallest mature specimens recorded by Springer (1960) were a 213 cm TL male and a 221 cm TL female. Springer (1950c) reported litters of seven to eight pups, while Stevens and McLoughlin (1991) noted from three to 15 pups. Birth size is probably around 70 cm TL based on the largest embryos (65 to 70 cm TL) reported by Fourmanoir (1961) and free swimming specimens with fresh umbilical scars seen by Bass *et al.,* (1973). Based on 29 individuals (3 mature, 2 almost mature), 50 percent maturity for females is 192.5 cm FL (L. Natanson, NEFSC, unpubl. data). Based on 12 individuals (2 mature) 50 percent maturity for males is 179 cm FL (Natanson, unpubl. data). The lengths of the gestation period and of the breeding cycle have not been reported. The location of the nurseries is unknown.

Impact of fisheries: Springer (1950c) stated that the bignose shark appeared to be the most common large shark of the edges of the continental shelves in the West Indian region, and that the species made up a substantial portion of the catch in the Florida shark fishery of the1940s. In some areas bignose sharks are mistaken for sandbar sharks.

***Essential Fish Habitat for Bignose Shark*:**

Note: At this time, insufficient data is available to differentiate EFH between the juvenile and adult size classes; therefore, EFH is the same for those life stages.

- **Neonate/YOY (≤84 cm TL):** Insufficient data to determine EFH for this lifestage.
- **Juveniles and Adults:** EFH designation for juveniles and adults have been combined and are considered the same. Localized areas from Louisiana through the west coast Florida to the Florida Keys in the Gulf of Mexico, and the east coast of Florida and South Carolina in the Atlantic. Continuous EFH from North Carolina to New Jersey. Please refer to Figure 5.34 for detailed EFH map and Table 5.1 for life stage size information.

5.1.4.6.2 Blacktip Shark

Blacktip shark (C*archarhinus limbatus*) The blacktip shark is circumtropical in shallow coastal waters and offshore surface waters of the continental shelves. In the southeastern United States it ranges from Virginia to Florida and the Gulf of Mexico. Upon examining a large number of museum specimens, Garrick (1982) believed it to be a single worldwide species. However, Dudley and Cliff (1993), working off South Africa, and Castro (1996), working on blacktip sharks off the southeastern United States, showed that there were significant differences among the various populations. For example, the median size for blacktip sharks in the Atlantic is 126.6 cm fork length, whereas the median size in the Gulf region is 117.3 cm fork length. In addition, researchers investigated the genetic population structure of blacktip sharks in the Atlantic and Gulf of Mexico and found genetic differences between Atlantic and Gulf of Mexico populations (Keeney *et al*., 2003; Keeney *et al*., 2005). Considering the documented long-distance movements of blacktip sharks (Kohler *et al*., 1998), the magnitude and geographical scale of genetic differentiation indicates a strong tendency for female blacktip sharks to exhibit a high degree of site-fidelity (philopatry) for Gulf or Atlantic natal nurseries (Keeney *et al*., 2003; Keeney *et al*., 2005).

The blacktip shark is a fast moving shark that is often seen at the surface, frequently leaping and spinning out of the water. It often forms large schools that migrate seasonally north-south along the coast and exhibit a strong diel pattern in their aggregations thought to be related to predator avoidance or improved feeding efficiency (Heupel and Simpendorfer, 2005a). This species is much sought after in the eastern United States because of the quality of its flesh. The blacktip and the sandbar shark are the two primary species in the U.S. commercial fisheries. In the markets of the United States "blacktip" has become synonymous with good quality shark; therefore, many other species are also sold under that name.

Reproductive potential: Off the southeastern United States males mature at between 142 and 145 cm total length and females at about 156 cm TL (Castro, 1996). According to Branstetter and McEachran (1986), in the western North Atlantic males mature at 139 to 145 cm total length at four to five years and females at 153 cm total length at six to seven years. A similar pattern is evident in the Atlantic and Gulf of Mexico, with larger size at maturity in the Atlantic than in the Gulf region. However, these ages are unvalidated and based on a small sample. Branstetter and McEachran (1986) estimated the maximum age at ten years, and gave the von Bertalanffy parameters for combined sexes as: L_4 = 171, K= 0.284, t_o= -1.5.

The young are born at 55 to 60 cm total length in late May and early June in shallow coastal nurseries from Georgia to the Carolinas (Castro, 1996), and in bay systems in the Gulf of Mexico (Carlson, 2002; Parsons, 2002), and the Texas coast (Jones and Grace, 2002). Litters range from one to eight pups (Bigelow and Schroeder, 1948) with a mean of four. The gestation cycle lasts about a year; the reproductive cycle is biennial (Castro, 1996).

In general, nursery areas are thought to be used for two main reasons: predator avoidance and food abundance (Branstetter, 1990; Castro, 1993b; Simpfendorfer and Milward, 1993). However, work by Heupel and Hueter (2002) found that prey abundance is not the main factor directing the movement patterns and habitat choice of juvenile blacktip sharks within one nursery area on the west coast of Florida. Rather, predator avoidance may be more important in the use of the nursery grounds by these young animals than prey abundance (Heupel and Hueter 2002). Mortality in this nursery was shown to be the highest for neonates within the first 15 weeks of life; Heupel and Simpendorfer (2002) showed that 61 and 91 perecnt of neonates died within in this time period due to natural and fishing mortality. In addition, examination of home range size within nursery areas showed a population-wide increase in home range size over time (Heupel *et al*., 2004). Therefore, Heupel and Simpendorfer (2005b) argued that larger reserve areas would be needed to protect nursery grounds and provide better protection for young sharks when they were most vulnerable within the nursery area.

According to Castro (1993b), the nurseries are on the seaward side of coastal islands of the Carolinas, at depths of two to four meters. Carlson (2002) found neonates in depths of 2.1 to 6.0 m under a variety of habitat conditions. Castro (1993b) found neonates over muddy bottoms off Georgia and the Carolinas, while Hueter found them over seagrass beds off western Florida (Mote Laboratory CSR, unpubl. data). Gurshin (2007) found the summer population of blacktip sharks around the Sapelo Island National Estuarine Research Reserve appeared to consist primarily of young-of-the-year and small juveniles, suggesting that the estuary system of Sapelo Island, Georgia served as primary and secondary nursery habitats.

Juvenile blackip sharks have also been found in Winyah Bay and North Inlet, South Carolina, and this area has been suggested as a secondary nursery habitat for this species (Abel *et al*., 2007). Blacktip sharks were captured in South Carolina waters from May until early November and ranged in size from 44.7 to approximately 185.0 cm FL (Abel *et al*., 2007). Blacktip sharks occurred at temperatures between 19°C and 31°C and over a salinity range of 13 to 37 ppt, although 98 percent were captured at salinities between 25 and 37 ppt (Abel *et al*., 2007). Both adult female and male blacktip sharks were observed between June and November in nearshore waters, and from May to early October in estuarine waters (Abel *et al*., 2007). A total of 190 neonate and young-of-the-year blacktip sharks were collected during the study (Abel *et al*., 2007). With the exception of one individual, neonates and young-of-the-year were captured exclusively in estuarine waters between May and early September, indicating the importance of the estuaries as primary nurseries for this species (Abel *et al*., 2007). Neonate blacktip sharks with umbilical remains ranged in size from 44.7 to 59.3 cm FL (mean = 51.2 cm FL), which was slightly larger than the size range at parturition reported by Castro (1996) (Abel *et al*., 2007). Parturition occurred over an approximately 1-month period during May and June (Abel *et al*., 2007). By mid-September young-of-the-year had migrated into nearshore waters (Abel *et al*., 2007). Juvenile blacktip sharks, ranging in size from 72.5 to 111.3 cm FL, were caught in both estuarine and nearshore waters, indicating that this species utilizes both of these areas as secondary nurseries (Abel *et al*., 2007). Juveniles were first seen in nearshore waters in mid-May (Abel *et al*., 2007). By the end of May juveniles were collected in both nearshore and estuarine waters (Abel *et al*., 2007). Juvenile blacktip sharks were not captured in estuaries after the beginning of September and presumably migrated out of South Carolina nearshore waters by the beginning of October (Abel *et al*., 2007). Juvenile blacktip sharks (63 to88.5 cm TL) were also collected along the eastern seaboard from northern Cape Canaveral (latitude 28°40'N) south to the Jupiter Island area (latitude 27°04'N) in water depths of 3 to 11 m (Adams and Paperno, 2007).

On the west coast of Florida, Yankeetown has proven to be the most productive blacktip shark primary nursery followed by Charlotte Harbor, Tampa Bay, Ten Thousand Islands, and the Florida Keys (Hueter and Tyminski, 2007). Neonate blacktip sharks (N = 1,933, TL = 42–74 cm) have been documented in all five of these Florida areas, and significant pupping takes place along the Texas coast as well (Hueter and Tyminski, 2007). Blacktip shark pupping begins as early as mid-April and can continue until as late as the first week of September, with the peak occurring in June (Hueter and Tyminski, 2007). Steiner *et al*. (2007) found blacktip sharks were most abundant in the Ten Thousand Islands area between May and August, with clear peaks in June and July. Specimens still showing an umbilical scar in the Ten Thousand Islands area were reported from the beginning of May through the beginning of August (Steiner *et al*., 2007). Immature blacktip sharks were occasionally caught in the estuary, but they usually stayed around the Gulf front islands. Overall, blacktip sharks caught in the Ten Thousand Islands were estimated to be a couple of days old (umbilical scar still open) to 5+ years (Steiner *et al*, 2007).

Young-of-the-year blacktip sharks remain in the nurseries throughout the warm months and begin their fall migration in October and November when water temperatures drop to around

20°C. Heupel (2007) concluded that temperature drops were the primary cue that juvenile blacktip sharks used to time their emigration from nursery areas. However, young-of-the-year and juvenile blacktip sharks have been found in the warm water effluents of Tampa Bay and Yankeetown power plants during the winter months (Hueter and Tyminski, 2007). Tag/recapture data suggest that first-year blacktip sharks leaving the north-central Florida nurseries (Yankeetown area) in the fall migrate south as far as the Marquesas Islands west of the Florida Keys (a minimum distance of 519 km; Hueter *et al*. 2005) (Hueter and Tyminski, 2007). In preparation for winter, adult blacktip sharks of Florida migrate to wintering grounds off southern Florida and the Keys (Steiner *et al*., 2007). Young-of-the-year blacktip sharks begin their northward spring migration back to the primary nursery areas as early as late February but more typically in March and April, and thus these areas function additionally as secondary nurseries for one-year-old as well as older juvenile blacktip sharks (Hueter and Tyminski, 2007). Older juvenile year-classes return to these nursery areas beginning in March and remain there throughout the summer before undergoing their fall migration in October and November (Hueter and Tyminski, 2007). These juveniles often move well into the estuaries and are found in salinities as low as 17 ppt (Hueter and Tyminski, 2007).

Mote CSR collaborative studies indicate that immature blacktip sharks also are commonly found associated with nearshore oil rigs during the warm months along the upper Texas coast as well as coastal areas of Mississippi and Louisiana (Hueter and Tyminski, 2007; Parsons and Hoffmayer, 2007; Neer *et al*., 2007). Neer *et al*. (2007) has shown that central Louisiana's nearshore coastal waters appear to be important pupping and nursery areas for blacktip sharks with males ranging from 45.6 to 109.5 cm FL and females ranging fro 43.9 to 110.8 cm FL. Blacktip sharks regularly frequent Terrebonne/Timbalier Bay system in central Louisiana in June and July (Neer *et al*., 2007). Temperature ranged from 22.2°C to 32.4°C, while salinity ranged from 11.0 to 37.3 ppt over the sampling period, and dissolved oxygen ranged from 2.89 to 9.61 mg/l, with more blacktips being found in warmer, more saline waters (Neer *et al*., 2007). Parsons and Hoffmayer (2007) collected juvenile blacktip sharks in Mississippi Sound and Mobile Bay off the coasts of Mississippi and Alabama. Young-of-year and juvenile blacktip shark collections made in these areas water between 3.1 and 8.2 m in mean depth, 27.1°C and 30.6°C mean temperature, 18 and 20 parts per thousand (ppt) mean salinity, 5.5 and 7.3 ppm mean dissolved oxygen, 10.7 and 20.3 cm/s mean current speed, and 80 to 130 cm mean Secchi depth (Parsons and Hoffmayer, 2007). Large numbers of young-of-the-year blacktips were collected north of Dauphin Island, in the lower reaches of the Mobile Bay, Fort Morgan, Sand Island, north of Horn Island, and near the mouth of Bay St. Louis, with high catch-per-unit-effort occurring in May and June and the highest in July when waters were about 29° to 33°C (Parsons and Hoffmayer, 2007).

Impact of fisheries: The blacktip shark is caught in many diverse fisheries throughout the world. Off the southeastern United States it is caught in commercial longlines set in shallow coastal waters, but it is also pursued as a gamefish. There are localized gillnet fisheries in federal waters off Florida that target blacktips during their migrations, when the schools are close to shore in clear waters. Aircraft are often used to direct net boats to the migrating schools, often resulting in the trapping of large schools. The species is pursued commercially throughout its range and is targeted because it is often found in shallow coastal waters. Their habit of migrating in large schools along shorelines could make this species extremely vulnerable to organized drift gillnet fisheries.

Essential Fish Habitat for Blacktip Shark

- **Neonate/YOY (≤75 cm TL):** Coastal areas in the Gulf of Mexico from Texas through the Florida Keys. In Atlantic coastal areas from northern Florida through Georgia, and the mid-coast of South Carolina. Please refer to Figure 5.35 for detailed EFH map.

- **Juvenile (76 to 136 cm TL):** Coastal areas in the Gulf of Mexico from Texas through the Florida Keys. In Atlantic coastal areas localized off of the southeast Florida coast and from West Palm Beach, Florida to Cape Hattaras. Please refer to Figure 5.36 for detailed EFH map.

- **Adult (≥137 cm TL):** Coastal areas in the Gulf of Mexico from Texas through the Florida Keys. In Atlantic coastal areas southeast Florida to Cape Hattaras. Please refer to Figure 5.37 for detailed EFH map.

5.1.4.6.3 Bull Shark

Bull shark (*Carcharhinus leucas*) The bull shark is a large, shallow water shark that is cosmopolitan in warm seas and estuaries (Castro, 1983). It often enters fresh water, and may penetrate hundreds of kilometers upstream; bull sharks are the only shark species that is known to be physiologically capable of spending extended periods in freshwater (Thorson *et al*., 1973).

Reproductive potential: Males mature 210 to 220 cm TL or 14 to 15 years of age, while females mature >225 cm TL or 18+ years of age (Branstetter and Stiles, 1987). Growth parameters have been estimated by Branstetter and Stiles (1987) as L_∞ = 285 cm TL, K= 0.076, t_0= -3.0 yr. Recent work by Neer *et al*. (2005) estimated von Bertalanffy growth model parameters as L_∞ = 300.7 cm FL, K= 0.042, t_0= -6.84 yr and estimated the theoretical longevity of bull sharks as 38.6 yrs. Bull sharks have been documented to have a wide range in size-at-birth from 62 cm FL off South Africa, 63.5 to 68 cm FL for bull sharks in Brazilian waters, 51 to 67.6 cm FL for a animals collected off Florida, and 55.5 cm to 66 cm for pups collected off Louisiana (Sadowsky, 1971; Clark and von Schmidt, 1965; Cliff and Dudley, 1991). However, simulations incorporating variability in size-at-birth produced similar von Bertalanffy growth model results as those using a fixed size-at-birth (Neer *et al*., 2005). Jensen (1976) stated that litters ranged from one to ten pups and that the average size was 5.5 pups. The gestation period is estimated at ten to eleven months (Clark and von Schmidt, 1965). The length of the reproductive cycle has not been published, but it is probably biennial. In the United States the nursery areas are in low salinity estuaries of the Gulf of Mexico Coast (Castro, 1983) and the coastal lagoons of the east coast of Florida (Snelson *et al.,* 1984).

On the east coast of Florida, juvenile bull sharks ranging from 75.4 to 146 cm TL were collected from northern Cape Canaveral (latitude 28°40'N) south to the Jupiter Island area (latitude 27°04'N) in water depths of 3 to 11 m (Adams and Paperno, 2007). On the west coast of Florida, young bull sharks are relatively common during the warm months along Florida's Gulf coast and have been documented by the Mote CSR in the areas of Yankeetown, Tampa Bay, Charlotte Harbor, Ten Thousand Islands, and the Keys as well as in Texas coastal waters (Hueter and Tyminski, 2007). The primary nurseries for this species are typically in lower salinity estuaries and river mouths (as low as 0.9 ppt) (Hueter and Tyminski, 2007). Neonate bull sharks have been found in Yankeetown, Tampa Bay, Charlotte Harbor, Ten Thousand Islands, and Texas between the months of May and August (Hueter and Tyminski, 2007). Young-of-the-year bull sharks are found in these same areas throughout the warm months and remain in these primary nurseries until as late as November or until water temperatures fall to about 21°C (Hueter and Tyminski, 2007). However, first-year bull sharks have been documented in Florida estuaries at temperatures as low as 16.4°C, returning to these nursery areas the following spring as early as March. Thus, these same Florida areas (Yankeetown, Tampa Bay, Charlotte Harbor, Ten Thousand Islands, and the Keys) may also function as secondary nurseries for the bull shark (Hueter and Tyminski, 2007). Older juveniles return to these nursery areas in the spring as early as April and remain in the bays throughout the summer before undertaking their fall migration in October and November (Hueter and Tyminski, 2007). Texas bull sharks show a similar temporal pattern (Hueter and Tyminski, 2007); although older juvenile bull sharks utilize estuarine nursery areas (1.7 to 41.1 ppt), they do not appear to venture as far into freshwater as the neonates and young-of-the-year (Hueter and Tyminski, 2007). Additionally, young-of-the-year and older juvenile bull sharks have been found in the warm water effluents of Tampa Bay and Yankeetown power plants during the winter months (Hueter and Tyminski, 2007). Presumably, these sharks become entrapped within these warm water plumes when the temperature of the surrounding water falls below the sharks' tolerance level, but definitive data are lacking (Hueter and Tyminski, 2007). Steiner *et al*. (2007) found sharks did not travel far between capture and recapture locations, indicating a relatively low rate of movement of the bull sharks within the estuary. In addition, adult female bull sharks may enter the Ten Thousand Islands estuary to give birth (Steiner *et al*., 2007).

Other work by Simpendorfer *et al*. (2005) found neonate and young-of-the-year animals in the Caloosahatchee River, San Carlos Bay, and Pine Island Sound on the west coast of Florida. In this river system, small individuals were found in the Caloosahatchee River and larger individuals were found in the Pine Island Sound area; size class segregation was thought to minimize intra-specific predation. Different size classes were also shown to prefer different salinity and temperature regimes where <1 year old individuals were most common in salinities between 7 and 17.5 ppt and were found in the highest temperatures (Simpendorfer *et al*. 2005). Work by Wiley and Simpendorfer (2007) also documented neonate and juvenile bull sharks within the Everglades National Park (73 to 210 cm TL), suggesting that this may be a nursery ground for this species. In particular, sizes <150 cm were found in the Whitewater Bay region, but larger size classes of bull sharks occurred in coastal marine areas of the Everglades (Wiley and Simpendorfer, 2007). In the Everglades National Park, bull sharks were found in salinities < 25 ppt, but seemed to avoid salinities > 30 ppt, with most bull sharks being caught between 15 and 29 ppt. Bull sharks were also caught in water temperatures of 30 °C and higher and waters between 1.2 and 2.2 m in depth (Wiley and Simpendorfer, 2007).

Louisiana's coastal and inland estuarine waters are also important primary and secondary nursery areas for bull sharks. Blackburn *et al*. (2007) found bull sharks ranging from 44 to 136.2 cm FL collected in the interior of Lake Pontchartrain, the Pearl River system, Little Lake/Barataria Bay and its inland waters, the Terrebonne/Timbalier Bay system, and the Atchafalaya/Vermilion Bay system in the coastal waters off Louisiana. Neonates (sharks with FL ≤ 82.3 cm) and juveniles (sharks with FL ≥ 82.4 cm) were collected in all six estuarine environments, with most neonate and juvenile bull sharks being collected from Lake/Barataria

Bay (Blackburn *et al*., 2007). The seasonal distribution of bull sharks in Louisiana appears most concentrated in the spring and summer months (Blackburn *et al*., 2007). Bull sharks were collected from March to September in salinities ranging from 0.0 to 32.1 ppt, water temperatures ranging from 15.0°C to 37.0°C, and turbidity ranging from 10 to 200 cm (Blackburn *et al*., 2007). Immature bull sharks have also been found in Mississippi Sound and Mobile Bay off the coasts of Mississippi and Alabama at salinities of 14 to 17.1 ppt (Parsons and Hoffmayer, 2007).

Impact of fisheries: The bull shark is a common coastal species that is fished in both artisanal and industrial/modern fisheries. Clark and von Schmidt (1965) found it to be the most common shark caught in their survey of the sharks of the central Gulf coast of Florida, accounting for 18 percent of the shark catch. Dodrill (1977) reported it to be the seventh most commonly taken shark at Melbourne Beach, Florida, composing 8.6 percent of all longline landings. Thorson (1976) recorded a marked decline of the Lake Nicaragua-Rio, San Juan population from 1963 to1974, resulting from a small-scale, but sustained commercial fishing operation. This fishery intensified in 1968, and by 1972 bull sharks in the area had become so scarce that Thorson (1976) predicted that any other developments would eliminate the bull shark from Lake Nicaragua. Russell (1993) indicated that the bull shark constituted three percent of the shark catch in the directed shark fishery in the U.S. Gulf of Mexico. Castillo (1992) referred to the species in Mexico as intensely exploited in both coasts. The bull shark is vulnerable to overfishing because of its slow growth, limited reproductive potential, and because it is pursued in numerous fisheries.

***Essential Fish Habitat for Bull Shark*:**

- **Neonate/YOY (≤95 cm TL):** Gulf of Mexico coastal areas along Texas, and localized areas off of Mississippi, the Florida Panhandle, and west coast of Florida; as well as the Atlantic mid-east coast of Florida. Please refer to Figure 5.38 for detailed EFH map.

- **Juveniles (96 to 219 cm TL):** Gulf of Mexico coastal areas along the Texas coast, eastern Louisiana to the Florida Panhandle, and the west coast of Florida through the Florida Keys. Atlantic coastal areas localized from the mid-east coast of Florida to South Carolina. Please refer to Figure 5.39 for detailed EFH map.

- **Adults (≥220 cm TL):** Gulf of Mexico along the southern and mid-coast of Texas to western Louisiana, eastern Louisania to the Florida Keys. East coast of Florida to South Carolina in the Atlantic. Please refer to Figure 5.40 for detailed EFH map.

5.1.4.6.4 Caribbean Reef Shark

Caribbean reef shark *(Carcharhinus perezi)* Caribbean reef sharks ranges from North Carolina, Bermuda, and the east coast of Florida to southern Brazil, including the northern Gulf of Mexico and the Antilles (Garrick, 1982; Compagno, 1984; Jensen *et al*., 1995). This is a poorly known, bottom-dwelling species that inhabits shallow coastal waters, usually around coral reefs (Castro, 1983).

Reproductive potential: Males mature at about 150 to 170 cm TL (Pikitch *et al*., 2005) and females at about 200 cm TL. Pups are born at about 70 cm TL, litters consisting of four to six pups. The reproductive cycle is biennial (Castro, unpub.). The nurseries have not been described. However, Pikitch *et al*. (2005) have documented small individuals at Glover's Reef Marine Reserve in Belize where equal numbers of males and females are present from May to July suggesting that Glover's Reef could also be a mating ground for these species (Pikitch *et al*., 2005). Caribbean reef sharks have been found at the Flower Garden Banks in the northwestern Gulf of Mexico, and it has been suggested that this area may function as essential fish habitat for Caribbean reef sharks (Childs, 2000).

Based on acoustic tagging of Caribbean reef sharks at Glover's Reef Marine Reserve in Belize, Chapman *et al*. (2005) determined that effective no-take marine reserves need to be large (boundaries of at least tens of kilometers) and need to encompass not only diverse habitats (ocean reefs, seagrass flats, lagoons) but also the areas that connect them (*e.g.*, major channels). In addition, Chapman *et al*. (2005) documented for the first time that Caribbean reef sharks cross the pelagic zone between reefs, which underscores the need for reserve networks and regulation of pelagic fisheries in the conservation of this species.

***Essential Fish Habitat for Caribbean Reef Shark*:**

Note: At this time, insufficient data is available to differentiate EFH by size classes; therefore, EFH is the same for all life stages.

- **Neonate/YOY, Juveniles, and Adults:** EFH designation for all life stages have been combined and are considered the same. Gulf of Mexico coastal areas along the Florida Keys. Atlantic coastal areas along the southern Florida coast. Puerto Rico and the Virgin Islands. Please refer to Figure 5.41 for detailed EFH map and Table 5.1 for life stage size information.

5.1.4.6.5 Dusky Shark

Dusky shark (*Carcharhinus obscurus*) The dusky shark is common in warm and temperate continental waters throughout the Atlantic, Pacific and Indian Oceans. It is a migratory species which moves north-south with the seasons. This is one of the larger species found from inshore waters to the outer reaches of continental shelves. It used to be important as a commercial species and a game fish, but is currently prohibited.

Reproductive potential: Males mature at 290 cm total length and reach at least 340 cm total length, while females mature at about 300 cm total length and reach up to 365 cm total length. Dusky sharks are one of the slowest growing requiem sharks. This species matures at approximately 19 to21 years and may live up to 45 years (Natanson *et al.* 1995). Litters consist of six to14 pups, which measure 85 to 90 cm TL at birth (Castro, 1983). The gestation period is believed to be about 16 months (Clark and von Schmidt, 1965), but this has not been confirmed. Natanson (1990) gave the following parameters for males: L_{max}= 351 cm FL (420 cm total length), K= .047, t_o = !5.83; and for females: L_{max}= 316 cm total length (378 cm total length), K= .061, t_o=-4.83. The growth rate is believed to be about ten cm/yr for the young and five cm/yr for the adults. Age and growth information can also be found in Natanson *et al.* (1995).

Dusky shark neonates often inhabit nursery areas in coastal waters. For example, Castro (1993b) reported that dusky sharks gave birth in Bulls Bay, South Carolina in April and May, while Musick and Colvocoresses (1986) stated that the species gives birth in the Chesapeake Bay, Maryland in June and July. Grubbs and Musick (2002) also noted that young dusky sharks use nearshore waters in Virginia as nursery areas, but that they rarely enter estuaries.

Impact of fisheries: The dusky shark has historically played an important role in the coastal shark fisheries. It is valued for its flesh as well as its fins which are sold overseas for use in shark fin soup. This species is often taken as bycatch in both the bottom and pelagic longline fisheries, making it highly vulnerable to overfishing. This species is currently prohibited and is a candidate for listing under the Endangered Species Act.

***Essential Fish Habitat for Dusky Shark*:**

Note: At this time, insufficient data is available to differentiate EFH between the juvenile and adult size classes, therefore, EFH is the same for those life stages.

- **Neonate/YOY (≤121 cm TL):** Areas along the Atlantic east coast of Florida to the mid-coast of Georgia, South Carolina to southern Cape Cod. Please refer to Figure 5.42 for detailed EFH map.

- **Juvenile and Adult:** EFH designation for juvenile and adult life stages have been combined and are considered the same. Localized areas in the central Gulf of Mexico, southern Texas, the Florida Panhandle, mid-west coast of Florida, and Florida Keys. Atlantic east coast of Florida, and South Carolina to southern Cape Cod. Please refer to Figure 5.43 for detailed EFH map and Table 5.1 for life stage size information.

5.1.4.6.6 Galapagos Shark

Galapagos shark (*Carcharhinus galapagensis*) The Galapagos shark is circumtropical in the open ocean and around oceanic islands (Castro, 1983). It is very similar to the dusky shark and is often mistaken for it, although the dusky shark prefers continental shores (Castro, 1983). The Galapagos shark is very seldom seen in U.S. waters. However, a few Galapagos sharks are undoubtedly caught off the east coast every year, which have probably been misidentified as dusky sharks.

Reproductive potential: Males reach maturity between 205 and 239 cm TL and females between 215 and 245 cm TL (Wetherbee *et al.*, 1996). Pups are born at slightly over 80 cm TL (Dulvy and Reynolds, 1997). Litters may range from four to16 pups with the average litter size being 8.7. Juveniles typically inhabit waters shallower than 82 feet (25 m) (Compango, 1984b). Although the gestation cycle is estimated to last about a year (Wetherbee *et al.*, 1996), the length of the reproductive cycle for this species is not known.

Impact of fisheries: The Galapagos shark is of little economic importance (Compango, 1984b).

***Essential Fish Habitat for Galapagos Shark*:**

- **Neonate/YOY (≤97 cm TL):** At this time, available information is insufficient for the identification of EFH for this life stage.

- **Juveniles (98-214 cm TL):** At this time, available information is insufficient for the identification of EFH for this life stage.

- **Adults (≥215 cm TL):** At this time, available information is insufficient for the identification of EFH for this life stage.

5.1.4.6.7 Lemon Shark

Lemon shark (*Negaprion brevirostris*) The lemon shark is common in the American tropics, inhabiting shallow coastal areas, especially around coral reefs. During migration, this species can be found in oceanic waters but tends to stay along the continental and insular shelves (Morgan, 2008). Lemon sharks are reported to use coastal mangroves as nursery habitats, although this is not well documented in the literature. There is evidence that two separate populations exist within the western Atlantic Ocean: one in the Caribbean and one in the Gulf of Mexico. The primary population in continental U.S. waters is found off south Florida, although adults stray north to the Carolinas and Virginia in the summer. Additional life history information can be found in Sundstrom *et al.* (2001) and Barker *et al.* (2005).

Reproductive potential: Lemon sharks typically mature around 228 cm TL (Springer, 1950b), at approximately 11.6 years for males and 12.7 years for females (Brown and Gruber, 1988). This species is described as slow growing and long-lived (at least 20 years of age) with the von Bertalanffy parameters: L_4 =317.65, K= .057, and t_o= -2.302 (Brown and Gruber, 1988). Lemon shark reproductive cycles are biennial (Castro, 1993b), mating occurs in shallow water during the spring months (Morgan, 2008), and gestation lasts ten (Springer, 1950b) to 12 months (Clark and von Schmidt, 1965). Litters typically consist of five to 17 pups, which measure about 64 cm TL at birth (Springer, 1950b; Clark and von Schmidt, 1965). The shallow waters around mangrove islands (Springer 1950b) off tropical Florida and the Bahamas have been shown to serve as nursery areas for this species. Lemon shark neonates have also been found in Tampa Bay, Florida during the month of May, at temperatures of 22.0° to 25.4°C, salinities of 26.8 to 32.6 ppt, and DO of 5.9 to 9.6 ml/l, while juveniles can be found over a wider area off western Florida and in a wider range of temperatures and salinities (Hueter and Tyminski, 2007).

Impact of fisheries: The lemon shark is targeted commercially and recreationally throughout its range. Lemon shark meat and fins are used for human consumption. Fins are marketed for shark-fin soup base, liver oil for vitamins, the carcass for fish meal, and the hides for leather (FishBase, 2008). Anecdotal evidence indicates that lemon sharks are vulnerable to local depletions.

***Essential Fish Habitat for Lemon Shark*:**

- **Neonate/YOY (≤86cm TL):** Gulf of Mexico coastal areas along the Texas mid-coast and the Florida Keys, and a localized area on the mid-west coast of Florida. Puerto Rico and Virgin Islands. Please refer to Figure 5.44 for detailed EFH map.

- **Juveniles (87 to 239 cm TL):** Gulf of Mexico coastal areas along Texas, eastern Louisiana, and the Florida Panhandle through the Florida Keys. Coastal areas along the Atlantic east coast of Florida. Puerto Rico and Virgin Islands. Please refer to Figure 5.45 for detailed EFH map.

- **Adults (≥240 cm TL):** Gulf of Mexico coastal areas along the west coast of Florida through the Florida Keys. Localized coastal areas along the southern and northern east coast of Florida in the Atlantic. Please refer to Figure 5.46 for detailed EFH map.

5.1.4.6.8 Narrowtooth Shark

Narrowtooth shark (*Carcharhinus brachyurus*) This is a coastal-pelagic species of widespread distribution in warm temperate waters throughout the world. In general, it is a temperate shark, absent or rare in tropical waters (Bass *et al.*, 1973). Although the species has been reported for the California coast by Kato *et al*. (1967) as *C. remotus*, and for the southwest Atlantic, few data exist for the western north Atlantic. The narrowtooth shark commonly occupies a variety of habitats from freshwater and brackish areas of large rivers to shallow bays and estuaries. It has been found from the surf line to depths of up to 328 feet (100 m), but is believed to range deeper (Press, 2008).

Reproductive potential: Males mature between 200 and 220 cm TL, and females mature below 247 cm TL. The young are born at about 60 to 70 cm TL. Six pregnant females averaged 16 embryos, with a range of 13 to 20 pups per litter (Bass *et al.,* 1973). Walter and Ebert (1991) calculated age at sexual maturity at 13 to 19 years for males and 19 to 20 years for females. They commonly reach maturity at 205.7 to 236.2 cm TL and 226.1 to 243.8 cm TL for males and females, respectively (Press, 2008). Gestation is believed to last a year (Cliff and Dudley, 1992). The length of the reproductive cycle is not known, but it is probably biennial as it is for most large carcharhinid sharks. The maximum size for a narrowtooth shark is reported to be 292.1 cm TL. The age at maturity is 13 years old for males, and 20 years old for females and the maximum age is unknown.

It is believed that reproduction in narrowtooth sharks occurs biennially. According to the limited data that is available on the biology of this species, parturition in South Africa most likely occurs in June or July and litters range from 13 to 24 pups with an average of 15. Other studies have combined data from several locations and suggest varying parturition times from June to February. Gestation is estimated to last 12 months with the young approximately 59 to70 cm TL at birth. The narrowtooth shark utilizes inshore bays and coasts as nursery areas (Press, 2008).

Impact of fisheries: Because it appears to be a very slow growing carcharhinid (based on the unvalidated ages by Walter and Ebert (1991), the narrowtooth shark is probably vulnerable to overfishing.

***Essential Fish Habitat for Narrowtooth Shark*:**

- **Neonate:** At this time, available information is insufficient for the identification of EFH for this life stage.

- **Juveniles:** At this time, available information is insufficient for the identification of EFH for this life stage.

- **Adults:** At this time, available information is insufficient for the identification of EFH for this life stage.

5.1.4.6.9 Night Shark

Night shark (*Carcharhinus signatus*) This carcharhinid shark inhabits the waters of the western North Atlantic from Delaware to Brazil and the west coast of Africa. It is a tropical species that seldom strays northward. The night shark is typically found near outer continental shelves of subtropical waters at depths greater than 275 to 366 m during the day and about 183 m at night (Castro, 1983).

Reproductive potential: There is little information on night shark reproductive processes. Litters usually consist of 12 to 18 pups which measure 68 to 72 cm TL at birth (Castro, 1983). Length at maturity has been reported for females as 150 cm FL (178 cm TL) (Compagno, 1984). The nurseries remain undescribed. Hazin *et al.* (2000) and Santana and Lessa (2004) provide additional information on reproduction and age and growth, respectively. Back-calculated size at birth was 66.8 cm and maturity was reached at 180 to190 cm (age 8) for males and 200 to 205 cm (age ten) for females. Age composition, estimated from an age-length key, indicated that juveniles predominate in commercial catches, representing 74.3 percent of the catch. A growth rate of 25.4 cm/yr was estimated from birth to the first band (*i.e.*, juveniles grow 38 percent of their birth length during the first year), and a growth rate of 8.55 cm/yr was estimated for eight to ten year-old adults (Santana and Lessa, 2004).

Impact of fisheries: The night shark was abundant along the southeast coast of the United States and the northwest coast of Cuba before the development of the swordfish fishery of the 1970s. Although not targeted, night sharks make up a segment of the shark bycatch in the pelagic longline fishery. Historically, night sharks comprised a significant proportion of the artisanal Cuban shark fishery but today they are rarely caught. Although information from some fisheries has shown a decline in catches of night sharks, it is unclear whether this decline is due to changes in fishing tactics, market, or species identification. Despite the uncertainty in the decline, the night shark is currently listed as a species of concern (*i.e.*, candidate species) to the Endangered Species Act due to alleged declines in abundance resulting from fishing effort (*i.e.*, overutilization) (Carlson *et al.*, 2008). Martinez (1947) stated that the Cuban shark fishery relied heavily on the night shark, which constituted 60 to 75 percent of the total shark catch, and that the average annual catch for 1937 to 1941 was 12,000 sharks. Guitart Manday (1975) documented a precipitous decline in night shark catches off the Cuban northwest coast during the years 1971 to 1973. Berkeley and Campos (1988) stated that this species represented 26.1 percent of all sharks caught in swordfish fisheries studied by them along the east coast of Florida from 1981 to 1983. Anecdotal evidence from commercial swordfish fishermen also indicates that in the late 1970s it was not unusual to have 50 to 80 dead night sharks, usually large gravid females, in every set from Florida to the Carolinas. During the 1970s, sports fishermen in south Florida often resorted to catching night sharks when other more desirable species (marlins) were not biting. The photographic record of sport fishing trophies landed shows that large night sharks were caught daily and landed at the Miami docks in the 1970s. Today, the species is rare along the southeast coast of the United States. The World Conservation Union (IUCN) currently lists night sharks globally as vulnerable based on population declines throughout its western Atlantic Ocean range due to target and bycatch exploitation by fisheries (Carlson *et al*., 2008).

***Essential Fish Habitat for Night Shark*:**

Note: At this time, insufficient data is available to differentiate EFH by size classes, therefore, EFH is the same for all life stages.

- **Neonate/YOY, Juveniles, and Adults:** EFH designation for all life stages have been combined and are considered the same. In the Gulf of Mexico off Texas, Louisania, and the Florida Panhandle to the Florida Keys. Southern and mid-east coast of Florida and South Carolina to Delware in the Atlantic. Please refer to Figure 5.47 for detailed EFH map and Table 5.1 for life stage size information.

5.1.4.6.10 Sandbar Shark

Sandbar shark (*Carcharhinus plumbeus*) The sandbar shark is cosmopolitan in subtropical and warm temperate waters. It is a common species found in many coastal habitats. The North Atlantic population of sandbar sharks ranges from Cape Cod to the western Gulf of Mexico, and migrates seasonally, segregating by sex during much of the year (Conrath and Musick, 2007). It is a bottom-dwelling species most common in 20 to 55 m of water, but occasionally found at depths of about 200 m.

Reproductive potential: The sandbar shark is a slow growing species. Both sexes reach maturity at about 147 cm total length or approximately 5 feet (Merson, 1998). Estimates of age at maturity range from 15 to 16 years (Sminkey and Musick, 1995) to 29 to 30 years (Casey and Natanson, 1992), although 15 to 16 years is the commonly accepted age of maturity. The von Bertalanffy growth parameters were proposed for combined sexes are L_4= 186 cm FL (224 cm total length; 168 cm PCL), K= 0.046, t_o= -6.45 by Casey and Natanson (1992); and re-evaluated by Sminkey and Musick (1995) as L_4= 164 cm PCL (219 cm total length; 182 cm Fl), K= 0.089, and t_o= -3.8. Young are born at about 60 cm total length (smaller in the northern parts of the North American range) from March to July. Litters consist of one to 14 pups, with nine being the average (Springer, 1960). The gestation period lasts about a year and reproduction is biennial (Musick *et al.,* 1993). Hoff (1990) used an age at maturity of 15 years, a life span of 35 years, and a two-year reproductive cycle to calculate that each female may reproduce only ten times.

In the United States, sandbar shark nursery areas are typically in shallow coastal waters from Cape Canaveral, Florida (Springer, 1960), to Martha's Vineyard, Massachusetts. Delaware Bay, Delaware (McCandless *et al.*, 2002; 2007), Chesapeake Bay, Maryland (Grubbs and Musick, 2007), Great Bay, New Jersey (Merson and Pratt, 2002, 2007) and the waters off Cape

Hatteras, North Carolina (Jensen *et al.*, 2002; Conrath and Muskick, 2007) are important primary and secondary nurseries. Primary nurseries are where parturition occurs and where neonate and young-of-the-year sharks are present, whereas secondary nurseries are generally utilized by older sharks following departure from primary nursery areas (Merson and Pratt 2001, 2007; McCandless *et al*., 2007). Size and sex data from surveys in waters of Nantucket Sound, Massachusetts indicate that this region also provides secondary nursery habitat for this species. Temperatures during periods when sandbar sharks were caught typically ranged from 20° to 24°C and depths from 2.4 to 6.4 m (Skomal, 2007). Neonates have been captured in Delaware Bay in late June. Young-of-the-year were present in Delaware Bay until early October when the temperature fell below 21°C. Grubbs and Musick (2007) reported that the principal nursery in Chesapeake Bay is limited to the southeastern portion of the estuary, where salinity is great than 20.5 ppt and depth is greater than 5.5 m. Another nursery may exist along the west coast of Florida and along the northeast Gulf of Mexico. Hueter and Tyminski (2002) found neonates off Yankeetown, Florida from April to July, in temperatures of 25.0° to 29.0°C and salinities of 20.4 to 25.9 ppt. Neonate sandbar sharks were found in an area between Indian Pass and St. Andrew Sound, Florida in June when the temperature had reached 25°C (Carlson, 2002).

Impact of fisheries: The sandbar shark is one of the most important commercial species in the shark fishery of the southeastern United States, along with blacktip sharks. It is a preferred species because of the high quality of its flesh and large fins. Commercial longline fishermen pursue sandbar stocks in their north-south migrations along the coast; their catches can be as much as 80 to 90 percent sandbar sharks in some areas.

U.S. Fishery Status: Stock assessments in 2006 indicated that the stock was overfished with overfishing occurring. As a result, in 2008 NMFS implemented Amendment 2 to the Consolidated HMS FMP, which greatly reduced fishing mortality on sandbar sharks. Currently the only directed fishing that is authorized on sandbar sharks is under the auspices of the shark research fishery. Sandbar sharks were also prohibited from retention in the recreational fishery beginning in 2008. It is considered highly vulnerable to overfishing because of its slow maturation and heavy fishing pressure, as evidenced in the catch-per-unit-effort (CPUE) declines in U.S. fisheries.

***Essential Fish Habitat for Sandbar Shark*:**

- **Neonate/YOY (≤78 cm total length):** Localized coastal area on the Florida Panhandle. Atlantic coastal areas localized along Georgia and South Carolina, and from Cape Lookout to Long Island, New York. Please refer to Figure 5.48 for detailed EFH map.

- **Juvenile (79 to 190 cm total length):** Localized areas along the Atlanic coast of Florida, South Carolina, and southern North Carolina, and from Cape Lookout to southern New England. Please refer to Figure 5.49 for detailed EFH map.

- **Adult (≥191 cm total length):** Localized area off of Alabama, and coastal areas from the Florida Panhanle to the Florida Keys in the Gulf of Mexico. Atlantic coastal areas throughout Florida to southern New England. Please refer to Figure 5.50 for detailed EFH map.

- **Habitat Areas of Particular Concern (HAPC):** Important nursery and pupping grounds have been identified in shallow areas and at the mouth of Great Bay, New Jersey, in lower and middle Delaware Bay, Deleware, lower Chesapeake Bay, Maryland, and near the Outer Banks, North Carolina, and in areas of Pamlico Sound and adjacent to Hatteras and Ocracoke Islands, North Carolina, and offshore of those islands (Figure 5.51).

5.1.4.6.11 Silky Shark

Silky shark (*Carcharhinus falciformis*) The silky shark inhabits warm, tropical, and subtropical waters throughout the world. Primarily, the silky is an offshore, epipelagic shark, but juveniles venture inshore during the summer. In the western Atlantic, it ranges from Massachusetts to Brazil including the Gulf of Mexico and Caribbean Sea (Bigelow and Schroeder, 1948)). Tagging data indicate movement of silky sharks between the Gulf of Mexico and the U.S. Atlantic coast (Kohler *et al*., 1998).

Reproductive potential: Data on the silky shark are variable. There is a strong possibility that different populations may vary in their reproductive potential. Litters range from six to 14 pups, which measure 75 to 80 cm TL at birth (Castro, 1983). According to Bonfil *et al.* (1993), the silky shark in the Campeche Bank, Mexico, has a 12-month gestation period, giving birth to ten to 14 pups, with an average of 76 cm TL during late spring and early summer, possibly every two years. Males mature at 225 cm TL (about ten years) and females at 232 to 245 cm TL (>12 yrs of age). The von Bertanffy parameters estimated by Bonfil *et al.* (1993) are: L_4 = 311 cm TL, K= 0.101, and t_o= -2.718 yr. Maximum ages were 20+ years for males and 22+ years for females (Bonfil *et al.,* 1993). Springer (1967) describes reefs on the outer continental shelf as nursery areas. Bonfil *et al,* (1993) mentions the Campeche Bank as a prime nursery area in the Atlantic. Data suggest a size at first sexual maturity for the silky shark in the equatorial Atlantic of about 230 cm, for females, and from 210 to 230 cm, for males. The monthly distribution of female sexual stages do not show any clear trend, suggesting that, at least close to the equator, the species might not have a clear seasonal cycle of gestation. Litter size ranged from 4 to 15, with a sex ratio of embryos equal to 1:1.4 male: female (Hazin *et al*., 2007)

Impact of Fisheries: The silky shark is caught frequently in swordfish and tuna fisheries. Berkeley and Campos (1988) found it to constitute 27.2 percent of all sharks caught in swordfish vessels off the east coast of Florida from 1981 to 1983. Bonfil *et al,* (1993) considered that the life-history characteristics of slow growth, late maturation, and limited offspring may make it vulnerable to overfishing. In all probability, local stocks of this species cannot support sustained heavy fishing pressure. Silky sharks were prohibited from retention in the recreational fishery beginning in 2008.

***Essential Fish Habitat for Silky Shark*:**

Note: At this time, insufficient data is available to differentiate EFH by size classes, therefore, EFH is the same for all life stages.

- **Neonate/YOY, Juvenile, and Adult:** EFH designation for all life stages have been combined and are considered the same. In the Gulf of Mexico from the southern coast of Texas across the central Gulf of Mexico, and from eastern Louisiana to the Florida Keys. Atlantic east coast from Florida to New Jersey, with localized areas in southern New England. Please see Figure 5.52 for detailed EFH map.

5.1.4.6.12 Spinner Shark

Spinner shark (*Carcharhinus brevipinna*) The spinner shark is a common, coastal-pelagic, warm-temperate and tropical shark of the continental and insular shelves (Compagno, 1984). It is a common inhabitant of inshore waters less than 30 m deep, but ranges offshore to at least 150 m deep (Aubrey and Snelson, 2007). The spinner shark is often seen in schools, leaping out of the water while spinning. It is a migratory species, but its patterns are poorly known. Off the eastern United States it ranges from Virginia to Florida and in the Gulf of Mexico.

Predator-prey Relationships: A study on shark foraging ecology conducted by Bethea *et al.* (2004) in Apalachicola Bay, Florida, showed that young-of-the-year and juvenile spinner sharks fed mainly on teleosts, with Clupeids (mostly *Brevoortia* spp.) the dominant prey.

Reproductive potential: Males mature at 130 cm TL or four to five years, females mature at 150 to 155 cm TL or seven to eight years (Branstetter, 1987a). According to Branstetter (1987a), males reach maximum size at ten to 15 years and females at 15 to 20 years. However, he added the caveat that as sharks near their maximum size, their growth is slower, therefore, their maximum ages may be much greater. Branstetter (1987a) gave von Bertalanffy parameters for both sexes were: L_4 = 214 cm, K= 0.212, t_o = -1.94 yr. The ages have not been validated. According to Garrick (1982), the species reaches a maximum size of 278 cm TL. Jong *et al.* (2005) found both male and female spiner sharks to reach maturity at about 210-220 cm. The spinner shark has a biennial reproductive cycle (Castro, 1993c), young born at 60 to 75 cm TL in late May and early June. The litters usually consist of six to 12 pups (Castro, 1983). However, Jong *et al.* (2005) found litters ranging from three to 14 pups.

In the Carolinas, the nursery areas are in shallow coastal waters (Castro, 1993c); however, the extent of the nursery areas is unknown. Hueter and Tyminski (2007) found juveniles along the west coast of Florida in temperatures of 21.9° to 30.1°C, salinities of 21.0 to 36.2 ppt, and DO 3.5 to 5.0 ml/l. The primary pupping grounds for the species in Florida is not clearly defined (Hueter and Tyminski, 2007). However, Apalachicola Bay, Florida has been identified as a nursery area for spinner sharks (Bethea *et al.*, 2004). Adult sharks move into this system in late May to early June to give birth. Young-of-the-year are present in the area by the end of June and remain until fall when they migrate offshore. Aubrey and Snelson (2007) reported spinner shark nursery areas in shallow inshore waters of the central east coast of Florida between Cape Canaveral and Cocoa Beach. These were sandy bottom areas where sea surface temperatures ranged from 24.5° to 30.5°C and mean salinity was 36 ppt. This area approximates the relatively unprotected littoral and surf zones and adjacent bays and nurseries that have been previously reported for spinner sharks. However, this is the first nursery area identified for the spinner shark on the east coast of Florida, and only one of two on the east coast of the United States, (the other being in the Carolinas) (Aubrey and Snelson, 2007). Other nursery areas for the spinner shark have been found along the beaches and in the bays of Texas during the summer months, and juvenile spinner sharks also have been found in the coastal waters of Mississippi and Louisiana and along the beaches of Tampa Bay in Florida. Larger juveniles have been captured off Sarasota and Tampa Bay (Hueter and Tyminski, 2007).

Impact of fisheries: The spinner shark is similar in reproductive potential and habits to the blacktip shark, and its vulnerability to fisheries is probably very similar to that of the blacktip. In fact, the blacktip-spinner complex is a commonly used category that combines the landings of these two species because of species similarities and difficulties in distinguishing the two species.

***Essential Fish Habitat for Spinner Shark*:**

- **Neonate/YOY (≤70 cm TL):** Localized coastal areas in the Gulf of Mexico along Texas, eastern Louisania, the Florida Panhandle, Florida west coast, and the Florida Keys; and in the Atlantic along the east coast of Florida to southern North Carolina. Please refer to Figure 5.53 for detailed EFH map.

- **Juveniles (71 to 179 cm TL):** Gulf of Mexico coastal areas from Texas to the Florida Panhandle, and the mid-west coast of Florida to the Florida Keys. Atlantic east coast of Florida through North Carolina. Please refer to Figure 5.54 for detailed EFH map.

- **Adults (≥180 cm TL):** Localized areas in the Gulf of Mexico off of southern Texas, Louisania trhough the Florida Panhandle, and from the mid-coast of Florida through the Florida Keys. In the Atlantic along the east coast of Florida, and localized areas from South Carolina to Virginia. Please refer to Figure 5.55 for detailed EFH map.

5.1.4.6.13 Tiger Shark

Tiger shark (*Galeocerdo cuvier*) The tiger shark inhabits warm waters in both deep oceanic and shallow coastal regions (Castro, 1983). In the western North Atlantic Ocean, tiger sharks occur in coastal and offshore waters from approximately 40° to 0°N, and have been documented to make transoceanic migrations (Driggers *et al.*, 2008). In the North Atlantic they are rarely encountered north of the Mid-Atlantic Bight (Skomal, 2007). A study by Heithaus *et al*. (2002) on tiger sharks in Australia showed they preferred shallow seagrass habitats, and this was influenced by prey availability, which is greater in shallow waters. The tiger shark is one of the larger species of sharks, reaching over 550 cm TL and over 900 kg. Its characteristic tiger-like markings and unique teeth make it one of the easiest sharks to identify. It is one of the most dangerous sharks and is believed to be responsible for many attacks on humans (Castro, 1983).

Reproductive potential: Tiger sharks mature at about 290 cm TL (Castro, 1983; Simpfendorfer, 1992). The pups measure 68 to 85 cm TL at birth. Litters are large, usually consisting of 35 to 55 pups (Castro, 1983). According to Branstetter *et al.* (1987), males mature in seven years and females in ten years, and the oldest males and females were 15 and 16 years of age. The ages have not been validated. Branstetter *et al*. (1987) gave the growth parameters for an Atlantic sample as L_4 = 440 cm TL, K= 0.107, and t_o= -1.13 years, and for a Gulf of Mexico sample as L_4 = 388 cm TL, K= 0.184, and t_o= -0.184. There is little data on the length of the reproductive cycle. Simpfendorfer (1992) stated that the females do not produce a litter each year. The length of the gestation period appears to be about one year (Castro, In Press).

Nurseries for the tiger shark appear to be in offshore areas, but they have not been well described. Natanson *et al*. (1998) reported that nursery areas in the western North Atlantic occur at approximately 35°N and from 33° 45' to 29° 20'N along the east coast of the United States, out to a depth of 100 m. Driggers *et al.* (2008), however, concluded from their investigations from 1995 through 2006, that tiger sharks in the western North Atlantic do not use specific areas as nurseries, although it appears that parturition occurs over a broad range, with areas of high neonate abundance that could be considered important pupping areas within a range extending from 27° to 35°N, larger than previously reported by Natanson *et al*. (1998), with the region from 31° to 33°N probably representing the most important pupping areas. Although neonate tiger sharks are frequently caught in the northern Gulf of Mexico, the locations of pupping or nursery areas in this basin have not been identified (Driggers *et al*., 2008). However, Driggers *et al*. (2008) found areas of highest abundance of tiger shark neonates to be between 83° and 88°W and 93° and 95°W. Hueter and Tyminski (2007) report young-of-the-year collected during surveys in water depths 20 to50 m in July and August along the Louisiana, Mississippi, Alabama, and Florida coasts, and older juveniles occasionally along the central Florida Gulf coast.

Impact of Fisheries: This species is frequently caught in coastal shark fisheries but is usually discarded due to low fin and meat value.

***Essential Fish Habitat for Tiger Shark*:**

- **Neonate/YOY (≤204cm TL):** Off Texas, western Lousiania, and the Florida Panhandle in the Gulf of Mexico. In the Atlantic from the mid-east coast of Florida to Virgina. Please refer to Figure 5.56 for detailed EFH map.

- **Juveniles (205 to 319 cm TL):** In the central Gulf of Mexico and off Texas and Louisiana, and from Mississippi through the Florida Keys. Atlantic east coast from Florida to New England. Please refer to Figure 5.57 for detailed EFH map.

- **Adults (≥320 cm TL):** In the Gulf of Mexico, from Texas to the west coast of Florida, and the Florida Keys. Atlantic east coast from Florida to southern New England. Please refer to Figure 5.58 for detailed EFH map.

5.1.4.7 Sand Tiger Sharks

5.1.4.7.1 Bigeye Sandtiger Shark

Bigeye sand tiger (*Odontaspis noronhai*) This is one of the rarest large sharks. Its large eyes and uniform dark coloration indicate that it is a deep-water species. The few catch records that exist indicate that it frequents the upper layers of the water column at night. The species was originally described based on a specimen from Madeira Beach, Florida. A few specimens were caught at depths of 600 to 1,000 m off Brazil (Compagno, 1984). A 321 cm TL immature female was caught in the Gulf of Mexico, about 70 miles east of Port Isabel, TX in 1984.

Another specimen was caught in the tropical Atlantic (5° N; 35°W) at a depth of about 100 m where the water was about 3,600 m deep. These appear to be all the records for the species. Nothing is known of its habits. Possession of this species is prohibited in Atlantic waters of the United States.

***Essential Fish Habitat for Bigeye Sand Tiger Shark*:**

- **Neonate/YOY:** At this time, available information is insufficient for the identification of EFH for this life stage.

- **Juveniles:** At this time, available information is insufficient for the identification of EFH for this life stage.

- **Adults:** At this time, available information is insufficient for the identification of EFH for this life stage.

5.1.4.7.2 Sandtiger Shark

Sand tiger shark (*Carcharias taurus*) The sand tiger shark is a large, coastal species found in tropical and warm temperate waters throughout the world. It is often found in very shallow water (4 m) (Castro, 1983). It is the most popular large shark in aquaria, because, unlike most sharks, it survives easily in captivity. It has been fished for its flesh and fins in coastal longline fisheries, although possession of this species in Atlantic waters of the United States is now prohibited. In the northwestern Atlantic, mature sand tiger males and juveniles occur between Cape Cod and Cape Hatteras while mature and pregnant females inhabit the more southern waters between Cape Hatteras and Florida (Gilmore, 1993). The species is a generalized feeder, consuming a variety of teleost and elasmobranch prey (Gelsleichter *et al.*, 1999).

Reproductive potential: According to Gilmore (1983), males mature at about 191.5 cm TL. According to Branstetter and Musick (1994), males reach maturity at 190 to 195 cm TL or four to five years and females at more than 220 cm TL or six years. The largest immature female seen by J. Castro was 225 cm TL and the smallest gravid female was 229 cm TL, suggesting that maturity is reached at 225 to 229 cm TL. The oldest fish in Branstetter and Musick's (1994) sample of 55 sharks was 10.5 years old, an age that has been exceeded in captivity (Govender *et al.*, 1991). The von Bertalanffy parameters, according to Branstetter and Musick (1994), are for males: L_{max}= 301 cm, K= 0.17, and t_o= -2.25; and for females: L_{max}= 323 cm, K= 0.14, and t_o= -2.56 yrs. Gilmore (1983) gave growth rates of 19 to 24 cm/yr for the first years of life of two juveniles born in captivity. The sand tiger has an extremely limited reproductive potential, producing only two young per litter (Springer, 1948). Ecological aspects of reproduction, including the timing and location of reproductive events, gestation, and nursery grounds are unknown through most of the sand tiger shark range, although information on some aspects of the reproductive ecology is available for the northwestern Atlantic Ocean (Lucifora *et al.*, 2002). In North America the sand tiger gives birth in March and April to two young that measure about 100 cm TL. Parturition (birth of the young) is believed to occur in winter in the southern portions of its range, and the neonates migrate northward to summer nurseries. The nursery areas are the following Mid-Atlantic Bight estuaries: Chesapeake, Delaware, Sandy Hook, and

Narragansett Bays as well as coastal sounds. Branstetter and Musick (1994) suggested that the reproductive cycle is biennial, but other evidence suggests annual parturition.

Impact of fisheries: The species is extremely vulnerable to overfishing because it congregates in coastal areas in large numbers during the mating season. These aggregations are attractive to fishermen, although the effects of fishing these aggregations probably contribute to local declines in the population abundance. Its limited fecundity (two pups per litter) probably contributes to its vulnerability. In the United States there was a very severe population decline in the early 1990s, with sand tigers nearly disappearing from North Carolina and Florida waters. Musick *et al.* (1993) documented a decrease in the Chesapeake Bight region of the U.S. Mid-Atlantic coast. In 1997, NMFS prohibited possession of this species in U.S. Atlantic waters.

***Essential Fish Habitat for Sand Tiger Shark*:**

- **Neonate/YOY (≤129cm TL):** Along the Atlantic east coast from northern Florida to Cape Cod. Please refer to Figure 5.59 for detailed EFH map.

- **Juveniles (130 to 229 cm TL):** Localized areas along the mid-east coast of Florida and South Carolina and from North Carolina to mid-New Jersey coast in the Atlantic. Please refer to Figure 5.60 for detailed EFH map.

- **Adults (≥230 cm TL):** Localized areas along the mid and northern east coast of Florida, South Carolina, and southern North Carolina, and from Cape Lookout to southern New Jersey in the Atlantic. Please refer to Figure 5.61 for detailed EFH map.

5.1.4.8 Whale Sharks

Whale shark (*Rhincodon typus*) The whale shark is a sluggish, pelagic filter feeder, often seen swimming on the surface. It is the largest fish in the oceans, reaching lengths of 1,210 cm TL and perhaps longer. It is found throughout all tropical seas, usually far offshore (Castro, 1983).

Predator-prey relationships: There are very few observations of aggregations of whale sharks. Feeding aggregations of whale sharks have been reported in the Atlantic, Indian and Pacific Oceans, typically aggregating in areas of high biological activity (Burks *et al*., 2006). Whale sharks have been observed by Burks *et al*. (2006) in the northern Gulf of Mexico where they appeared to be more abundant in the western region than in the eastern. Over the course of their 1989-1998 study, 119 whale sharks were observed in the northern Gulf, 45 of which were observed in aggregations. Two whale sharks were observed at the head of DeSoto Canyon, an upwelling area south of the Florida panhandle. Hoffmayer *et al*. (2005) also reported a large aggregation of 30 to 100 individuals in the same area. In 2006, Hoffmayer *et al*. (2007) observed an aggregation of 16 whale sharks in the north central Gulf of Mexico, west of the Mississippi River Delta feeding on recently spawned little tunny eggs by skimming the surface of the water as they swam with their lower jaw positioned slightly under the surface. This represents the first confirmed observation of a feeding aggregation of whale sharks in the Gulf of Mexico. The estimated length of the whale sharks ranged from 6.0 to 12.0 m TL, with most being greater than 8.0 m TL.

Reproductive potential: Discoveries by Joung *et al.* (1996) indicate that the whale shark is the most prolific of all sharks. The only gravid female examined carried 300 young in several stages of development. The embryos measured 580 to 640 mm TL, the largest appearing ready for birth. The length of the reproductive cycle is unknown, but is probably biennial such as the closely related nurse shark (*Ginglymostoma cirratum*) and most other large sharks (Castro, 1996). Based on unpublished information on the growth rate of one surviving embryo from a female reported by Joung *et al*. (1996), the whale shark may be the fastest growing shark. Only a handful of small juveniles have ever been caught, probably because of the extremely fast growth rate or high mortality rate of juveniles. The location of the whale shark nurseries is unknown.

Impact of fisheries: There are very few observations of aggregations of whale sharks. The range of the whale shark may be extremely vast, perhaps encompassing entire ocean basins. Thus it may be necessary to consider whale shark fisheries on an ocean-wide perspective. There have been a few small fisheries for whale sharks in India, the Philippines, and Taiwan, but it is of little commercial importance elsewhere. The whale shark used to be fished for its flesh, but presently the fins and oil are also used. Generally, the size of the whale shark safeguards it from most fisheries. Records of the Taiwanese fishery demonstrate that whale sharks, like most elasmobranchs, are susceptible to overfishing. In 1997, NMFS prohibited possession of this species in U.S. Atlantic waters.

***Essential Fish Habitat for Whale Shark*:**

Note: At this time, insufficient data is available to differentiate EFH by size classes, therefore, EFH is the same for all life stages.

- **Neonate/YOY:** Central Gulf of Mexico from Texas to the Florida Panhandle. Please refer to Figure 5.62 for detailed EFH map.

- **Juveniles:** EFH for all life stages have been combined and are considered the same. Please refer to Figure 5.62 for detailed EFH map.

- **Adults:** EFH for all life stages have been combined and are considered the same. Please refer to Figure 5.62 for detailed EFH map.

5.1.5 Small Coastal Sharks

5.1.5.1 Angel Sharks

Atlantic angel shark *(Squatina dumeril)* The angel shark is a flattened shark that resembles a ray. It is a benthic species inhabiting coastal waters of the United States from Massachusetts to the Florida Keys, the Gulf of Mexico, and the Caribbean. It is common from southern New England to the Maryland coast (Castro, 1983).

Reproductive potential: Maturity is probably reached at a length of 90 to 105 cm TL. The pups measure 28 to 30 cm TL at birth. Up to 16 pups in one litter have been observed (Castro, 1983). The species has a biennial reproductive cycle with a gestation period of approximately 10 months (Baremore and Carlson, 2004). Baremore and Carlson (2004) report median length at maturity for males to be 89 cm and for females 83 cm.

***Essential Fish Habitat for Atlantic Angel Shark*:**

Note: At this time, insufficient data is available to differentiate EFH between the juvenile and adult size classes, therefore, EFH is the same for those life stages.

- **Neonate/YOY (≤31 cm TL):** Insufficient data to determine EFH for this lifestage.
- **Juveniles and Adults:** EFH designation for juvenile and adult life stages have been combined and are considered the same. Localized areas off of eastern Louisiana, and from Mississippi to the Florida Panhandle in the Gulf of Mexico. Atlantic east coast from Cape Lookout to the mid-coast of New Jersey. Please refer to Figure 5.63 for detailed EFH map and Table 5.1 for life stage size information.

5.1.5.2 Hammerhead Sharks

5.1.5.2.1 Bonnethead Shark

Bonnethead (*Sphyrna tiburo*) The bonnethead is a small hammerhead shark that inhabits shallow coastal waters where it frequents sandy or muddy bottoms. It is confined to the warm waters of the western hemisphere (Castro, 1983). Bonnethead sharks feed mainly on benthic prey such as crustaceans and mollusks. They do not appear to exhibit long distance migratory behavior and thus, little or no mixing of populations (Lombardi-Carlson, 2007).

Reproductive potential: Studies conducted along the Florida Gulf coast found female bonnethead sharks in some locations to have a slower growth rate than males and significant differences in size at maturity (Lombardi-Carlson, 2007). Parsons (1993) reported males maturing at about 70 cm TL, and females at about 85 cm TL). The reproductive cycle is annual (Castro, pers. obs.). Parsons (1993) estimated the gestation period of two Florida populations at 4.5 to 5 months, one of the shortest gestation periods known for sharks. Litters consist of eight to12 pups, with the young measuring 27 to 35 cm TL at birth (Castro, 1983; Parsons, 1993). Heuter and Tyminski (2007) found young-of-the-year and juveniles in the west coast of Florida at temperatures of 16.1° to 31.5°C, salinities of 16.5 to 36.1 ppt, and DO of 2.9 to 9.4 ml/l. Parthenogenesis (development of an embryo from an egg without male genetic contribution) in a bonnethead shark was reported to have opccurred in a U.S. aquarium, whereby an adult female that had been held captive in the absence of males for three years gave birth to a normally developed live female pup; the validity of this birth occurring through parthenogenesis was later confirmed by DNA analysis (Chapman *et al.*, 2007)

Impact of fisheries: The bonnethead is at a lesser risk of overfishing because it is a fast growing species that reproduces annually and, due to its small size, is generally not targeted by commercial fisheries. Although bonnetheads are caught as bycatch in gillnet fisheries operating in shallow waters of the southeastern United States, many of these fisheries have been prohibited by various states, and therefore forced into deeper Federal waters where gillnets are less effective. Bonnethead bycatch in the U.S. Gulf of Mexico shrimp fishery seems to have remained stable over the last twenty years, from 1974 to 1994 (Pellegrin, 1996). This stock was determined to not be overfished with no overfishing occurring in 2008 (May 7, 2008; 73 FR 25665).

***Essential Fish Habitat for Bonnethead Shark*:**

- **Neonate/YOY (≤55 cm TL):** Coastal areas in the Gulf of Mexico along Texas, and from eastern Mississippi through the Florida Keys. Atlantic east coast from the mid-coast of Florida to South Carolina. Please refer to Figure 5.64 for detailed EFH map.

- **Juveniles (56 to 81 cm TL):** Coastal areas in the Gulf of Mexico along Texas, and from eastern Mississippi through the Florida Keys. Atlantic east coast from the mid-coast of Florida to South Carolina. Please refer to Figure 5.65 for detailed EFH map.

- **Adults (≥82 cm TL):** Coastal areas in the Gulf of Mexico along Texas, and from eastern Mississippi through the Florida Keys. Atlantic east coast from the mid-coast of Florida to Cape Lookout. Please refer to Figure 5.66 for detailed EFH map.

5.1.5.3 Requiem Sharks

5.1.5.3.1 Atlantic Sharpnose Shark

Atlantic sharpnose shark (*Rhizoprionodon terraenovae*) The Atlantic sharpnose shark is a small coastal carcharhinid, inhabiting the waters of the northeast coast of North America. It is a common year-round resident along the coasts of South Carolina, Florida, and in the Gulf of Mexico and an abundant summer migrant off Virginia. Frequently, these sharks are found in schools of uniform size and sex (Castro, 1983). The Atlantic sharpnose shark is the most abundant and exploited small coastal shark in U.S. Atlantic and Gulf of Mexico waters (Cortés, 2002). Atlantic sharpnose sharks are known to occur in a variety of coastal habitats in the Gulf of Mexico, some of which are proposed nursery areas (McCandless *et al*., 2002). In the northeast Gulf of Mexico, juvenile and mature Atlantic sharpnose sharks recruit to coastal waters beginning in April (Carlson and Brusher, 1999). Neonate sharks begin arriving in June (Carlson and Brusher, 1999; Carlson, 2002) and all life stages are present by late June and generally remain in-shore until they emigrate offshore in the fall (Carlson and Brusher, 1999).

Reproductive potential: The male Atlantic sharpnose sharks mature at around 65 to 80 cm TL and grow to 103 cm TL. The females mature at 85 to 90 cm TL and reach a length of 110 cm TL. Litters range from four to seven pups, which measure 29 to 32 cm TL (Castro, 1983). Mating is in late June; the gestation period is about 11 to 12 months (Castro and Wourms, 1993). The von Bertalanffy growth parameter estimates for the species in the Gulf of Mexico are L_4 = 110, K= 0.39, and t_o= -0.86 yr (Carlson and Baremore, 2003). Cortés (1995) calculated the population=s intrinsic rate of increase was, at best, r= .044, or a finite increase of e_r = 1.045, with a mean generation time of 5.8 years. Off South Carolina the young are born in late May and early June in shallow coastal waters (Castro and Wourms, 1993). Hueter and Tyminski (2007) found neonates off the west coast of Florida at Yankeetown and Anclote Key during the months of May to July. These neonates were found in temperatures of 24.0° to 30.7°, salinities of 22.8 to 33.7 ppt, and DO of 5.7 ml/l. Larger juveniles were also found in the area in temperatures of 17.2° to 33.3°C, salinities of 22.8 to 35.5 ppt, and DO of 4.5 to 8.6 ml/l.

Crooked Island Sound and the Apalachicola Bay system (*e.g.*, St. Vincent Island) have also been hypothesized to serve as nursery areas for Atlantic sharpnose sharks in the northeast Gulf of Mexico (Carlson, 2002; Bethea *et al*., 2006). Young of the year (YOY) and juveniles were found in temperatures of 21.8° to 31.7° C, salinities of 29.0 to 37.2, and DO of 2.7 to 6.9 ml/l. Habitat associations for YOY included mud, sand, and seagrass, and for juveniles, sand, seagrass, and mud in descending order of predominance (Bethea *et al*., 2006). A recent study indicates that juvenile sharpnose sharks may not exhibit philopatry (tendancy to return to a specific location in order to breed or feed), but likely utilize a series of coastal bays and estuaries throughout the juvenile stage (Carlson *et al*., 2008).

Impact of fisheries: Large numbers of Atlantic sharpnose sharks are taken as bycatch in the U.S. shrimp trawling industry. The Texas Recreational Survey, NMFS Headboat Survey, and the U.S. Marine Recreational Fishing Statistics Survey have estimated a slow increase in the sharpnose fishery. The Atlantic sharpnose is a fast-growing species that reproduces yearly. In spite of being targeted by recreational fisheries and the large bycatch in the shrimp industry, the populations seem to be maintaining themselves. This stock was determined to not be overfished with no overfishing occurring in 2008 (May 7, 2008, 73 FR 25665).

Essential Fish Habitat for Atlantic Sharpnose:

- **Neonate/YOY (≤60 cm TL):** Gulf of Mexico coastal areas from Texas through the Florida Keys. In the Atlantic from the mid-coast of Florida to Cape Hattaras. Please refer to Figure 5.67 for detailed EFH map.

- **Juveniles (61 to 71 cm TL):** Gulf of Mexico coastal areas from Texas through the Florida Keys. In the Atlantic from the mid-coast of Florida to Cape Hattaras, and a localized area off of Delaware. Please refer to Figure 5.68 for detailed EFH map.

- **Adults (≥72 cm TL):** Gulf of Mexico from Texas through the Florida Keys out to a depth of 200 meters. In the Atlantic from the mid-coast of Florida to Maryland. Please refer to Figure 5.69 for detailed EFH map.

5.1.5.3.2 Blacknose Shark

Blacknose shark (*Carcharhinus acronotus*) The blacknose shark is a common coastal species that inhabits the western North Atlantic from North Carolina to southeast Brazil (Bigelow and Schroeder, 1948). It is very abundant in coastal waters from the Carolinas to Florida and parts of the Gulf of Mexico during summer and fall (Castro, 1983). Parsons and Hoffmeyer (2007) stated that the blacknose shark is an infrequent visitor to the shallow waters of the north-central Gulf of Mexico as they only captured five blacknose sharks between 1997 and 2000 using gillnet gear between Bay St. Louis, Mississippi to Perdido Bay, Alabama.

Branstetter (1981) reported capturing this species on longline gear using longline gear further offshore, indicating that the blacknose shark is a deeper water resident and that the north-central Gulf of Mexico is not an important nursery area for this species. However, Carlson (2002) used gillnet surveys from 1993-2000 and reported blacknose juveniles and neonates present in northwest Florida (from St. Andrews Bay to Apalachee Bay) from May through October ranging in size from 39.5 to 135 cm TL. Blacknose sharks were found in water temperatures ranging from 20.8-33.6°C, in salinities averaging 32.1 ppt, and in water depths averaging 3.7 m (Carlson, 2002). Blacknose sharks were found over a variety of bottom types in northwest Florida and tolerated dissolved oxygen levels to 2.0 mg l^{-1} (Carlson, 2002).

Schwartz (1984) hypothesized that there are two separate populations in the western Atlantic. Tag recapture data for this species show a strong philopatric behavior and an annual homing cycle (Heuter *et al*., 2005; Heuter and Tyminski, 2007). Blacknose sharks are abundant in coastal waters off South Carolina from May to October with the first occurrence generally corresponding to the water temperature reaching 24°C with mating taking place in the late spring and early summer (Ulrich *et al*., 2007). There has been no indication of habitat partitioning between adults and juveniles.

Reproductive potential: Maturity is reached at approximatley 100 cm TL. Litters consist of three to six pups, which measure 50 cm TL at birth (Castro, 1983). In the Atlantic Ocean, blacknose sharks reach sexual maturity at 4.5 years of age and give birth to an average 3.53 pups/year with a maximum observed age of of 12.5 years (Driggers *et al*., 2007). In the Gulf of Mexico, female blacknose sharks mature at 6.6 years, a maximum observed age of 11.5 years, and give birth to 3.13 pups/year (Driggers *et al*., 2007; Sulikowski *et al*., 2007). Sulikowski *et al*. (2007) determined that reproductive activity peaks in May through July in the northern Gulf of Mexico. Males also have a higher maximum age in the South Atlantic compared to the Gulf of Mexico (105. yrs vs. 9.5 yrs; Driggers *et al*., 2007). In addition, Sulikowski *et al*. (2007) found that blacknose sharks have a clearly defined annual reproductive cycle in the Gulf of Mexico, compared to the South Atlantic where blacknose sharks have a biennial reproductive cycle (Driggers *et al*., 2004), whereas Hazin *et al*. (2002) suggested annual reproduction off northeastern Brazil. The species is common throughout the year off Florida, suggesting that part of the population may be non-migratory and that nursery areas may exist in Florida as well.

Neonate (TL = 42-50 cm) and young-of-the-year (TL = 36-62 cm) blacknose sharks are found along Gulf of Mexico beaches in the Tampa Bay and Charlotte Harbor areas throughout June, migrating out of these areas in October (Hueter and Tyminski, 2007). Hueter and Tyminski (2007) found 13 neonates in the Ten Thousand Islands and off Sarasota in June and July at temperatures 29° to 30.1°C, salinities of 32.2 to 37.0 ppt, and DO of 6.5 ml/l. They also found young-of-the-year and juveniles at temperatures of 17.3° to 34°C, salinities of 25.0 to 37.0 ppt, and DO of 4.8 to 8.5 ml/l. Castro has reported neonates in Bulls Bay, South Carolina (Castro,1993a), and Ulrich *et al.* (2007) collected 15 young-of-the-year blacknose sharks in nearshore waters, suggesting the possibility that blacknose sharks make limited use of South Carolina’s nearshore waters as a nursery.

Hueter and Tyminski (2007) found older juveniles of this species present along Gulf of Mexico beaches off Tampa Bay and Charlotte Harbor beginning in early March and remaining throughout the summer months. Juvenile blacknose sharks are rarely seen after October in the inshore Gulf waters but are present in the Florida Keys in the winter months.

Impact of fisheries: Blacknose sharks are caught predominantly (36-70 percent) in the shrimp trawl fishery as bycatch. Landings also occur in commercial fisheries targeting sharks using longline and gillnet gear. Total annual removals of blacknose sharks averaged 82,500/year between 1993 and 2005. There are also significant landings of blacknose sharks in recreational fisheries. The 2007 stock assessment found estimates of biomass are below 1.0 and fishing mortality is greater than 1.0 indicating an overfished condition with overfishing continuing to occur. This stock was determined to be overfished with overfishing occurring in 2008 (May 7, 2008, 73 FR 25665).

***Essential Fish Habitat for Blacknose Shark*:**

- **Neonate/YOY (≤55 cm TL):** In the Gulf of Mexico coastal areas from the Florida Panhandle and west coast of Florida. In Atlantic coastal areas from Georgia to southern North Carolina. Please refer to Figure 5.70 for detailed EFH map.

- **Juveniles (56 to 90 cm TL):** Localized areas off Texas and western Louisania, and coastal areas from Mississippi through the Florida Keys in the Gulf of Mexico. Atlantic east coast from the mid-coast of Florida to Cape Hattaras. Please refer to Figure 5.71 for detailed EFH map.

- **Adults (≥91 cm TL):** Localized areas off Texas and central Louisania, and coastal areas from eastern Louisiania through the Florida Keys in the Gulf of Mexico Atlantic east coast from the mid-coast of Florida to Cape Hattaras. Please refer to Figure 5.72 for detailed EFH map.

5.1.5.3.3 Caribbean Sharpnose Shark

Caribbean sharpnose shark (*Rhizoprionodon porosus*) The Atlantic sharpnose and the Caribbean sharpnose sharks are cognate species, or a species with a common origin, separable only by having different numbers of precaudal vertebrae (Springer, 1964). However, they have non-overlapping ranges, as the Caribbean sharpnose shark inhabits the Atlantic from 24°N to 35°S, while the Atlantic sharpnose is found at latitudes higher than 24°N. Their biology is very similar. The Caribbean sharpnose shark is a prohibited species; therefore, it can not be retained in commercial or recreational fisheries.

***Essential Fish Habitat for Caribbean Sharpnose*:**

- **Neonate:** At this time, available information is insufficient for the identification of EFH for this life stage.

- **Juveniles:** At this time, available information is insufficient for the identification of EFH for this life stage.

- **Adults:** At this time, available information is insufficient for the identification of EFH for this life stage.

5.1.5.3.4 Finetooth Shark

<u>Finetooth shark (*Carcharhinus isodon*)</u> This is a common inshore species of the western Atlantic. It ranges from North Carolina to Brazil. It is abundant along the southeastern United States and the Gulf of Mexico (Castro, 1983). Sharks captured in the northeastern Gulf of Mexico ranged in size from 48 to 150 cm total length were generally found in water temperatures averaging 27.3°C and depths of 4.2 m (Carlson, 2002). Important nursery habitat is located in South Carolina (Castro, 1993b; Ulrich and Riley, 2002; Abel *et al.*, 2007), Louisiana (Neer *et al.*, 2002), and off the coast of Texas (Jones and Grace, 2002). Adult, juvenile, and neonate specimens were collected in Winyah Bay and North Inlet, South Carolina at sites where salinity was at least 23.5 practical salinity units (psu) (Abel *et al*., 2007). Ulrich *et al*. (2007) collected 965 finetooth sharks in waters adjacent to South Carolina ranging in size from 38.3 to 137 cm FL. They found that finetooth sharks generally arrive when water temperatures reach 22°C (mid-May) and remain until water temperatures drop to 20°C (October). In the Gulf of Mexico, 71 adult, neonate, and juvenile finetooth sharks were collected in Terrebonne and Timbalier Bays off the coast of Louisiana between 1999 and 2003 and were collected most frequently in the mid to late summer (Neer *et al*., 2007). Hendon and Hoffmeyer (2007) found that young of the year finetooth sharks seek different types of habitat than their older conspecifics in the eastern portion of the Mississippi sound region.

Reproductive potential: Males mature at about 130 cm total length and females mature at about 135 cm TL. The young measure 48 to 58 cm TL at birth. Litters range from two to six embryos, with an average of four. The gestation period lasts about a year, and the reproductive cycle is biennial. Some of the nurseries are in shallow coastal waters of South Carolina (Castro, 1993a; Abel *et al.*, 2007) and the Gulf of Mexico. Neer *et al*. (2007) collected pregnant female finetooth sharks in September in the vicinity of Terrebonne and Timbalier Bays off the coast of Louisiana, in temperatures ranging from 27.2° to 29.5°C, salinities between 27.1 and 29.8 ppt, and at depths between 2.1 and 8.2 m. Additional life history information can be found in Carlson *et al.* (2003), Hoffmayer and Parsons (2003), and Bethea *et al*. (2004).

Ulrich *et al*. (2007) collected neonate finetooth sharks with umbilical scars from late May until mid-June exclusively in estuarine waters in salinities ranging from 18 to 37 ppt. The abundance of neonate finetooth sharks in South Carolina's estuarine waters indicated that this area is a primary nursery area for this species (Ulrich *et al.*, 2007). Hueter and Tyminski (2007) collected a 63 cm (TL) young-of-the-year specimen in the vicinity of Yankeetown, Florida, suggesting that pupping takes place in that area. The average depth of this nursery area is 1.8-2.4 m with temperatures ranging between 17° to 32.4°C and salinities ranging from 15.8 to 34.9 ppt. Neer *et al*. (2007) collected one neonate finetooth shark in May, which suggests that the vicinity of Terrebonne and Timbalier Bay's off coastal Louisiana are pupping grounds in early spring as well. Gurshin (2007) sampled 13 neonate finetooth sharks in estuarine waters in the vicinity of the lower Duplin River and Doboy Sound in the vicinity of the Sapelo Island National Estuarine Research Reserve off the coast of Georgia the summer (June-August) of 1997. Bottom water temperatures ranged from 25° to 30°C and salinities were between 24 to 26 ppt. Peak abundance occurred at the end of June and first half of July. Hendon and Hoffmeyer (2007) found that young-of-the-year finetooth sharks were abundant in the eastern portion of the Mississippi Sound, specifically off western Horn, Sound, and Round Islands.

Juvenile finetooth sharks were observed by Ulrich *et al*. (2007) in May through August off South Carolina in salinities ranging from 25 to 37 ppt. Additionally, shallow coastal waters less than five meters deep with muddy bottoms, and on the seaward side of coastal islands from Apalachee Bay to St. Andrews Bay, Florida, especially around the mouth of the Apalachicola River. Bethea *et al.* (2004) collected 109 juvenile finetooth sharks in the vicinity of Apalachicola Bay for a study to compare the foraging ecology of four shark species. The study showed that juvenile finetooth sharks occurred in coastal waters out to the 25 m isobath from Mobile Bay, Alabama to Atchafalaya Bay, Louisiana from 88° W to 91.4°W, and from near Sabine Pass, Texas at 94.2°W to Laguna Madre, Texas at 26°N; also, coastal waters out to the 25 m isobath from South Carolina north to Cape Hatteras, North Carolina at 35.5°N. Older juveniles (N = 70; TL = 22-127 cm) were observed by Hueter and Tyminski (2007) along the beaches of the lower Texas coast during spring and fall migrations. Neer *et al*. (2007) collected a total of 33 males and 38 females ranging in size from 49.2 to 117.9 cm (FL) in the vicinity of Terrebonne and Timbalier Bays off the coast of Louisina. These specimens were collected in areas with water temperatures ranging from 27.2° to 29.5°C, in salinities between 27.1 and 29.8 ppt, and at depths between 2.1 and 8.2 m. Parsons and Hoffmeyer (2007) sampled 440 young-of-the-year and juvenile finetooth sharks between Bay St. Louis, Mississippi and Perdido Bay, Alabama in depths ranging from 3.1 to 8.2 m depth, at temperatures between 27.1° and 30.6°C, in salinities ranging from 18 to 20 ppt. Hendon and Hoffmeyer (2007) caught juvenile finetooth sharks with varying levels of catch per unit effort in the Mississippi Sound north of Cat, Ship, Horn, and Petit Bois Islands off the coast of Louisiana. Five juvenile finetooth sharks were collected by Gurshin (2007) in the vicinity of the lower Duplin River and Doboy Sound in the vicinity of the Sapelo Island National Estuarine Research Reserve off the coast of Georgia the summer (June-August) of 1997. Bottom water temperatures ranged from 25° to 30°C and salinities were 24 to 26 ppt. Peak abundance occurred at the end of June and first half of July.

In estuarine waters, however, the ratio of adult males to females was 1.25:1. Adults off South Carolina were caught in salinities ranging from 30 to 37 ppt (Ulrich *et al*., 2007). Winyah Bay and North Inlet, estuaries in northeast South Carolina, were identified as pupping habitat for adult finetooth sharks. Additionally, shallow coastal waters less than five meters deep with muddy bottoms, and on the seaward side of coastal islands from Apalachee Bay to St. Andrews Bay, Florida, especially around the mouth of the Apalachicola River, including areas identical to those for juveniles: coastal waters out to the 25 m isobath from Mobile Bay, Alabama to Atchafalaya Bay, Louisiana from 88° to 91.4°W, and from near Sabine Pass, Texas at 94.2°W to Laguna Madre, Texas at 26°N. Hendon and Hoffmeyer (2007) caught adult finetooth sharks with varying levels of catch per unit effort in the Mississippi Sound north of Cat, Ship, Horn, and Petit Bois Islands between the islands and the coast of Louisiana.

Impact of fisheries: Finetooth sharks comprise only a small fraction of the small coastal shark landings and are managed as a single stock throughout their range. They are caught commercially using gillnets, longlines, and handlines (in descending order). Recreational catch has been approximately half of the commercial catch since the 1990s. Generally, finetooth sharks are not caught in shrimp trawls as frequently as other small coastal sharks

The 2002 stock assessment indicated that overfishing of finetooth sharks was occurring. The 2007 stock assessment produced estimates of biomass that were above 1.0 and estimates of fishing mortality that were below 1.0, suggesting that the species is no longer experiencing overfishing and is not overfished. However, the assessment suggested a cautious management strategy due to the lack of data which influenced the number of models that could be employed (SEDAR 13, 2007).

***Essential Fish Habitat for Finetooth Shark*:**

Note: At this time, insufficient data is available to differentiate EFH between the juvenile and adult size classes; therefore, EFH is the same for those life stages.

- **Neonate/YOY (≤85 cm total length):** Along the Gulf of Mexico coast of Texas, eastern Louisiana, Mississippi, Alabama, and the Florida Panhandle. Atlantic east coast along Georgia and South Carolina. Please refer to Figure 5.73 for detailed EFH map.

- **Juvenile and Adult:** EFH designation for juvenile and adult life stages have been combined and are considered the same. Localized coastal areas along southern Texas and Key West, Florida, and from eastern Louisiana through the Florida Panhandle in the Gulf of Mexico. Atlantic east coast from the mid-coast of Florida to Cape Hattaras. Please refer to Figure 5.74 for detailed EFH map and Table 5.1 for life stage size information.

5.1.5.3.5 Smalltail Shark

Smalltail shark *(Carcharhinus porosus)* This is a small, tropical, and subtropical shark that inhabits shallow coastal waters and estuaries in the western Atlantic, from the Gulf of Mexico south to Brazil (Castro, 1983). A few specimens have been caught in the Gulf of Mexico off Louisiana and Texas.

Reproductive potential: There is almost no published data on its reproductive processes. Females observed in Trinidad were in different stages of gestation, suggesting a wide breeding season. Embryos up to 35 cm TL were observed. The reproductive cycle appears to be annual. Lessa *et al*. (1999b) conducted life history research off the coast of Brazil where smalltail sharks comprise a more significant portion of commercially caught elasmobranchs. Males and females reach sexual maturity at 71 and 70 cm, respectively. The largest smalltail shark ever collected off the coast of Brazil was 134 cm.

Impact of fisheries: The smalltail shark is a prohibited species and can not be retained in commercial or recreational fisheries. However, based on research conducted off the coast of Brazil, Lessa *et al.* (1999b) conclude that fisheries for smalltail sharks mainly affect juveniles, which could result in growth-overfishing because of their slow growth, small litters, and long gestation period.

Essential Fish Habitat for Smalltail Shark

- Note: At this time, there is insufficient data to designate EFH.

5.1.6 Pelagic Sharks

5.1.6.2 Cow sharks

5.1.6.2.1 Bigeye Sixgill Shark

Bigeye sixgill shark (*Hexanchus nakamurai*) This is a poorly known deep-water shark that was not described until 1969 (Springer and Waller, 1969). Bigeye sixgill sharks may move to the surface at night in the tropics (Compagno 1984; Compagno *et al*., 1989) and have been found as deep as 600 m (Bunkley-Williams and Williams, 2004). In North America most catches have come from the Bahamas and the Gulf of Mexico. This shark has a wide but patchy distribution. It has been sporadically caught in the western central Atlantic in the Bahamas (Compagno, 1984; Springer and Waller, 1969), Dominican Republic (Bunkley-Williams and Williams, 2004), Costa Rica (Compagno, 1984), Cuba (Claro, 1994), Mexico (Bonfil, 1977), Nicaragua (Compagno, 1984), Trinidad and Tobago (Ramjohn, 1999), Venezuela (Cervigón *et al*., 1993); it also occurs in parts of the eastern Atlantic, Indian Ocean, and Western Pacific (Compagno and Niem, 1998). Museum records for this fish represent new locality records for Florida, the Florida Keys, the Gulf of Mexico, Puerto Rico (Dennis, 2003), and Tortola. New deep-water records were also found for Barbados, Puerto Rico, the southern Caribbean Sea, and St. Thomas in museum specimens.

Essential Fish Habitat for Bigeye Sixgill Shark:

- Note: At this time, there is insufficient data available to designate EFH.

5.1.6.2.2 Sevengill Shark

Sevengill shark (*Heptranchias perlo*) This is a deep-water species of the continental slopes, where it appears to be most common at depths of 27 to 1,000 m (Compango, 1984a). *Heptranchias perlo* was first described by Bonnaterre in 1788, and is commonly known as the sharpnose sevengill shark; it may be confused with the broadnose sevengill shark (*Notorynchus cepedianus*). It has a world-wide distribution in deep tropical and warm temperate waters with the exception of the northeast Pacific Ocean (Compango, 1984a). In the western Atlantic Ocean, this shark is distributed from North Carolina and northern Gulf of Mexico to Cuba and from Venezuela south to Argentina, and in the eastern Atlantic from Morocco to Namibia, including the Mediterranean Sea. The sharpnose sevengill shark is also found in the Indian Ocean in waters off southwestern India, Aldabra Island, southern Mozambique, and South Africa. Distribution in the Pacific Ocean occurs from Japan to China, Indonesia, Australia, and New Zealand as well as off the coast of northern Chile (Compango, 1984a).

Sharpnose sevengill sharks feed primarily on benthic organisms, mainly teleosts and cephalopods, batoids, and benthic invertebrates. *Heptranchias perlo* has displayed a generalist feeding strategy with enhanced feeding and activity during night time (Frentzel-Beyme and Koster, 2002).

Reproductive potential: Sevengill sharks grow to a maximum length of 137 cm TL (Compango, 1984a). Size at maturity is about 85 cm for males and 89 to 93 cm for females (Compango, 1984a). Maximum size recorded was 214 cm, but was possibly an error (Compango, 1984a). Litters consist of nine to 20 pups, which measure about 25 cm TL at birth (Castro, 1983). According to Tanaka and Mizue (1977), off Kyushu, Japan the species reproduces year round. Biologists have observed formation of mucus on the tips of the claspers on mature and subadult males. It is believed this indicates the onset of maturity and perhaps sexual activity (Compango, 1984a; Frentzel-Beyme and Koster, 2002). The lengths of the reproductive and gestation cycles as well as the location of nurseries are unknown.

Impact of fisheries: The sharpnose sevengill shark is sometimes caught in large numbers as bycatch in fisheries using bottom trawls or longlines (Compagno, 1984). In North America it is occasionally seen in small numbers as bycatch of tilefish longlines (Castro, unpubl. data). The species is currently assessed as "Near Threatened" by the World Conservation Union (IUCN).

Essential Fish Habitat for Sevengill Shark:

- Note: At this time, there is insufficient data available to designate EFH.

5.1.6.2.3 Sixgill Shark

Sixgill shark (*Hexanchus griseus*) The sixgill shark is one of the largest and most primitive sharks known. The shark is primarily a deepwater species living in deep, cool waters, close to the bottom (100 to1,000 m), possibly rising to surface at night to feed (Serena, 2005). These sharks have been found to dive as deep as 1,500 m (Carey and Clark, 1995). Juveniles stray into very shallow, cool waters.

The sixgill shark is one of the wider ranging sharks, residing in temperate and tropical seas around the world (Castro, 1983). In the western Atlantic Ocean, this range includes from North Carolina to Florida and from the northern Gulf of Mexico to northern Argentina including Nicaragua, Costa Rica, and Cuba. This species is also found in deep waters (600 to 900 m) around Bermuda (Carey and Clark, 1995). In the eastern Atlantic, this shark is found from Iceland and Norway south to Namibia, including the Mediterranean Sea (Serena, 2005). Its range in the Indian Ocean includes waters off Madagascar and Mozambique. It also resides in the Pacific Ocean with distribution in the western Pacific from eastern Japan to Australia and New Zealand as well as Hawaii. In the eastern Pacific, the sixgill shark has been documented in waters from the Aleutian Islands, Alaska south to Baja California, Mexico and Chile (Hart, 1973; Castro, 1983; Compango, 1984a; Serena, 2005).

The sixgill shark feeds nocturnally on a wide variety of prey items. It consumes large bony and cartilaginous fishes such as dolphinfish, billfish, flounder, cod, hagfish, lampreys, chimaeras, and rays. Spiny dogfish (*Squalus acanthias*), longnose dogfish (*Squalus blainvillei*), shortnose dogfish (*Squalus megalops*), and prickly sharks (*Echinorhinus cookei*) are also consumed by the sixgill shark (Ebert, 1986). Other prey includes small fishes, snails, crabs, shrimp, and squid. It also scavenges on the carrion of seals, sea lions, and whales as well as on bait from longlines set for other targeted fisheries.

Reproductive potential: Very few mature sixgill sharks have been examined by biologists; thus the reproductive processes are poorly known (McFarlane *et al*., 2002). Ebert (1986) reported a 421 cm TL female to be gravid with term embryos. Springer and Waller (1969), based on the examination of a few large specimens, estimated that females reached maturity at 450 cm TL. The maximum reported size for this species is about 482 cm TL (Compango, 1984a). Females tend to be slightly larger than males, averaging around 4.3 m in length while males tend to stay near 3.4 m (Bauml, 2004). Males reach maturity at lengths of 300 cm and 200 kg while females mature at 400 cm in length and 400 kg in weight (Ebert, 1992). Although age determination is difficult (McFarlane *et al*., 2002), it is suggested that the corresponding age when males reach maturity is 11 to14 years and 18 to35 years for females.

The pups measure 60 to 70 cm TL at birth (Castro, 1983; Compango, 1984a). Reported litter sizes range from 22 to 108 (Compagno, 1984a; Ebert, 1992). Juveniles are often caught in coastal waters, suggesting that the nurseries are in waters much shallower than those inhabited by the adults (Compagno, 1984). Nothing else is known about its nurseries.

Impact of fisheries: Although juveniles are common in deep continental shelf waters and often enter coastal waters, the adults are seldom taken (Springer and Waller, 1969; Ebert, 1986). Apparently, adults are in waters deeper than those regularly fished, or perhaps these very large animals break the gear and escape. Thus, the very deep habitat of the adults or perhaps their large size seems to convey some measure of protection from most fisheries. According to Harvey-Clark (1995), in 1991 the sixgill shark became the target of a directed, subsidized, longline fishery off British Columbia, Canada. At about the same time, the species also became of interest as an ecotourism resource, with several companies taking diving tourists out to watch sixgill sharks in their environment. The fishery was unregulated and lasted until 1993, when the commercial harvest of sixgill sharks was discontinued due to conservation and management concerns. According to Harvey-Clark (1995), diver observations of sharks decreased in 1993, and it was unclear at the time whether the fishery or the ecotourism could be sustained. It is difficult to evaluate the vulnerability of the sixgill shark because of the lack of fisheries or landings data. The only fishing operations on record collapsed in a few years, suggesting that the species may be very vulnerable to overfishing. The sixgill shark is considered "Near Threatened" by the World Conservation Union (IUCN).

Essential Fish Habitat for Sixgill Shark:

- Note: At this time, there is insufficient data available to designate EFH.

5.1.6.3 Mackerel Sharks

5.1.6.3.1 Longfin Mako Shark

Longfin mako shark (*Isurus paucus*) This is a deep dwelling lamnid shark found in warm waters. The species was not described until 1966 and it is very poorly known.

Reproductive potential: There is very little data on the reproductive processes of the longfin mako. Litters consist of two to eight pups, which may reach 120 cm TL at birth (Castro, unpubl. data).

Impact of fisheries: The longfin mako is a seasonal bycatch of the pelagic tuna and swordfish fisheries. Possession of this species in Atlantic waters of the United States is now prohibited.

***Essential Fish Habitat for Longfin Mako Shark*:**

Note: At this time, insufficient data is available to differentiate EFH by size classes; therefore, EFH is the same for all life stages.

- **Neonate/YOY, Juveniles, and Adults:** EFH designation for all life stages have been combined and are considered the same. Central Gulf of Mexico through the Florida Keys. In the Atlantic from southern Florida through South Carolina, off North Carloina, and Cape Hatteras to Cape Cod. Please refer to Figure 5.75for detailed EFH map and Table 5.1 for life stage size information.

5.1.6.3.2 Porbeagle Shark

Porbeagle (*Lamna nasus*) The porbeagle shark is a lamnid shark common in deep, cold temperate waters of the North Atlantic, South Atlantic, and South Pacific Oceans that is valued as food. Francis *et al.* (2008) stated that separate porbeagle stocks occur in the northwestern and northeastern Atlantic, but stock identity is poorly understood in the Southern Hemisphere. Francis *et al*. (2007) provided evidence based on differing ages at sexual maturity and longevity that New Zealand and North Atlantic porbeagle sharks may be genetically isolated. The porbeagle shark is primarily an opportunistic piscivore with a diet characterized by a wide range of species (Joyce *et al*., 2002). In the northwest Atlantic, teleosts and cephalopods constituted 91 percent and 12 percent of porbeagle shark stomach contents, respectively. Campana and Joyce (2004) suggested that porbeagle sharks have evolved to take advantage of their thermorgulating capability by allowing them to seek out and feed on abundant coldwater prey in the absence of non-thermoregulating competitors.

Reproductive potential: Aasen (1963) estimated that maturity was reached at 150 to 200 cm TL for males and 200 to 250 cm TL for females. Jensen *et al*. (2002) found that males matured between 162 and 185 cm FL, and 50 percent were mature at 174 cm FL. Females matured between 210 and 230 cm FL, and 50 percent were mature at 218 cm FL. Francis *et al.* (2008) reported that age at 50 percent maturity for North Atlantic males and females were 8 and 13 years, respectively. Porbeagles have a protracted fall mating period from September to November (Jensen *et al.* 2002). Shann (1911) reported an embryo 61 cm TL, and estimated that porbeagle sharks were probably born at about 76 cm TL. Bigelow and Schroeder (1948) recorded a free swimming specimen at 76 cm TL. Gauld (1989) and Jensen *et al.* (2002) found the average number of young born to a female was 3.7 and 4.0, respectively, and the young are nourished through oophagy (Jensen *et al.* 2002). Porbeagles have a one-year reproductive cycle (Jensen *et al*, 2002;Aasen, 1963) and a gestation period lasting 8-9 months (Jensen *et al.* 2002).

Impact of fisheries: Porbeagle sharks are presently targeted in northern Europe and along the northeast coast of North America. Whether the porbeagle sharks in the North Atlantic constitute one or more separate stocks is not known. A small porbeagle shark fishery resumed in the early 1990s in the northeastern United States, after being practically non-existent for decades. Intensive fisheries have depleted the stocks of porbeagle sharks in a few years wherever they have existed, demonstrating that the species cannot withstand heavy fishing pressure. Cassoff *et al*. (2007) observed in the northwest Atlantic increased growth rate and decreased age at maturity following exploitation, which supports the hypothesis of a compensatory density-dependent growth response to population declines. This species was determined to be overfished with no overfishing occurring in 2007 (November 7, 2007, 71 FR 65086).

***Essential Fish Habitat for Porbeagle Shark*:**

- **Neonate/YOY, Juveniles, and Adults:** EFH designation for all life stages have been combined and are considered the same. Localized areas in the Atlantic off northern North Carolina, Delaware, and New Jersey. Southern New England through the Gulf of Maine. Please refer to Figure 5.76 for detailed EFH map and Table 5.1 for life stage size information. .

5.1.6.3.3 Shortfin Mako Shark

Shortfin mako shark (*Isurus oxyrinchus*) The shortfin mako shark is an oceanic species found in warm and warm-temperate waters throughout all oceans. Heist *et al*. (1996) found considerable intraspecific genetic variation and significant partitioning of haplotypes between the North Atlantic and other regions; however, there was no evidence of multiple subspecies of shortfin mako, nor of any past genetic isolation between shortfin mako populations. It feeds on fast-moving fishes such as swordfish, tuna, and other sharks (Castro, 1983) as well as clupeids, needlefishes, crustaceans and cephalopods (Maia *et al*. 2007a). MacNeil *et al*., (2005) found evidence of a cephalopod to bluefish diet switch in the spring. It is considered one of the great game fishes of the world, and its flesh is considered among the best to eat.

Reproductive potential: Considerable variation exists in the descriptions of reproductive life history for shortfin mako sharks. Cailliet and Mollet (1997) estimated that a female mako shark matures at four to six years, has a two-year reproductive cycle, and a gestation period of approximately 12 months. According to Pratt and Casey (1983), females mature at about 7 years of age; however, Campana *et al.* (2002) using radiocarbon assays found that the estimate may be incorrect. Bishop *et al*. (2006) considered Campana *et al.* (2002) when estimating median age at maturity in New Zealand waters to be 19 to 21 years for females and 7 to 9 years for males. In Maia *et al*. (2007b), length at maturity for males is estimated at 180 cm fork length and female maturation is estimated to occur between 210-290 cm FL. Cailliet *et al*. (1983) estimated the von Bertalanffy parameters (n= 44) for the shortfin as: L_4 = 3210 mm, K= .072, and t_o= -3.75. Litter size ranges from 4 to 25, and size at birth is approximately 70 cm TL (Mollet *et al.* 2000). Gestation period was estimated at 15-18 months and the reproductive cycle at 3 years. Based on cohort analysis of fish in the eastern North Atlantic, average growth was determined as 61.1 cm/year for the first year and 40.6 cm/year for the second year (Maia *et al.,* 2007b). There was a marked seasonality in growth, with average monthly rates of 5.0 cm/month in summer and 2.1 cm/month in winter. Lack of sex differences in cohort analysis for the first years of life is in accordance with previous studies reporting that male and female mako sharks grow at the same rate until they reach about 200 cm FL (Casey and Kohler, 1992; Campana *et al*., 2005). Bishop *et al*. (2006) described rapid initial growth rates to approx. 39 cm fork length in the first year. Thereafter, males and females grow at similar, but slower rates until about age 7 years, after which the relative growth of males declines. Life span estimates vary and have been published as 11.5 years (Pratt and Casey, 1983), 25 years for females (Cailiet and Mollet, 1997), 29 and 28 years for males and females, respectively (Bishop *et al,*. 2006).

Very weak evidence of population structure throughout the Atlantic and Pacific Oceans was found in microsatellite analysis by Schrey and Hiest (2003). This same study indicated that integrating the results from microsatellite- and mitochondrial-based studies may provide evidence for gender-biased dispersal for the shortfin mako. The significant genetic structure detected in mtDNA data indicate that female shortfin makos may exhibit philopatry for parturition sites, and thus reproductive stocks of makos may exist in the presence of considerable male-mediated gene flow. Pregnant shortfin makos have only been captured between 20° and 30° N or S (Gilmore, 1993); however, there is no information about the area where mating occurs.

Impact of fisheries: The shortfin mako is a common bycatch in tuna and swordfish fisheries. Because of their high market value, shortfin mako are usually the only sharks retained in some pelagic fleets with high shark bycatch rates. Off the northeast coast of North America, most of the catch consists of immature fish (Casey and Kohler, 1992). The index of abundance for shortfin makos in the commercial longline fishery off the Atlantic coast of the United States shows a steady decline (Cramer, 1996). The few indices available (ICES, 1995; Cramer, 1996; Holts *et al.*, 1996) indicate substantial population decreases. The median size of shortfin mako sharks in the commercial catch off the eastern coast of Canada has declined since 1998, suggesting the loss of larger sharks (Campana *et al*., 2005). Because the species is commonly caught in widespread swordfish and tuna operations, it is reasonable to assume that similar decreases are occurring in areas for which there are limited data.

***Essential Fish Habitat for Shortfin Mako*:**

Note: At this time, insufficient data is available to differentiate EFH by size classes, therefore, EFH is the same for all life stages.

- **Neonate/YOY, Juveniles, and Adults:** EFH designation for all life stages have been combined and are considered the same. Localized areas in the central Gulf of Mexico and the Florida Keys. In the Atlantic, localized areas off of Florida, South Carolina, and Maine, and from Cape Lookout though southern New England. Please refer to Figure 5.77 for detailed EFH map and Table 5.1 for life stage size information.

5.1.6.4 Requiem Sharks

5.1.6.4.1 Blue Shark

Blue shark (*Prionace glauca*) One of the most common and widest-ranging of sharks, the blue shark is cosmopolitan in tropical, subtropical and temperate waters. It is a pelagic species that inhabits clear, deep, blue waters, usually in temperatures of 10° to 20°C, at depths greater than 180 m (Castro, 1983). Its migratory patterns are complex and encompass great distances. Queiroz *et al*. (2005) reported that 28 of 34 blue sharks tagged in the northeast Atlantic travelled less than 1,000 km while the remaining fish travelled longer distances to north-west Africa, central Atlantic and the Bay of Biscay. One shark made a trans-Atlantic migration of 3,187 km from the tagging site. North-south movements seemed to be related to seasonal sea-surface temperature variation in the north-east Atlantic and seasonal segregation of different life stages also occurred. Males and females are known to segregate in many areas (Strasburg, 1958; Gubanov and Grigoryev, 1975). Strasburg (1958) showed that blue sharks are most abundant in the Pacific between latitudes of 40°N and 50°N.

Reproductive potential: Pratt (1979) used different criteria for determining maturity of males and gave a range of 153 to 183 cm FL for male maturity, but when he used the standard criterion of clasper calcification, he observed that the males reached maturity at 183 cm FL (218 cm TL). Bigelow and Schroeder (1948) suggested that females mature at 213 to 243 cm TL. Strasburg (1958) stated that the smallest gravid female seen by him measured 214 cm TL. Nakano (1994) used data from 105,600 blue sharks and stated that females matured at 140 to160 cm (166 and 191 cm TL, using the regression of Pratt), and males at 130 to 160 cm PCL, based on clasper development. Lessa *et al.* (2004) estimated size at maturity to be 225 cm TL for males and 228 cm TL for females. Francis and Duffy (2005) estimated reported size at maturity at about 190 to 195 cm FL for males and 170 to 190 cm FL for females in New Zealand waters. Skomal and Natanson (2003) found that full maturity is attained by 5 years of age in both sexes. Nakano (1994) gave the age at maturity as four or five years for males and five or six years for females, based on growth equations. According to Cailliet *et al*. (1983), blue sharks become reproductively mature at six or seven years of age.

According to Skomal and Natanson (2003), both sexes grew similarly to age seven, when growth rates decreased in males and remained constant in females. Skomal and Natanson (2003) also provide growth parameters that show the species grows faster and has a shorter life span than previously reported for the North Atlantic Ocean.

This is probably the most prolific of the larger sharks; litters of 28 to 54 pups have been reported often (Bigelow and Schroeder, 1948; Pratt, 1979), but up to 135 pups in a litter have also been reported (Gubanov and Grigoryev, 1975). Nakano (1994) observed 669 pregnant females in the North Pacific and stated that the number of embryos ranged from one to 62, with an average of 25.6 embryos. Strasburg (1958) gave the birth size as 34 to 48 cm TL. Suda (1953) examined 115 gravid females from the Pacific Ocean and concluded that gestation lasts nine months and that birth occurs between December and April. Pratt (1979) examined 19 gravid females from the Atlantic and used data from 23 other Atlantic specimens to arrive at a gestation period of 12 months. Nakano (1994) stated that gestation lasts about a year, based on length frequency histograms, but did not state how many gravid animals had been observed nor showed any data. The length of the reproductive cycle is believed to be annual.

The nursery areas appear to be in open oceanic waters in the higher latitudes of the range. Strasburg (1958) attributed the higher CPUE in the 30°N to 40°N zone of the Pacific Ocean in summer to the presence of newborn blue sharks, and commented on the absence of small blue sharks in the warmer parts of the range. Nakano (1994) also stated that parturition occurred in early summer between latitudes of 30°N to 40°N of the Pacific Ocean.

Impact of fisheries: Although finning is prohibited in U.S. Atlantic waters, blue sharks have historically been finned and discarded because of the low value of their flesh. Numerically, the blue shark is the top nontarget species captured by the U.S. Atlantic pelagic longline fleet (Beerkircher *et al*., 2002). The blue shark is one of the most abundant large vertebrates in the world, yet it may be vulnerable to overfishing because it is caught in tremendous numbers as bycatch in numerous longline fisheries. Catch rate information from the North Atlantic suggests that this species may be declining (Campana *et al*., 2006). Diaz and Serafy (2005) found that blue shark tolerance to the stresses associated with longline capture decreases with animal size at levels that vary with set duration.

***Essential Fish Habitat for Blue Shark*:**

- **Neonate/YOY (≤90 cm TL):** In the Atlantic in areas off of New Jersey through Cape Cod. Please refer to Figure 5.78 for detailed EFH map.

- **Juveniles (91 to 220 cm TL):** Localized areas in the Atlantic off the mid-east coast of Florida, South Carolina, and the Gulf of Maine, and from Cape Hattaras to New England. Please refer to Figure 5.79 for detailed EFH map.

- **Adults (≥221 cm TL):** Localized areas in the Atlantic off Florida and Georgia, and from South Carolina to the Gulf of Maine. Localized areas off Puerto Rico and the U.S. Virgin Islands. Please refer to Figure 5.80 for detailed EFH map.

5.1.6.4.2 Oceanic Whitetip Shark

Oceanic whitetip shark (*Carcharhinus longimanus*) The oceanic whitetip is one of the most common large sharks in warm oceanic waters (Castro, 1983). It is circumtropical and nearly ubiquitous in water deeper than 180 m and warmer than 21°C.

Reproductive potential: Both males and females appear to mature at about 190 cm TL (Bass *et al.*, 1973). The young are born at about 65 to 75 cm TL (Castro, 1983). The number of pups per litter ranges from two to ten, with a mean of six (Backus *et al.,* 1956; Guitart Manday, 1975). The length of the gestation period has not been reported, but it is probably ten to 12 months, as for most large carcharhinids. The reproductive cycle is believed to be biennial (Backus *et al.*, 1956). Although the location of nurseries has not been reported, preliminary work by Castro indicates that very young oceanic whitetip sharks are found well offshore along the southeastern United States in early summer, suggesting offshore nurseries over the continental shelves. Additional life history information can be found in Lessa *et al.* (1999a), Lessa *et al.* (1999c), and Whitney *et al.* (2004).

Impact of fisheries: Large numbers of oceanic whitetip sharks have been caught historically as bycatch in pelagic tuna and swordfish fisheries. Oceanic whitetip sharks were caught as bycatch during exploratory tuna longline fishing in the Gulf of Mexico and Caribbean Sea aboard the research vessel Oregon in the 1950s (Bullis and Captiva, 1955; Wathne, 1959; Iwamoto, 1965). While investigating these data from the 1950s, Baum and Myers (2004) reported that oceanic whitetip sharks accounted for over 60 percent of sharks captured. According to Berkeley and Campos (1988), oceanic whitetip sharks constituted 2.1 percent of the shark bycatch in the swordfish fishery along the east coast of Florida in 1981 to1983. Guitart Manday (1975) demonstrated a marked decline in the oceanic whitetip shark landings in Cuba from 1971 to1973. Baum and Myers (2004) estimated that oceanic whitetip shark abundance declined by over 99 percent in the Gulf of Mexico from the 1950s to the 1990s. Burgess *et al*. (2005b) published a reply to the Baum and Myers (2004) article challenging the appropriateness of some of the analyses. The oceanic whitetip shark is probably vulnerable to overfishing because of its limited reproductive potential, and because of high fishing mortality in various pelagic fisheries and in directed fisheries. There are no population or stock assessment data for the species in the Atlantic.

***Essential Fish Habitat for Oceanic Whitetip Shark*:**

Note: At this time, insufficient data is available to differentiate EFH by size classes; therefore, EFH is the same for all life stages.

- **Neonate/YOY, Juveniles, and Adults:** EFH designation for all life stages have been combined and are considered the same. Localized areas in the central Gulf of Mexico and Florida Keys. In the Atlanitc in depths greater than 200 meters from Florida to southern New England. Puerto Rico and the U.S. Virgin Islands. Please refer to Figure 5.81 for detailed EFH map and Table 5.1 for life stage size information.

5.1.6.5 Thresher Sharks

5.1.6.5.1 Bigeye Thresher Shark

Bigeye thresher shark (*Alopias superciliosus*) The bigeye thresher shark is cosmopolitan in warm and warm-temperate waters. It exhibits distinct twilight or dawn and dusk, vertical migrations, staying at 200 to 500 m depth during the day and at 10 to 130 m at night (Nakano *et al*., 2003; Weng and Block, 2004). Bigeye thresher sharks have also been captured on longlines set near the surface at night at depths from 0 to 65 m (Fitch and Craig, 1964; Stillwell and Casey, 1976; Thorpe, 1997; Buencuerpo *et al*., 1998). A pattern of slow ascents and relatively rapid descents during the night has been observed. Since bigeye thresher sharks have large eyes extending upwards onto the dorsal surface of the cranium, it may be more efficient for them to hunt prey, which are highlighted against the sea surface from below (Nakano *et al.*, 2003). Endothermy has been described for this species, which can provide a physiological advantage over ectothermic prey species and buffers the eyes and brain from the large temperature changes associated with diel vertical migration (Weng and Block, 2004). The longest straight-line movement of a conventionally tagged bigeye thresher shark to date is 2,767 km from waters off New York to the eastern Gulf of Mexico (Kohler and Turner, 2001). It feeds on squids of all sizes, including Humboldt squid and small fishes including Sciaenids (drums), Merlucciids (hakes), and Myctophids (lanternfishes) (Castro, 1983; Polo-Silva *et al*., 2007). This is one of the larger sharks, reaching up to 460 cm TL (Nakamura, 1935).

Reproductive potential: Males mature at about 270 cm TL and females at about 340 cm TL (Chen *et al*., 1997 and Moreno and Moron, 1992). Age at maturity were estimated by Liu *et al*. (1998) to be 12.3 to 13.4 years for females and 9 to 10 years for males. In Indonesian and northwestern Pacific waters, litters consisted of two embryos (Chen *et al*., 1997; White, 2007). The length of the reproductive cycle and the location of nursery areas are unknown. .

Impact of fisheries: The bigeye thresher shark is often caught as bycatch in swordfish fisheries. They will often dislodge several baits before impaling or hooking itself. The flesh and fins of the bigeye thresher shark are of poor quality, thus it is usually discarded dead in swordfish and tuna fisheries. Possession of this species in Atlantic waters of the United States is now prohibited.

***Essential Fish Habitat for Bigeye Thresher Shark*:**

Note: At this time, insufficient data is available to differentiate EFH by size classes; therefore, EFH is the same for all life stages.

- **Neonate/YOY, Juveniles, and Adults:** EFH designation for all life stages have been combined and are considered the same. Central Gulf of Mexico and off Key West, Florida. Atlantic east coast from southern to the mid-Florida coast, and from Georgia to southern New England. Localized areas off of Puerto Rico and the U.S. Virgin Islands. Please refer to Figure 5.82 for detailed EFH map and Table 5.1 for life stage size information.

5.1.6.5.2 Thresher Shark

Thresher shark (*Alopias vulpinus*) The common thresher shark is cosmopolitan in warm and temperate waters. It is found in both coastal and oceanic waters, but according to Strasburg (1958) it is more abundant near land. The thresher shark is capable of regional endothermy thus providing a physiological advantage over ectothermic prey species (Bernal and Sepulveda, 2005). It feeds on invertebrates such as squid and pelagic crabs as well as small fishes such as anchovy, sardines, hakes, and small mackerels (Preti *et al*., 2004).

Reproductive potential: According to Strasburg (1958), females in the Pacific mature at about 315 cm TL. According to Cailliet and Bedford (1983), males mature at about 333 cm TL. Cailliet and Bedford (1983) stated that the age at maturity ranges from three to seven years. Litters consist of four to six pups, which measure 137 to 155 cm TL at birth (Castro, 1983; Mancini and Amorim, 2006). According to Bedford (1985), gestation lasts nine months and female threshers give birth annually every spring (March to June).

Impact of fisheries: Thresher sharks are caught in many fisheries. Total catches of thresher sharks in the Atlantic peaked at about 5,300 fish in 1984 and 1999 (Cortés, 2002). A maximum of about 1,200 and 1,300 fish were estimated to have been landed by the commercial fishery in 1995 and 1997, respectively, whereas recreational landings peaked at about 5,250 fish in 1984. The maximum estimate of dead discards from the pelagic longline fishery was about 700 fish in 1989 (Cortés, 2002). Thresher shark (*Alopias spp*.) catch rates from the Pelagic Logbook series show a generally decreasing trend from 1987 to 1999, after an initial steep increase from 1986 to 1987 (Cortés, 2002). Off the U.S. Atlantic coast, the CPUE has shown a considerable decline (Cramer, 1996).

***Essential Fish Habitat for Thresher Shark*:**

Note: At this time, insufficient data is available to differentiate EFH by size classes; therefore, EFH is the same for all life stages.

- **Neonate/YOY, Juveniles, and Adults:** EFH designation for all life stages have been combined and are considered the same. Localized areas in the central Gulf of Mexico and Florida Keys. In the Atlantic, localized areas off the mid-east coast of Florida, Georgia, South Carolina, and the Gulf of Maine, and from North Carolina through Cape Cod. Localized areas off of Puerto Rico. Please refer to Figure 5.83 for detailed EFH map Please refer to Figure 5.82 for detailed EFH map and Table 5.1 for life stage size information.

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Table 5.1 Size ranges for different life stages of sharks.

Large Coastal Sharks	Young-of-the-year (1) TL (cm) ≤	Literature (2) young-of-the-year size range TL (cm)	Literature embryo size range or max embryo size in term females TL (cm)	Juveniles TL (cm)	Literature (4) M 1st maturity ≥ or range (50% mat) TL (cm)	Literature F 1st maturity ≥ or range (50% mat) TL (cm)	Adults F 50% mat or max range at 1st mat TL (cm) ≥
Cetorhinidae Cetorhinus maximus	240		150-200 Sund 43 cited in Francis & Duffy 02	242-979		810-980 Compagno 84	980
Sphyrnidae Sphyrna mokarran	89	89 Hueter & Tyminski 02	67.5 Clarke & von Schmidt 65	90-299		210-300 Steven & Lyle 89	300
S. lewini	60	40-60 Piercy et al 06	30-40 Piercy et al 06	61-179	(180) Piercy et al 06	(180) Piercy et al 06	180
S. zygaena	72		60* NMFS upubl.	67-219	220 Castro 83	220 Castro 83	220
Lamnidae Carcharodon carcharias	207	130-207 Wintner & Cliff 99	151 Uchida et al 96	208-499		450-500 Francis 96	500
Ginglymostomatidae Ginglymostoma cirratum**	52	28-52 Pratt & Carrier 02	28-30.5 Castro 00	53-230	214-214.6 Castro 00	222-231 Castro 00	231
Carcharhinidae Carcharhinus altimus	84		70 Fourmanoir 61	85-225		205-282 Compagno 84, Crow et al 96	282
C. limbatus	75	55-75 Carlson et al. 05	58-62.5*** Castro 93b & 96	76-136	(124) Carlson et al. 05	(137) Carlson et al. 05	137
C. leucas	95	70-95 Neer et al. 05	60-70 Neer et al. 05	96-219	(200) Neer et al. 05	(220) Neer et al. 05	220

Large Coastal Sharks	Young-of-the-year (1) TL (cm) ≤	Literature (2) young-of-the-year size range TL (cm)	Literature embryo size range or max embryo size in term females TL (cm)	Juveniles TL (cm)	Literature (4) M 1st maturity ≥ or range (50% mat) TL (cm)	Literature F 1st maturity ≥ or range (50% mat) TL (cm)	Adults F 50% mat or max range at 1st mat TL (cm) ≥
C. perezi	90	72-90 Garla et al 06		91-199		200 Compagno 84	200
C. obscurus	121	70-121 Simpfendorfer 00, Ulrich et al 07		122-299		257-300 Castro 99	300
C. galapagensis - NO DATA (all Atlantic data off Bermuda)	97		81 Wetherbee et al 96	97-214		215-245 Wetherbee et al 96	245
Negaprion brevirostris	86	55-86 Freitas et al 06, Hueter & Tyminski 02	62 Clarke & von Schmidt 65	87-239		240 Compagno 84	240
C. brachyurus - NO DATA	N/A		N/A	N/A	N/A	N/A	N/A
C. signatus	72	(50-60) Hazin et al 00, Carlson unpubl.		61-199	185-190 Hazin et al 00	200-205 Hazin et al 00	205
C. plumbeus	78	44-78 Merson 98	64 Castro 93b	79-190	(181) Merson 98	(191) Merson 98	191
C. falciformis	92	65-92 Bonfil et al 93	77 Bonfil et al 93	93-244	216 Bonfil et al 93	232-245 Bonfil et al 93	245
C. brevipinna	70	55-70 Carlson & Baremore 05	55 Carlson & Baremore 05	71-179	(170) Carlson & Baremore 05	(180) Carlson & Baremore 05	180
Galeocerdo cuvier	204	78-204 Natanson et al 99, Kneebone 05	82 NMFS upubl.	205-319	310 Branstetter et al 87	315-320 Branstetter et al 87	320

Large Coastal Sharks	Young-of-the-year (1) TL (cm) ≤	Literature (2) young-of-the-year size range TL (cm)	Literature embryo size range or max embryo size in term females TL (cm)	Juveniles TL (cm)	Literature (4) M 1st maturity ≥ or range (50% mat) TL (cm)	Literature F 1st maturity ≥ or range (50% mat) TL (cm)	Adults F 50% mat or max range at 1st mat TL (cm) ≥
Odontaspididae Odontaspis noronhai - NO DATA	N/A		N/A	N/A	N/A	N/A	N/A
Carcharias taurus	129	95-129 Gilmore et al 83, Goldman et al 06	106 Gilmore et al 83	130-229	190-195 Gilmore et al 83	220-230 Gilmore et al 83	230
Rhincodontidae Rhincodon typus LITTLE DATA, ONE MAP	N/A			N/A			N/A
Small Coastal Sharks							
Squatinidae Squatina dumeril							
Sphyrnidae Sphyrna tiburo	55	30-55 Lombardi-Carlson et al. 03	24.9 Lombardi-Carlson et al. 03	56-81	(72.1) Lombardi-Carlson et al. 03	(82.2) Lombardi-Carlson et al. 03	82
Carcharhinidae Rhizoprionodon terraenovae	60	33-60 Carlson & Baremore 03, Loeffer & Sedberry 03	32.3 Carlson & Baremore 03, Loeffer & Sedberry 03	61-71	(74.1) Carlson & Baremore 03, Loeffer & Sedberry 03	(72.3) Carlson & Baremore 03, Loeffer & Sedberry 03	72
Carcharhinus acronotus	55	45-55 Carlson et al 99	45 Carlson et al 99	56-	88.1 cm FL Driggers et al 04	90.9 cm FL Driggers et al 04	

Small Coastal Sharks	Young-of-the-year (1) TL (cm) ≤	Literature (2) young-of-the-year size range TL (cm)	Literature embryo size range or max embryo size in term females TL (cm)	Juveniles TL (cm)	Literature (4) M 1st maturity ≥ or range (50% mat) TL (cm)	Literature F 1st maturity ≥ or range (50% mat) TL (cm)	Adults F 50% mat or max range at 1st mat TL (cm) ≥
R. porosus - NO DATA							N/A
C. isodon	85	65-85 Carlson et al 03, Drymon et al in press	53 Castro (1993)	86-125	(120) Carlson et al 03, Drymon et al in press	(126) Carlson et al 03, Drymon et al in press	126
C. porosus LITTLE DATA, ONE MAP	N/A			N/A			N/A
Pelagic Sharks							
Hexanchidae Hexanchus vitulus LITTLE DATA, ONE MAP	N/A			N/A		140-175 Springer & Waller 69	175
Heptranchias perlo LITTLE DATA, ONE MAP	N/A			N/A		89-93 Compagno 84	N/A
Hexanchus griseus LITTLE DATA, ONE MAP	N/A			N/A		421-450 Springer & Waller 69, Ebert 86	N/A
Lamnidae Isurus paucus	163		135.5 NMFS upubl	164-244		245 Guitart-Manday 66	245
Lamna nasus	116	61-116 Jensen et al 02, Natanson et al 02	72 Jensen et al 02	117-217		(218) Jensen et al 02	218
I. oxyrinchus	140	71-140 Natanson et al 06	77 Duffy & Francis 01	141-297	(201) Natanson et al 06	(298) Natanson et al 06	298

Pelagic Sharks	Young-of-the-year (1) TL (cm) ≤	Literature (2) young-of-the-year size range TL (cm)	Literature embryo size range or max embryo size in term females TL (cm)	Juveniles TL (cm)	Literature (4) M 1st maturity ≥ or range (50% mat) TL (cm)	Literature F 1st maturity ≥ or range (50% mat) TL (cm)	Adults F 50% mat or max range at 1st mat TL (cm) ≥
Carcharhinidae							
Prionace glauca	90	35-90 Stevens 75, Silva 96, Skomal & Natanson 03	54.4 Pratt 1979	91-220	(218) Pratt 79	221 Pratt 79	221
C. longimanus	90	60-90 Leesa et al 99	75 Seki et al 98	91-179		180-190 Leesa et al 99	190
Alopiidae							
Alopias superciliosus	127		105.5 Gilmore 83	128-354		341-355 Stillwell and Casey 76, Moreno & Moron 92	355
A. vulpinus	191		159 Moreno et al 89	192-376	308 Gervelis 05 , NMFS unpubl.	377 Gervelis 05 , NMFS unpubl.	377

Table 5.2 References used to determine size ranges for sharks in Table 5.1.

*confirmed report of the smallest free swimming individual
**nurse sharks below 37 cm TL in the 1999 FMP database were actually embryos and not free swimming sharks
***Castro has seen one litter with sizes beyond the above range (70.4-74.2 cmTL). This litter was not included because it was unusually large for this species.
References cited:
Bonfil, R., R. Mena and D. de Anda. 1993. Biological parameters of commercially exploited silky sharks, *Carcharhinus falciformis*, from the Campeche Bank, Mexico. In S. Branstetter (ed.): Conservation biology of sharks. NOAA Technical Report NMFS 115. U.S. Dept. Comm., Miami. pp. 72-86.
Branstetter, S. 1987. Age and growth estimates for blacktip, *Carcharhinus limbatus,* and spinner, *C. brevipinna*, sharks from the northwestern Gulf of Mexico. Copeia 1997(4):964-975.
Branstetter, S. 1987. Age, growth and reproductive biology of the silky shark, *Carcharhinus falciformis*, and the scalloped hammerhead, *Sphyrna lewini*, from the northwestern Gulf of Mexico. Environmental Biology of Fishes 19(3):161-173.
Branstetter, S. and R. Stiles. 1987. Age and growth estimates of the bull shark, *Carcharhinus leucas*, from the northern Gulf of Mexico. Env. Biol. Fish. 20(3):169-181.
Carlson, J.K., E. Cortés , and A.G. Johnson. 1999. Age and growth of the blacknose shark, Carcharhinus acronotus, in the eastern Gulf of Mexico. Copeia 1999:684-691.
Carlson, J.K. and I.E. Baremore. 2003. Changes in the biological parameters of Atlantic sharpnose shark *Rhizoprionodon terraenovae* in the Gulf of Mexico: evidence for density-dependent growth and maturity? Marine and Freshwater Research 54:227-234.
Carlson, J.K., E. Cortés & D. Bethea. 2003. Life history and population dynamics of the finetooth shark, *Carcharhinus isodon*, in the northeast Gulf of Mexico. Fishery Bulletin 101:281-292.
Carlosn, J.K., J.R. Sulikowski, I.E. Baremore. 2005. Life history parameters for blacktip sharks, Carcharhinus limbatus, from the United States South Atlantic Bight and Eastern Gulf of Mexico. Large Coastal Shark SEDAR Data Workshop Document: LCS05/06-DW-10. National Marine Fisheries Service. Panama City, FL. 10pp.
Castro, J.A. and J. Mejuto. 1995. Reproductive parameters of blue shark *Prionace glauca* and other sharks in the Gulf of Guinea. Marine and Freshwater Research 46(6):967-933.
Castro, J.I. 1983. The sharks of North American waters. Texas A. & M. University Press, College Station. 180pp.
Castro, J.I. 1993a. The biology of the finetooth shark, *Carcharhinus isodon*. Environmental Biology of Fishes 36:219-232.
Castro, J.I. 1993b. The shark nursery of Bulls Bay, South Carolina, with a review of the shark nurseries of the southeastern coast of the United States. Environmental Biology of Fishes 38:37-48.
Castro, J.I. 1996. Biology of the blacktip shark, *Carcharhinus limbatus*, off the southeastern United States. Bulletin of Marine Science 59(3):508-522.
Castro, J.I. 1999. A preliminary evaluation of the status of shark species. FAO Fisheries Technical Paper 380, 72 pp.
Castro, J.I. 2000. The biology of the nurse shark, *Ginglymostoma cirratum*, off the Florida east coast and the Bahama Islands. Environmental Biology of Fishes 58:1-22.
Castro, J.I., C. M. Woodley, and R. L. Brudek. 1999. A preliminary evaluation of the status of shark species. FAO Fisheries Technical Paper 380. 72pp.
Clarke, E. and K. von Schmidt. 1965. Sharks of the central Gulf coast of Florida. Bulletin of Marine Science 15(1):13-83.
Clarke, T.A. 1971. The ecology of the scalloped hammerhead shark, *Sphyrna lewini*, in Hawaii. Pacific Science 25:133-144.
Compagno, L.J.V. 1984. FAO Species Catalog Vol. 4 Part 1: Sharks of the world: an annotated and illustrated catalogue of shark species known to date. FAO Fisheries Synopsis 125. FAO, Rome, Italy. 249pp.

Crow, G.L., C.G. Lowe, and B.M. Wetherbee. 1996. Shark records from longline fishing programs in Hawai'I with comments on Pacific Ocean distributions. Pacific Science 50(4):382-392.
Drymon, J.M.,W.B. Driggers, D. Oakley & G.F. Ulrich. In press. Investigating life history differences between finetooth sharks, *Carcharhinus isodon*, in the northern Gulf of Mexico and the western North Atlantic Ocean. Gulf of Mexico Science.
Duffy, C. and M.P. Francis. 2001. Evidence of summer parturition in shortfin mako (Isurus oxyrinchus) sharks from New Zealand waters. New Zealand Journal of Marine and Freshwater Research 35(2):319-324.
Ebert, D.A. 1986. Biological aspects of the sixgill shark, *Hexanchus griseus*. Copeia 1986(1):131-135.
Fourmanoir, P. 1961. Requins de la cote ouest de Madagascar. Memoires de L'Institut Scientifique de Madagascar. Tome IV. 81pp.
Francis, M.P. 1996. Observations on a pregnant white shark with a review of reproductive biology. Pages 157-172 in Great white sharks: the biology of *Carcharodon carcharias*. Academic Press, Inc. San Diego, CA.
Francis, M.P. and C. Duffy. 2002. Distribution, seasonal abundance and bycatch of basking sharks (*Cetorhinus maximus*) in New Zealand, with observations on their winter habitat. Marine Biology 140:831-842.
Freitas, R.H.A., R.S. Rosa, S.H. Gruber, and B.M. Wetherbee. 2006. Early growth and juvenile population structure of lemon sharks *Negaprion brevirostris* in the Atol das Rocas Biological Reserve, off north-east Brazil. Journal of Fish Biology 68:1319-1332.
Garla, R.C., D.D. Chapman, M.S. Shivji, B.M. Wetherbee, A.F. Amorim. 2006. Habitat of juvenile Caribbean reef sharks, *Carcharhinus perezi*, at two oceanic insular marine protected areas in the southwestern Atlantic Ocean: Fernando de Noronha Archipelago and Atol das Rocas, Brazil. Fisheries Research 81(2-3):236-241.
Gervelis, B.J. 2005. Age and Growth of the Thresher Shark, Alopias Vulpinas, in the Northwest Atlantic Ocean. Master's Thesis. University of Rhode Island, Kingston, Rhode Island.
Gilmore, R.G. 1983. Observations on the embryos of the longfin mako, *Isurus paucus*, and the bigeye thresher, *Alopias superciliosus*. Copeia 1983(2):375-382.
Gilmore, R.G. 1993. Reproductive biology of lamnoid sharks. Env. Biol. Fish. 38:95-114.
Gilmore, R.G., J.W. Dodrill, and P.A.Linley. 1983. Reproduction and embryonic development of the sand tiger shark, *Odontaspis taurus* (Rafinesque) Fish. Bull. 81(2):201-225.
Goldman, K.J., S. Branstetter, and J.A. Musick. 2006. A re-examination of the age and growth of sand tiger sharks, *Carcharias taurus*, in the western North Atlantic: the importance of ageing protocols and use of multiple back-calculation techniques. Environmental Biology of Fishes 77:241-252.
Guitart-Manday, D. 1966. Nuevo nombre para una especie de tiburon del genero *Isurus* (Elasmobranchii: Isuridae) de aguas Cubanas. Poeyana 15:1-9.
Hazin, F.H.V., F.M. Lucena, T.S.A.L. Souza, C.E. Boeckman, M.K. Broadhurst, and R.C. Menni. 2000. Maturation of the night shark, *Carcharhinus signatus*, in the southwestern equatorial Atlantic Ocean. Bulletin of Marine Science 66(1):173-185.
Hazin, F.H.V., P.G. Oliveira, and M.K. Broadhurst. 2002. Reproduction of the blacknose shark (*Carcharhinus acronotus*) in coastal waters off northeastern Brazil. Fish. Bull. 100:143-148.
Hoese, H.D. 1962. Sharks and rays of Virginia's seaside bays. Chesapeake Science 3(3):166-172.
Hueter, R.E. and J.P. Tyminski. 2002. Center for Shark Research (CSR) U.S. Shark Nursery Research Overview 1991-2001. Pages 116-135 in C.T. McCandless, H.L.Pratt Jr., and N.E. Kohler (editors): Shark nursery grounds of the Gulf of Mexico and the East Coast waters of the United States: an overview. An internal report to NOAA's Highly Migratory Species Office. NOAA Fisheries Narragansett Lab, 28 Tarzwell Drive, Narragansett, RI 02882.
Jensen, C.F., L.J. Natanson, H.L. Pratt, Jr., N.E. Kohler, and S.E. Campana. 2002. The reproductive biology of the porbeagle shark (*Lamna nasus*) in the western North Atlantic Ocean. Fish. Bull. 100:727-738.
Kneebone, J. 2005. Validated age and growth estimates for the tiger shark, *Galeocerdo cuvier*, in the western North Atlantic. Master's Thesis, University of New Hampshire, 75pp.
Leesa, R., R. Paglerani, F.M. Santana. 1999. Biology and morphometry of the oceanic whitetip shark, *Carcharhinus longimanus* (Carcharhinidae), off north-eastern Brazil. Cybium 23(4):353-368.
Loefer, J.K. and G.R. Sedberry. 2003. Life history of the Atlantic sharpnose shark (*Rhizoprionodon terraenovae*) (Richardson, 1836) off the southeastern United States. Fish. Bull. 101(1):75-88.
Lombardi-Carlson, L.A., E. Cortés, G.R. Parsons, and C.A. Manire. 2003. Latitudinal variateion in life-history traits of bonnethead sharks, *Sphyrna tiburo*,

(Carcharhiniformes:Sphyrnidae) from the eastern Gulf of Mexico. Marine and Freshwater Research 54:875-883.

Merson, R.R. 1998. Nursery grounds and maturation of the sandbar shark in the western North Atlantic. Ph.D. Dissertation, University of Rhode Island, Kingston, RI. 150pp.

Mollet, H.F., G. Cliff, H.L. Pratt, Jr., J.D. Stevens. 2000. Reproductive biology of the female shortfin mako, *Isurus oxyrinchus* Rafinesque, 1810, with comments on the embryonic development of lamnoids. Fish. Bull. 98(2):299-318.

Moreno, J.A. and J. Moron. 1992. Reproductive biology of the bigeye thresher shark, *Alopias superciliosus* (Lowe, 1839). Aust. J. Mar. Freshwater Res. 43:77-86.

Moreno, J.A., J.I. Parajua, and J. Moron. 1989. Biologia reproductiva y fenologia de *Alopias vulpinus* (Bonnaterre, 1788) (Squaliformes: Alopiidae) en el Atlantico nor-oriental y Mediterraneo occidental. Scientia Marina (Barcelona) 53(1):37-46.

Natanson, L.J., J.G. Casey, N.E. Kohler, and R. Colket, IV. 1999. Growth of the tiger shark, *Galeocerdo cuvier*, in the western North Atlantic based on tag returns and length frequencies; and a note on the effects of tagging. Fish. Bull. 97:944-953.

Natanson, L.J., J.J. Mello, and S.E. Campana. 2002. Validated age and growth of the porbeagle shark (*Lamna nasus*) in the western North Atlantic Ocean. Fish. Bull. 100(2):266-278.

Natanson, L.J., N.E. Kohler, D. Ardizzone, G.M. Cailliet, S.P. Wintner, and H.F. Mollet. 2006. Validated age and growth estimates for the shortfin mako, *Isurus oxyrhinchus*, in the North Atlantic Ocean. Environmental Biology of Fishes 77:367-383.

Neer, J.A., B.A. Thompson, J.K. Carlson. 2005. Age and growth of *Carcharhinus leucas* in the northern Gulf of Mexico: incorporating variability in size at birth. Journal of Fish Biology 67:370-383.

Parsons, G.R. 1983. The reproductive biology of the Atlantic sharpnose shark, *Rhizoprionodon terraenovae* (Richardson). Fish. Bull. 81(1):61-73.

Parsons, G.R. 1993. Geographic variation in reproduction between two populations of the bonnethead shark, *Sphyrna tiburo*. Env. Biol. Fish. 38:25-35.

Piercy, A.N., J.K. Carslon, J.A. Sulikowski, and G.H. Burgess. 2006. Age and growth of the scalloped hammerhead shark, *Sphyrn lewini*, in the north-west Atlantic Ocean and the Gulf of Mexico. Marine and Freshwater Research 58(1):34-40.

Pratt, Jr., H.L. 1979. Reproduction in the blue shark, *Prionace glauca*. Fishery Bulletin 77(2):445-470.

Pratt, Jr., H.L. and J.C. Carrier. 2002. The Florida Keys Nurse Shark Breeding and Nursery Grounds. Pages 136-142 in C.T. McCandless, H.L.Pratt Jr., and N.E. Kohler (editors): Shark nursery grounds of the Gulf of Mexico and the East Coast waters of the United States: an overview. An internal report to NOAA's Highly Migratory Species Office. NOAA Fisheries Narragansett Lab, 28 Tarzwell Drive, Narragansett, RI 02882.

Raschi, W., J.A. Musick, and L.J.V. Compagno. 1982. *Hypoprion bigelowi*, a synonym of *Carcharhinus signatus* (Pisces: Carcharhinidae), with a description of ontogenetic heterodonty in this species and notes on its natural history. Copeia 1982(1):102-109.

Seki, T., T. Taniuchi, H. Nakano, and M. Shimizu. 1998. Age, growth and reproduction of the oceanic whitetip shark from the Pacific Ocean. Fisheries Science 64(1):14-20.

Silva, A.A. H.M. Silva, and K. Erzini. 1996. Some results on the biology of the blue shark, *Prionace glauca*, in the North Atlantic based on data form a research cruise of the R/V Arquipelago in Azorean waters: a summary paper, 9 pp. Universidade dos Azores, Horta, Azores, Portugal.

Simpfendorfer, C.A. 2000. Growth rates of juvenile dusky sharks, *Carcharhinus obscurus* (Lesueur, 1818), from southwestern Australia estimated from tag-recapture data. Fish. Bull. 98(4):9=811-822.

Skomal, G.B. and L.J. Natanson. Age and growth of the blue shark (*Prionace glauca*) in the North Atlantic Ocean. Fish. Bull. 101:627-639.

Springer, S. Natural history of the sandbar shark, *Eulamia milberti*. Fish. Bull. 61(178):1-38.

Springer, S. and R.A. Waller. 1969. *Hexanchus vitulus*, a new sixgill shark from the Bahamas. Bulletin of Marine Science 19(1):159-174.

Stevens, J.D. 1975. Vertebral rings as a means of age determination in the blue shark (*Prionace glauca* L.) of southwest England. J. Mar. Biol. Assoc. U.K. 53:357-361.

Stevens, J.D. and J.M. Lyle. 1989. Biology of three hammerhead sharks (*Eusphyra blochii*, *Sphyrna mokarran* and *S. lewini*) from northern Australia Australian Journal of Marine and Freshwater Research 40:129-146.

Stillwell, C.E., and J.G. Casey. 1976. Observations on the bigeye thresher shark, *Alopias superciliousus*, in the western North Atlantic. Fish. Bull. 74(1):221-225.

Uchida, S., M. Toda, K. Teshima, and K. Yano. 1996. Pregnant white sharks and full-term embryos from Japan. *In*: A.P. Klimley and D.G. Ainley (eds.) Great white sharks: The biology of Carcharodon carcharias. Academic Press, New York: 139-155.

Ulrich, G. F., C.M. Jones, W.B. Driggers, III, M. Drymon, D. Oakley, C. Riley. 2007. Habitat utilization, relative abundance, and seasonality of sharks in the extuarine and nearshore waters of South Carolina. In C.T. McCandless, N.E. Kohler, and H.L.Pratt Jr.(editors): Shark nursery grounds of the Gulf of Mexico and the East Coast waters of the United States. American Fisheries Society Symposium 50, Bethesda, Maryland.
Wetherbee, B.M., G.L. Crow, and C.G. Lowe. 1996. Biology of the Galapagos shark, *Carcharhinus galapagensis*, in Hawaii. Env. Biol. Fish. 45:299-310.
Williams, F. 1977. Notes on the biology and ecology of the blue shark (*Prionace glauca*) in the eastern Pacific Ocean and a review of data from the World Ocean (unpublished manuscript).
Wintner, S.P. and G. Cliff. 1999. Age and growth determination of the white shark, *Carcharodon carcharias*, from the east coast of South Africa. Fish. Bull. 97(1):153-169.

Table 5.3 Essential fish habitat maps by species.

TUNAS

Figure 5.1 to 5.2 Atlantic albacore tuna (*Thunnus alalunga*)
Figure 5.3 to 5.4 Atlantic bigeye tuna (*Thunnus obesus*)
Figure 5.5 to 5.7 Atlantic bluefin tuna (*Thunnus thynnus*)
Figure 5.8 to 5.10 Atlantic skipjack tuna (*Katsuwonus pelamis*)
Figure 5.11 to 5.13 Atlantic yellowfin tuna (*Thunnus albacares*)

SWORDFISH

Figure 5.14 to 5.16 Swordfish (*Xiphias gladius*)

BILLFISH

Figure 5.17 to 5.19 blue marlin (*Makaira nigricans*)
Figure 5.20 to 5.21 white marlin (*Tetrapturus albidus*)
Figure 5.22 to 5.24 sailfish (*Istiophorus platypterus*)
Figure 5.25 longbill spearfish (*Tetrapturus pfluegeri*)

LARGE COASTAL SHARKS

Basking sharks - Cetorhnidae

Figure 5.26 basking shark (*Cetorhinus maximus*) All lifestages combined

Hammerhead sharks - Sphyrnidae

Figure 5.27 great hammerhead shark (*Sphyrna mokarran*) All lifestages combined
Figure 5.28 to 5.31 scalloped hammerhead shark (*S. lewini*)

Mackerel sharks - Lamnidae

Figure 5.31 white shark (*Carcharodon carcharias*) All lifestages combined

Nurse sharks - Ginglymostomatidae

Figure 5.32 to 5.33 nurse shark (*Ginglymostoma cirratum*)

Requiem sharks - Carcharhinidae

Figure 5.34 bignose shark (*Carcharhinus altimus*) All lifestages combined
Figure 5.35 to 5.39 blacktip shark (*C. limbatus*)
Figure 5.38 to 5.40 bull shark (*C. leucas*)
Figure 5.41 Caribbean reef shark (*C. perezi*) All lifestages combined
Figure 5.42 to 5.45 dusky shark (*C. obscurus*)
Figure 5.44 to 5.46 lemon shark (*Negaprion brevirostris*)
Figure 5.47 night shark (*C. signatus*) All lifestages combined
Figure 5.48 to 5.51 sandbar shark (*C. plumbeus*)
Figure 5.52 silky shark (*C. falciformis*) All lifestages combined
Figure 5.53 to 5.55 spinner shark (*C. brevipinna*)
Figure 5.56 to 5.58 tiger shark (*Galeocerdo cuvier*)

Sand tiger sharks - Odontaspididae

Figure 5.59 to 5.61 sand tiger shark (*Carcharias taurus*)

Whale sharks - Rhincodontidae

Figure 5.62 whale shark (*Rhincodon typus*) All lifestages combined

SMALL COASTAL SHARKS

Angel sharks - Squatinidae

Figure 5.63 Atlantic angel shark (*Squatina dumeril*) All lifestages combined

Hammerhead sharks - Sphyrnidae

Figure 5.64 to 5.66 bonnethead shark (*Sphyrna tiburo*)

Requiem sharks - Carcharhinidae

Figure 5.67 to 5.69 Atlantic sharpnose shark (*R.. terraenovae*)
Figure 5.70 to 5.72 blacknose shark (*C. acronotus*)
Figure 5.73 to 5.74 finetooth shark (*C. isodon*)
Smalltail shark (*C. porosus*) Not enough data for EFH

PELAGIC SHARKS

Cow sharks - Hexanchidae

Bigeye sixgill shark (*Hexanchus nakamurai*) Not enough data to designate EFH
Sevengill shark (*Heptranchias perlo*) Not enough data to designate EFH
Sixgill shark (*Hexanchus griseus*) Not enough data to designate EFH.

Mackerel sharks - Lamnidae

Figure 5.75 longfin mako shark (*Isurus paucus*) All lifestages combined
Figure 5.76 porbeagle shark (*Lamna nasus*) All lifestages combined
Figure 5.77 shortfin mako shark (*Isurus oxyrinchus*) All lifestages combined

Requiem sharks - Carcharhinidae

Figure 5.78 to 5.86 blue shark (*Prionace glauca*)
Figure 5.81 oceanic whitetip shark (*C. longimanus*) All lifestages combined

Thresher sharks - Alopiidae

Figure 5.82 bigeye thresher shark (*Alopias superciliosus*) All lifestages combined
Figure 5.83 thresher shark (*A. vulpinus*) All lifestages combined

Table 5.4 List of abbreviations and acronyms for EFH data sources used in the maps.

Belcher	Belcher and Shierling 2002
Carlson	Carlson 2002
COASTSPAN	Cooperative Atlantic States Shark Pupping and Nursery Area Program
CSTP	Cooperative Shark Tagging Program
CTS	Cooperative Tagging System
Curtis	Tobey Curtis pers. comm.
FPSR	Florida Program for Shark Research
Govoni	Govoni *et al*., 2003
Gurshin	Gurshin 2002
Jensen	Jensen *et al*., 2002
Jones/Grace	Jones and Grace 2002
Michel/ST	Michel and Steiner 2002
Mote	Mote Marine Laboratory
Neer	Neer *et al*., 2002
Parsons	Parsons 2002
POP	Pelagic Observer Program
SEAMAP	Southeast Area Monitoring and Assessment Program
SELL	Southeast Longline Survey
SOP	Shark Observer Program
Ulrich	Ulrich and Riley 2002

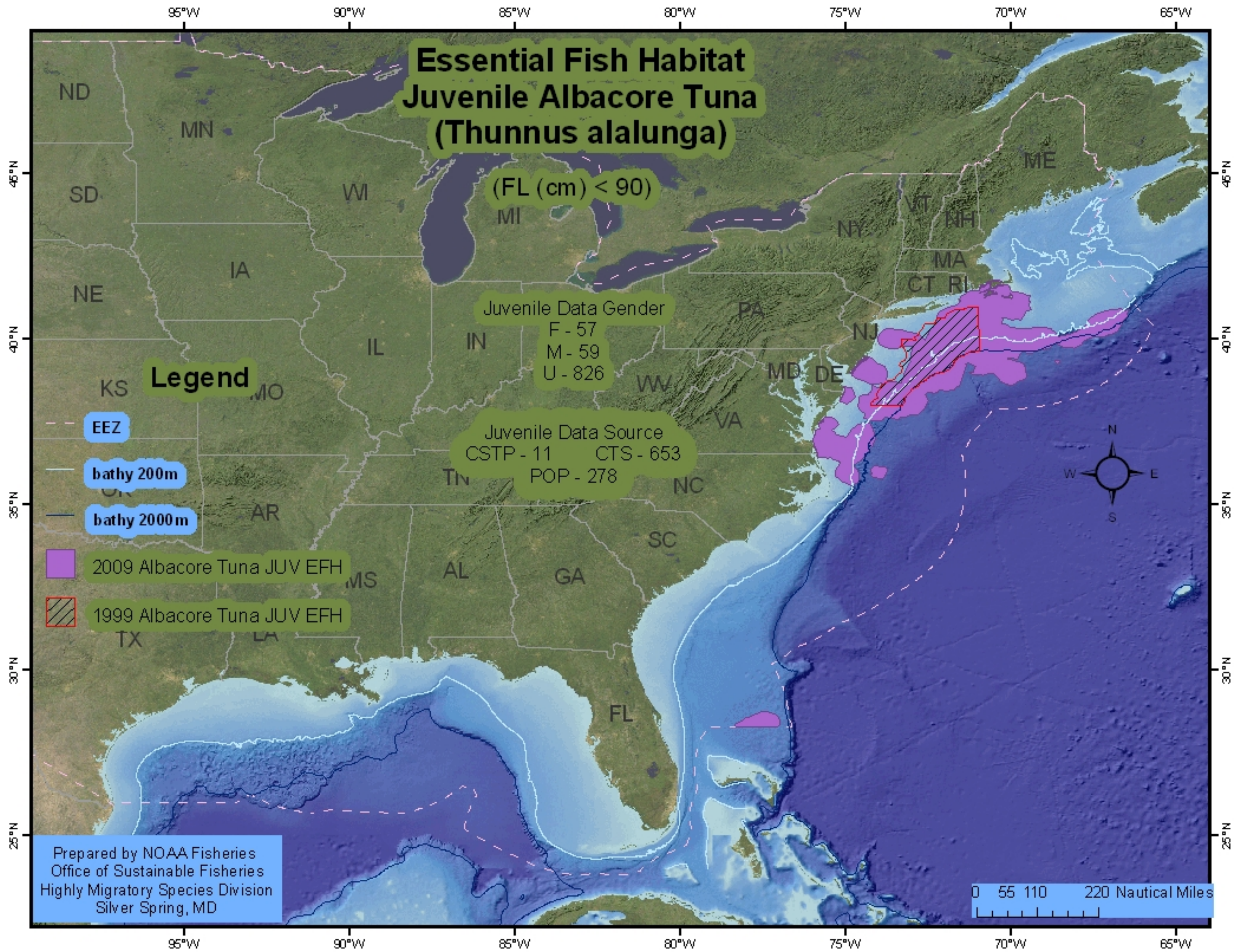

Figure 5.1 Atlantic Albacore Tuna: Juvenile.

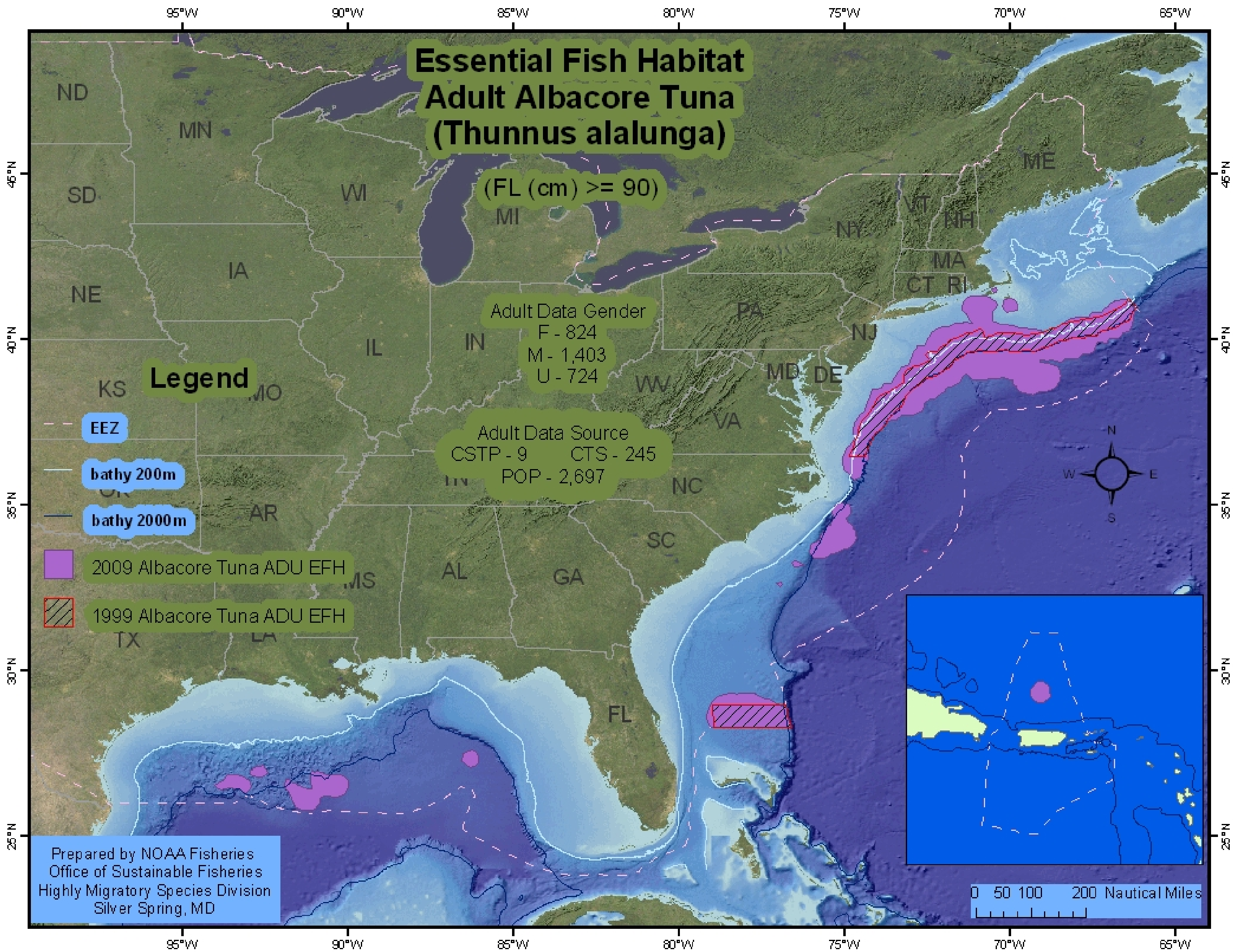

Figure 5.2 Atlantic Albacore Tuna: Adult.

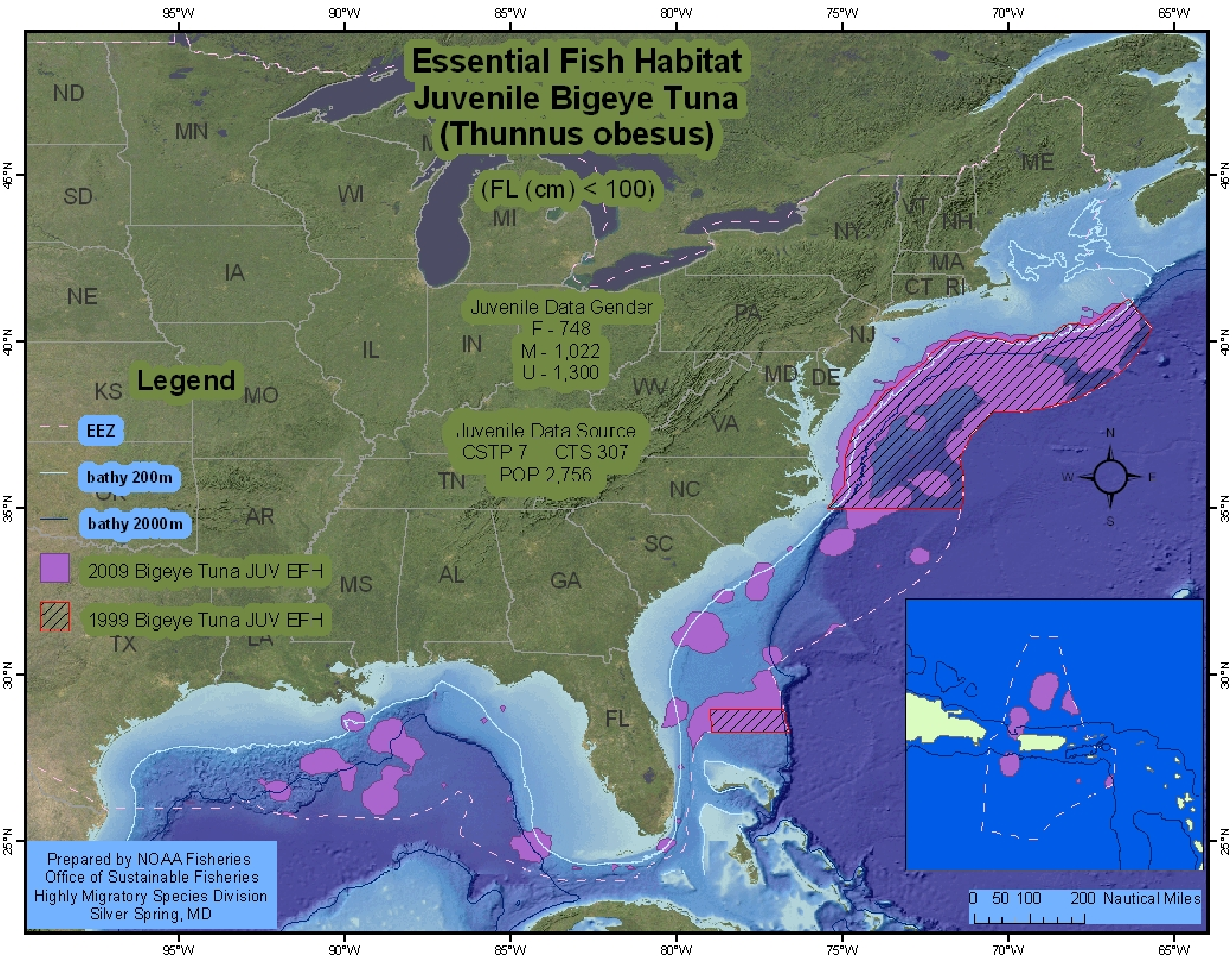

Figure 5.3 Atlantic Bigeye Tuna: Juvenile.

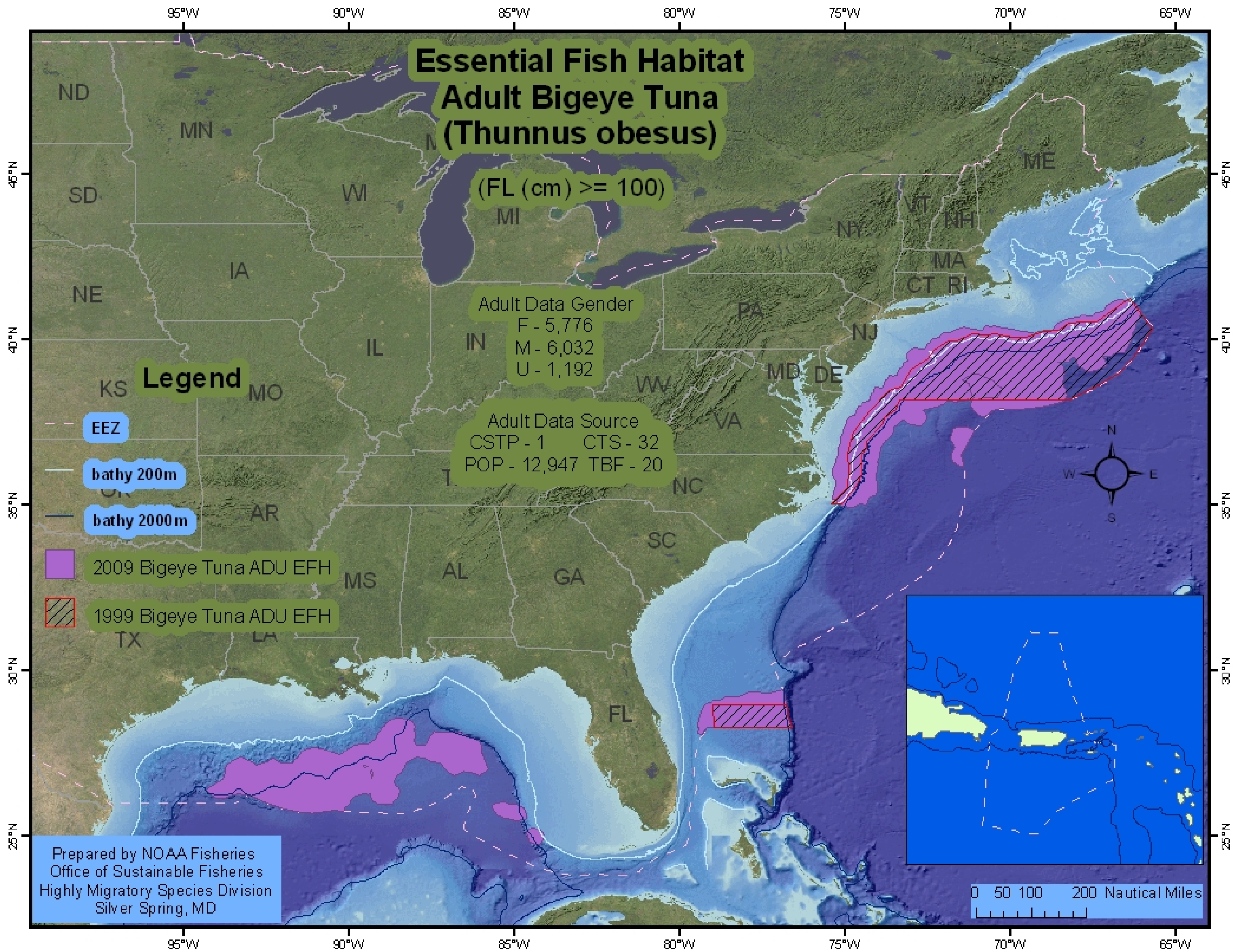

Figure 5.4 **Atlantic Bigeye Tuna: Adult.**

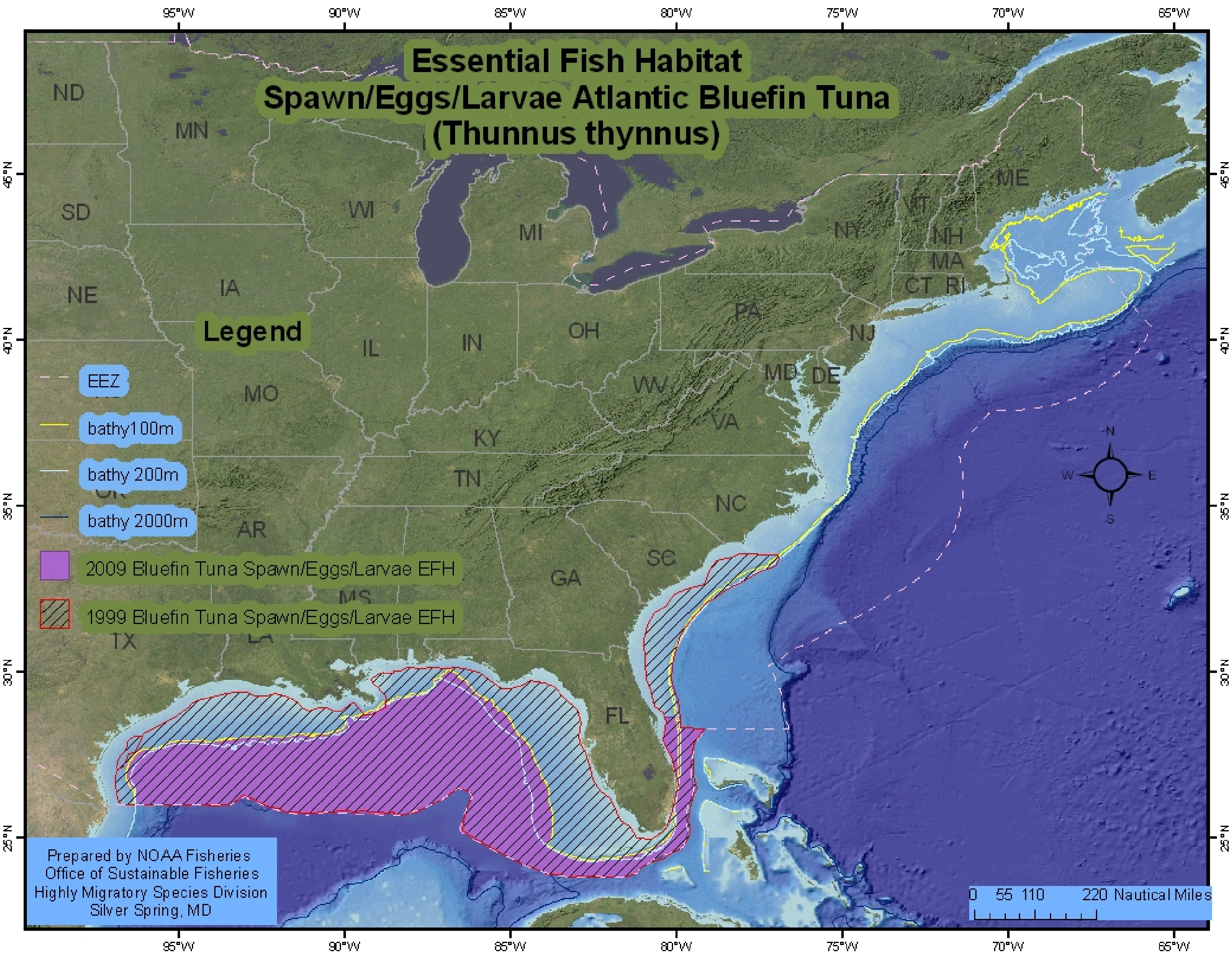

Figure 5.5 **Atlantic Bluefin Tuna: Spawning, Eggs, and Larvae.**

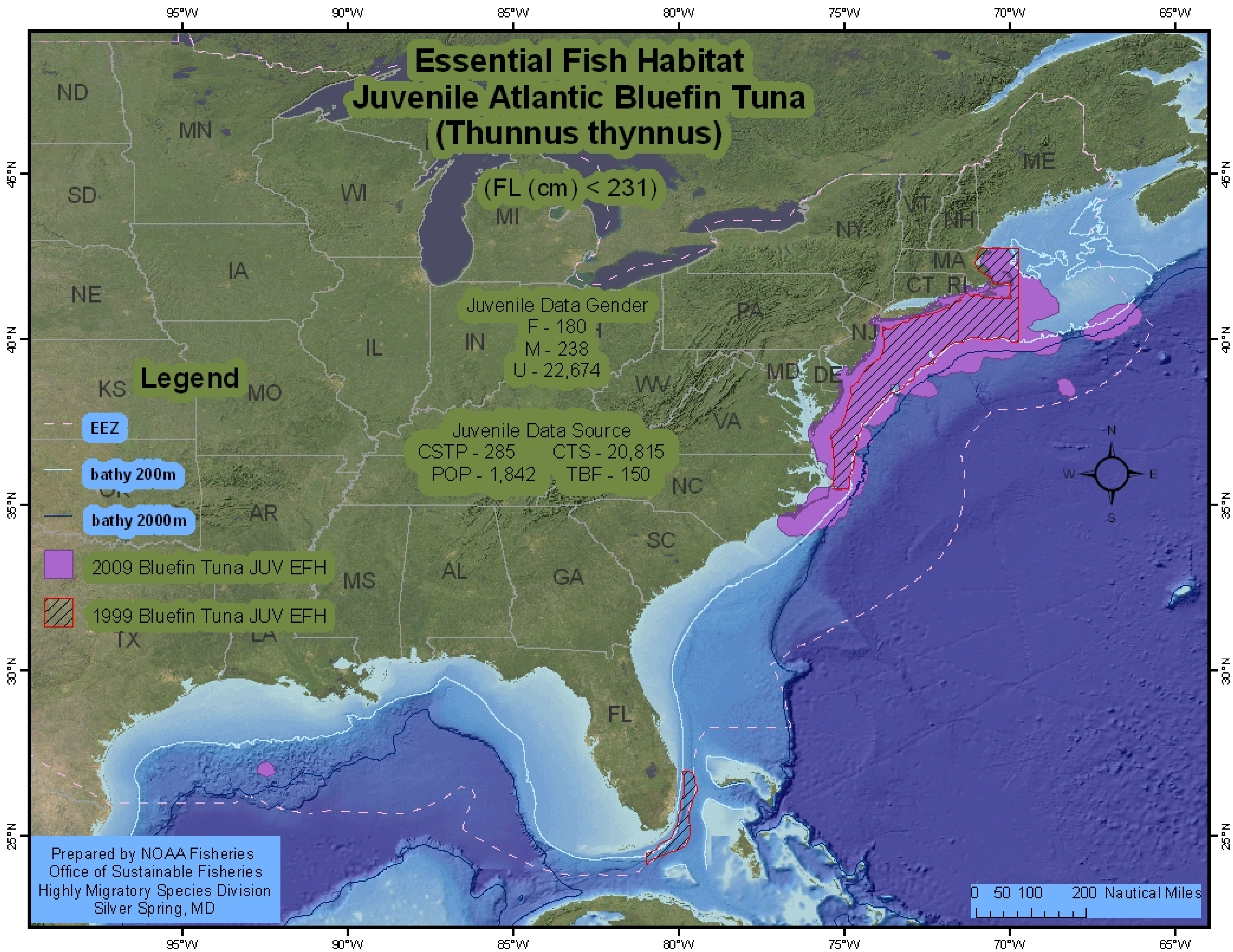

Figure 5.6 **Atlantic Bluefin Tuna: Juvenile.**

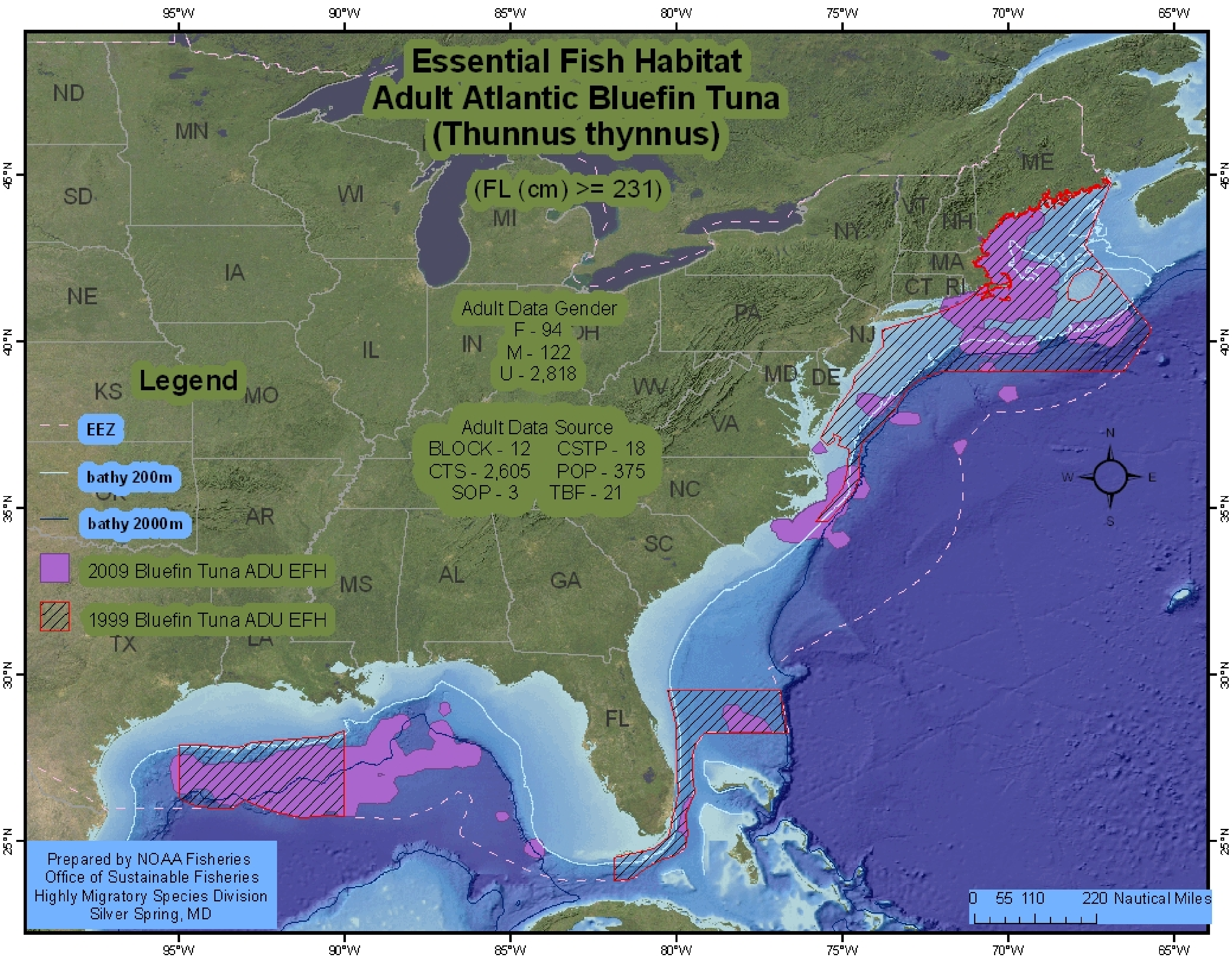

Figure 5.7 Atlantic Bluefin Tuna: Adult.

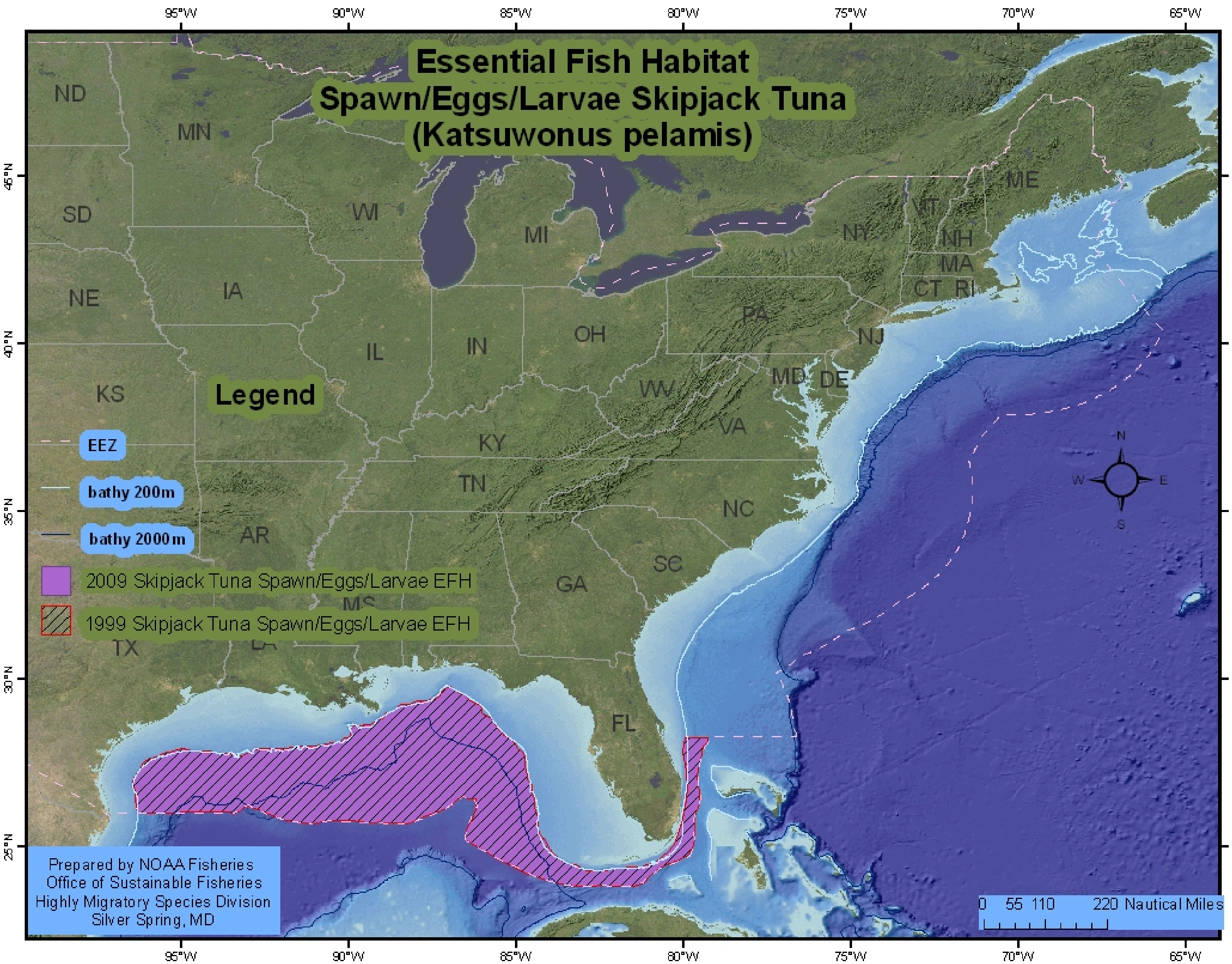

Figure 5.8 **Atlantic Skipjack Tuna: Spawning, Eggs, and Larvae. No changes have been made to the 1999 boundary.**

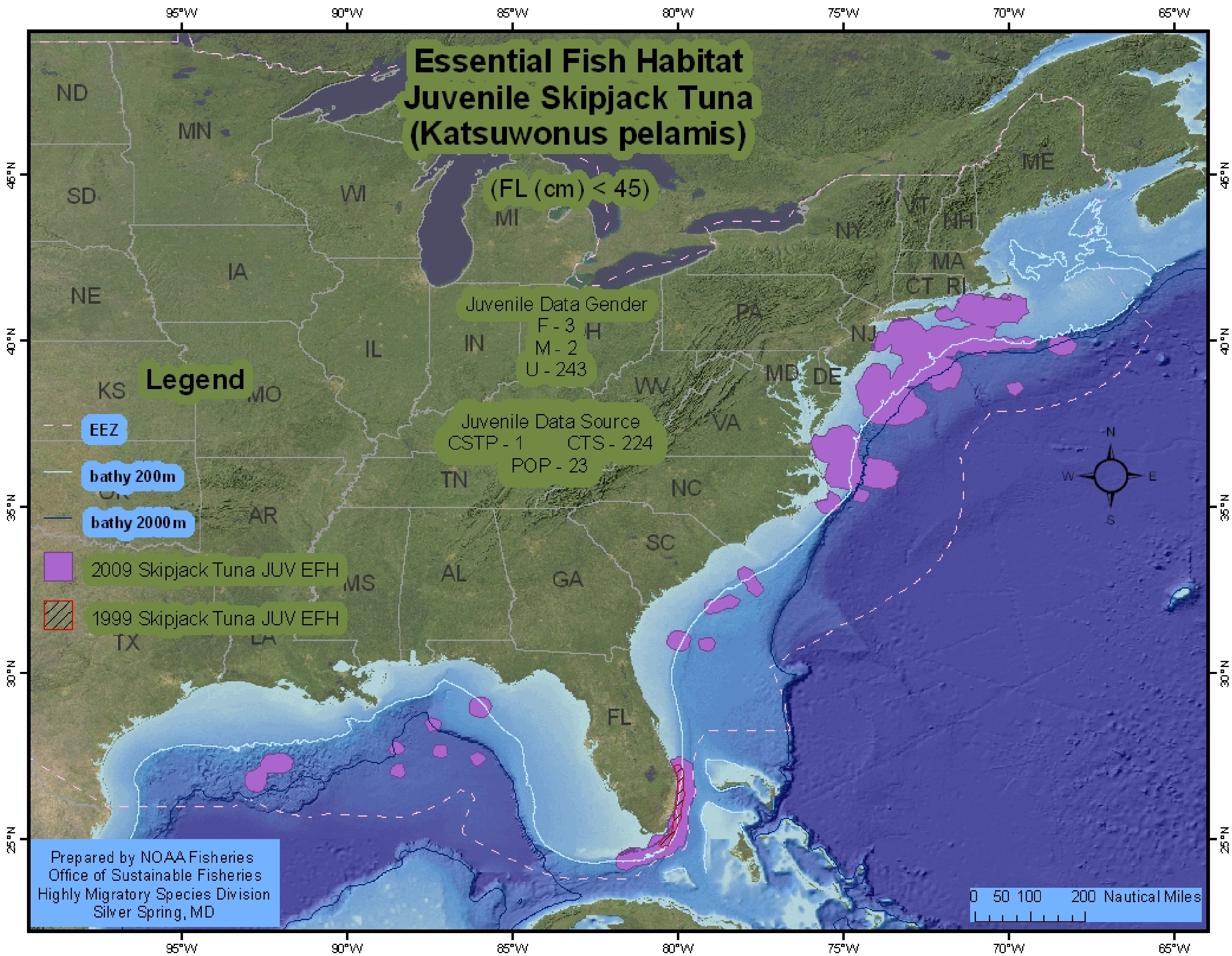

Figure 5.9 **Atlantic Skipjack Tuna: Juvenile.**

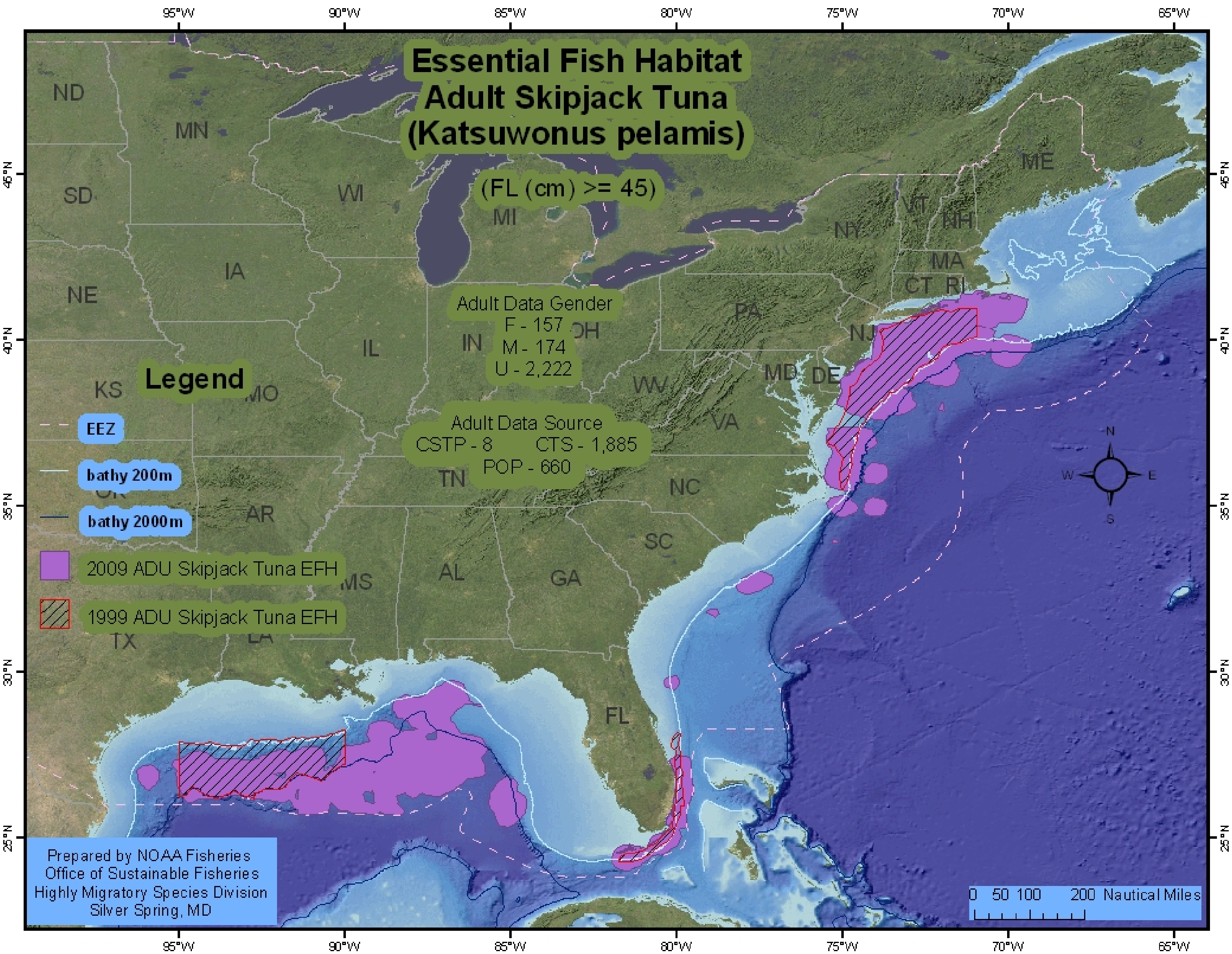

Figure 5.10 Atlantic Skipjack Tuna: Adult.

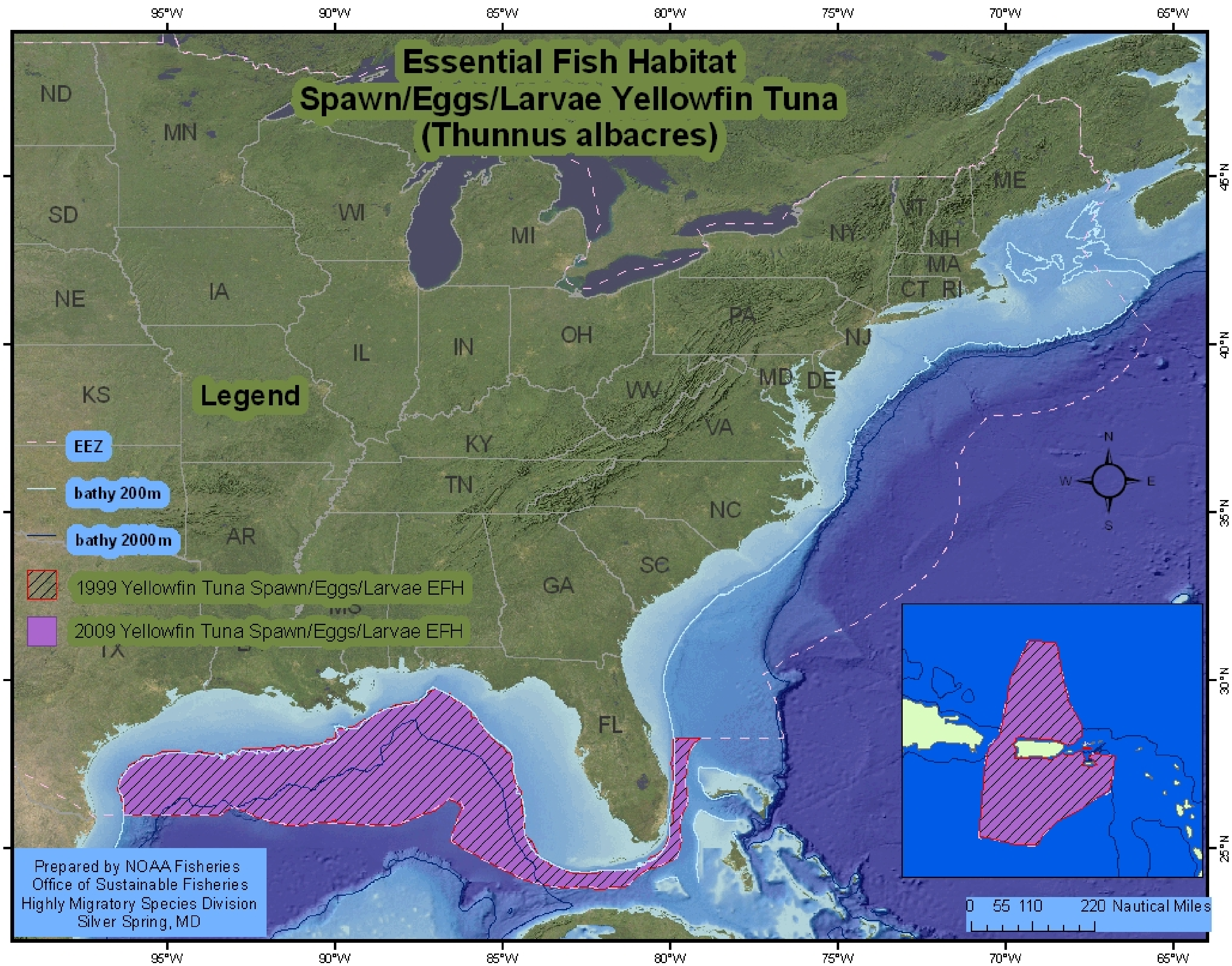

Figure 5.11 **Atlantic Yellowfin Tuna: Spawning, Eggs, and Larvae. No changes have been made to the 1999 boundary.**

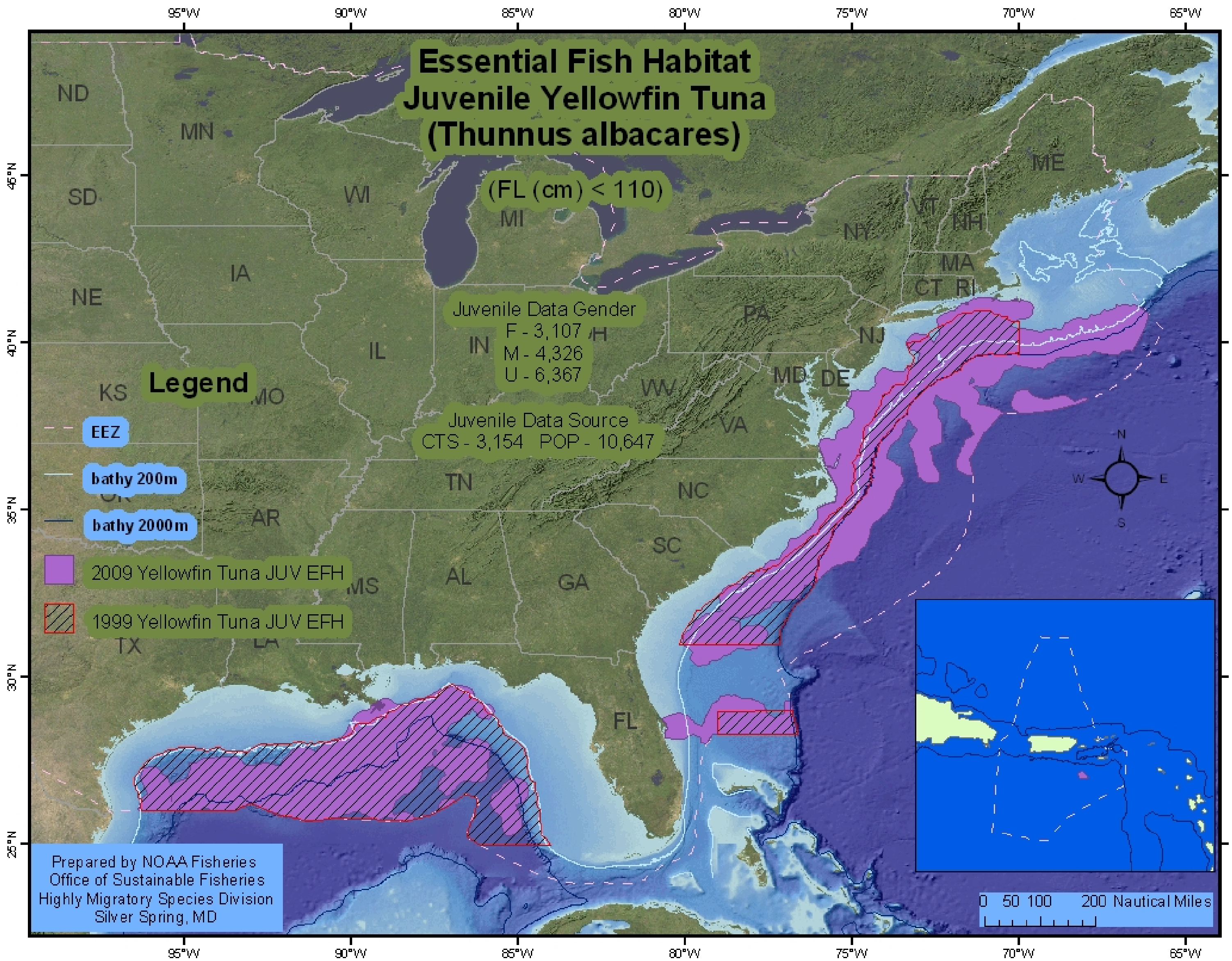

Figure 5.12 Atlantic Yellowfin Tuna: Juvenile.

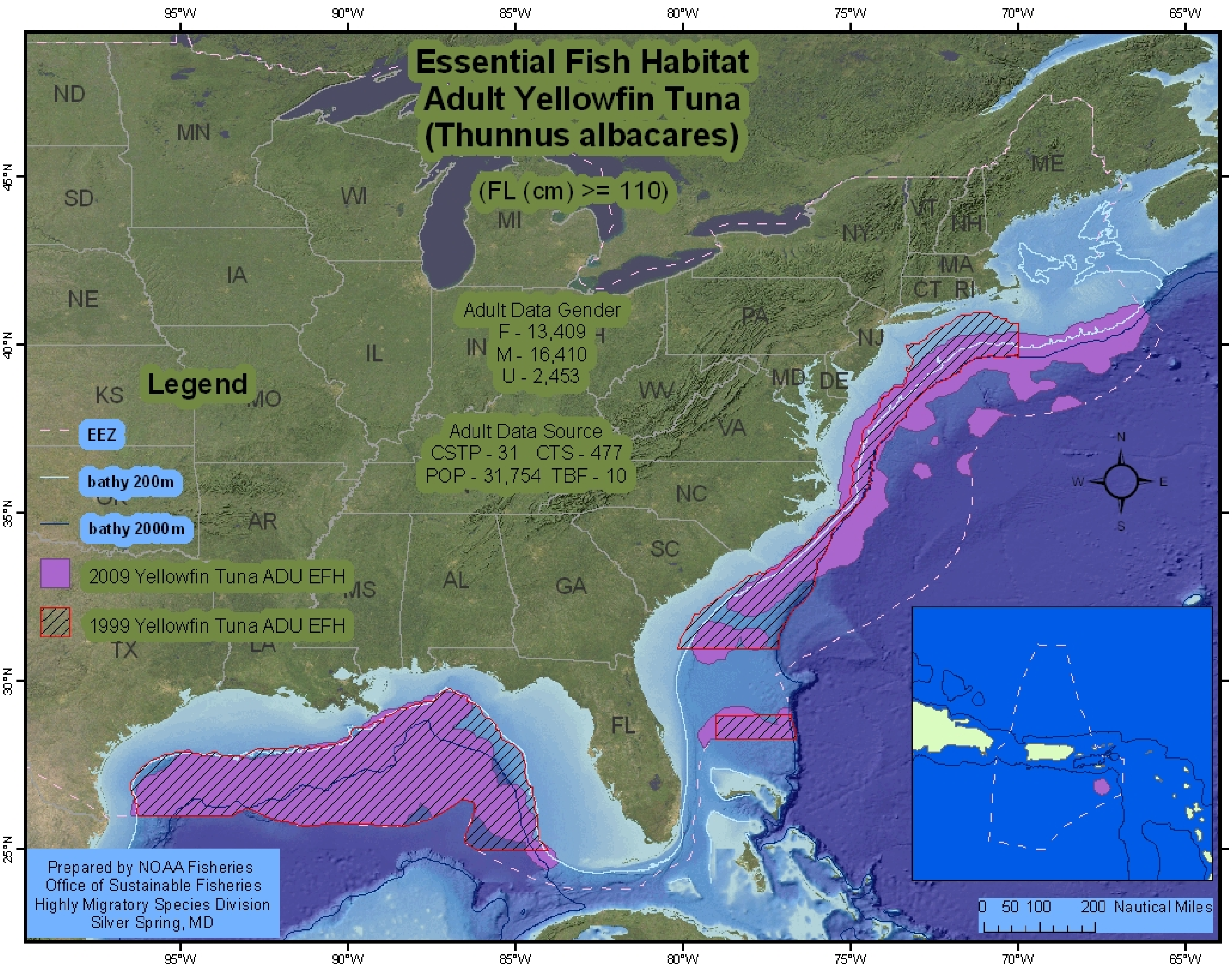

Figure 5.13 **Atlantic Yellowfin Tuna: Adult.**

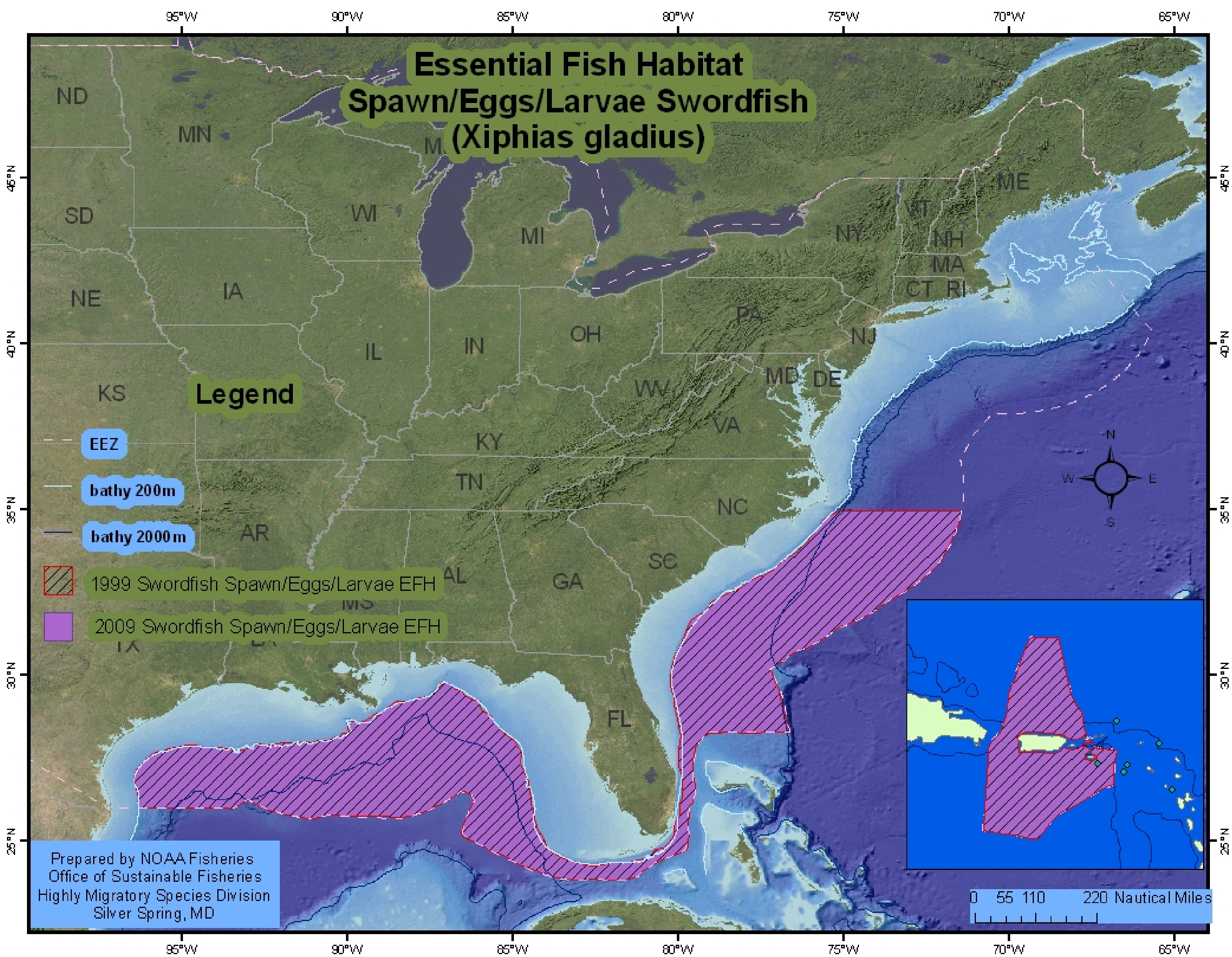

Figure 5.14 Atlantic Swordfish: Spawning, Eggs, and Larvae. No changes were made to the 1999 boundary.

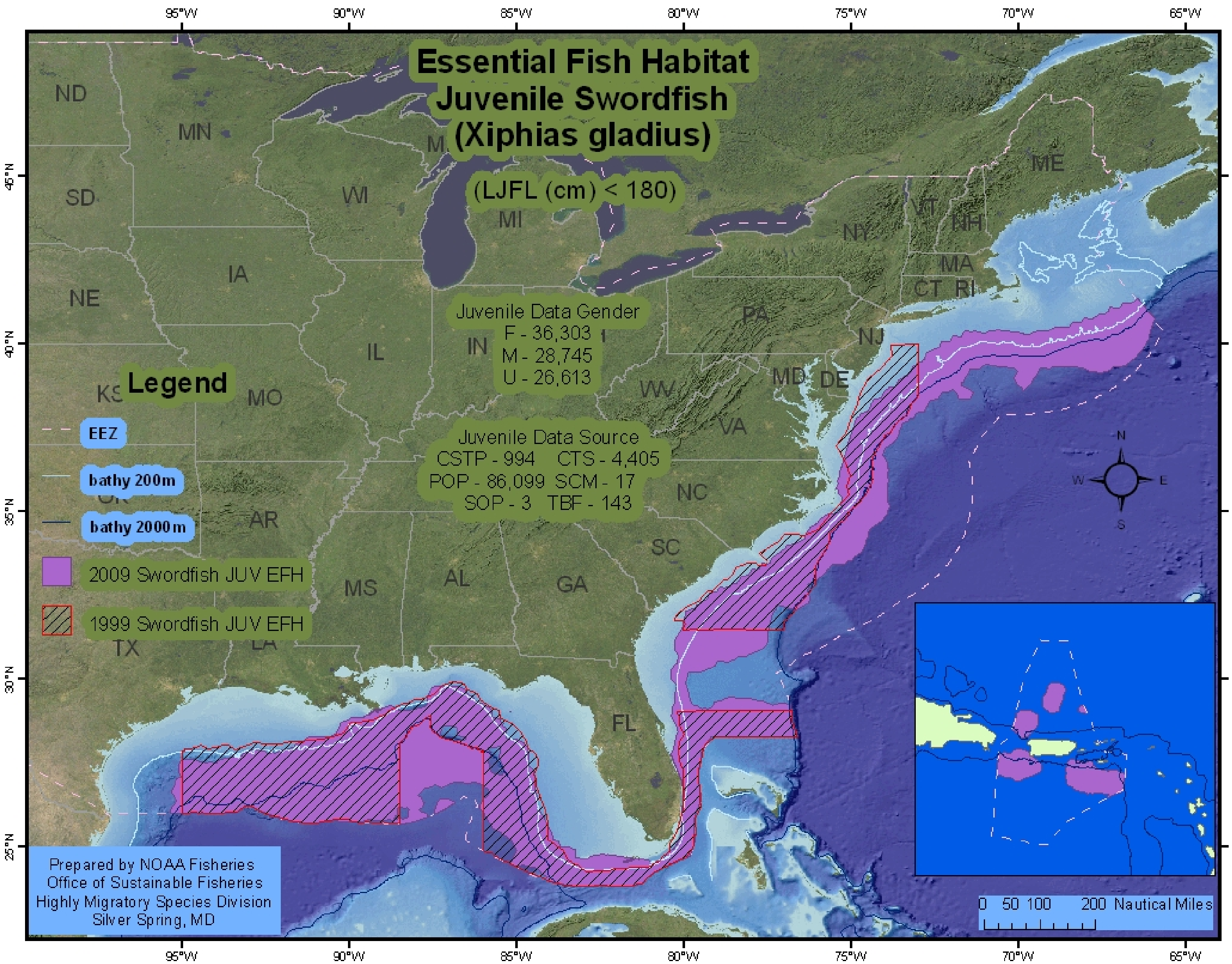

Figure 5.15 Atlantic Swordfish: Juvenile.

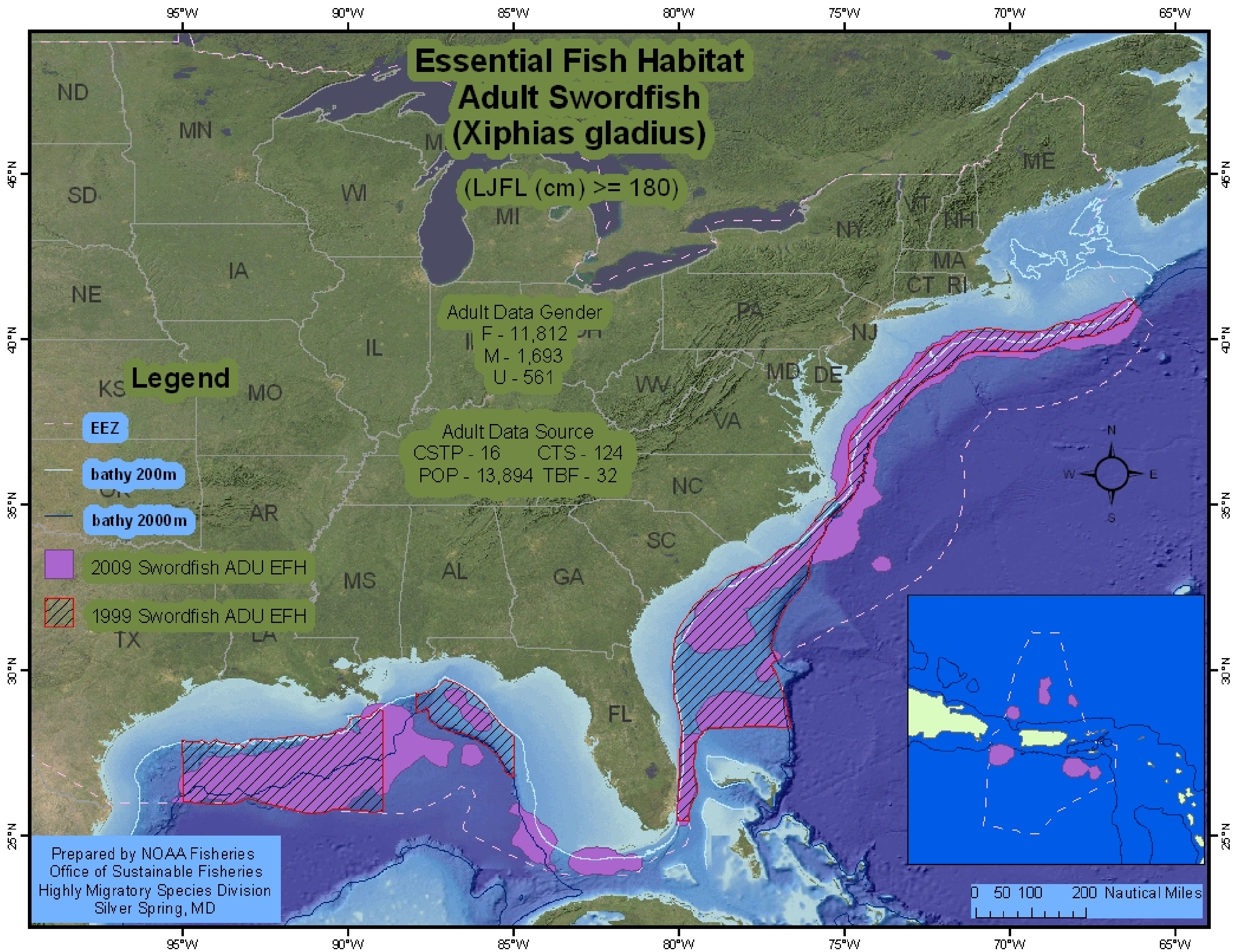

Figure 5.16 **Atlantic Swordfish: Adult.**

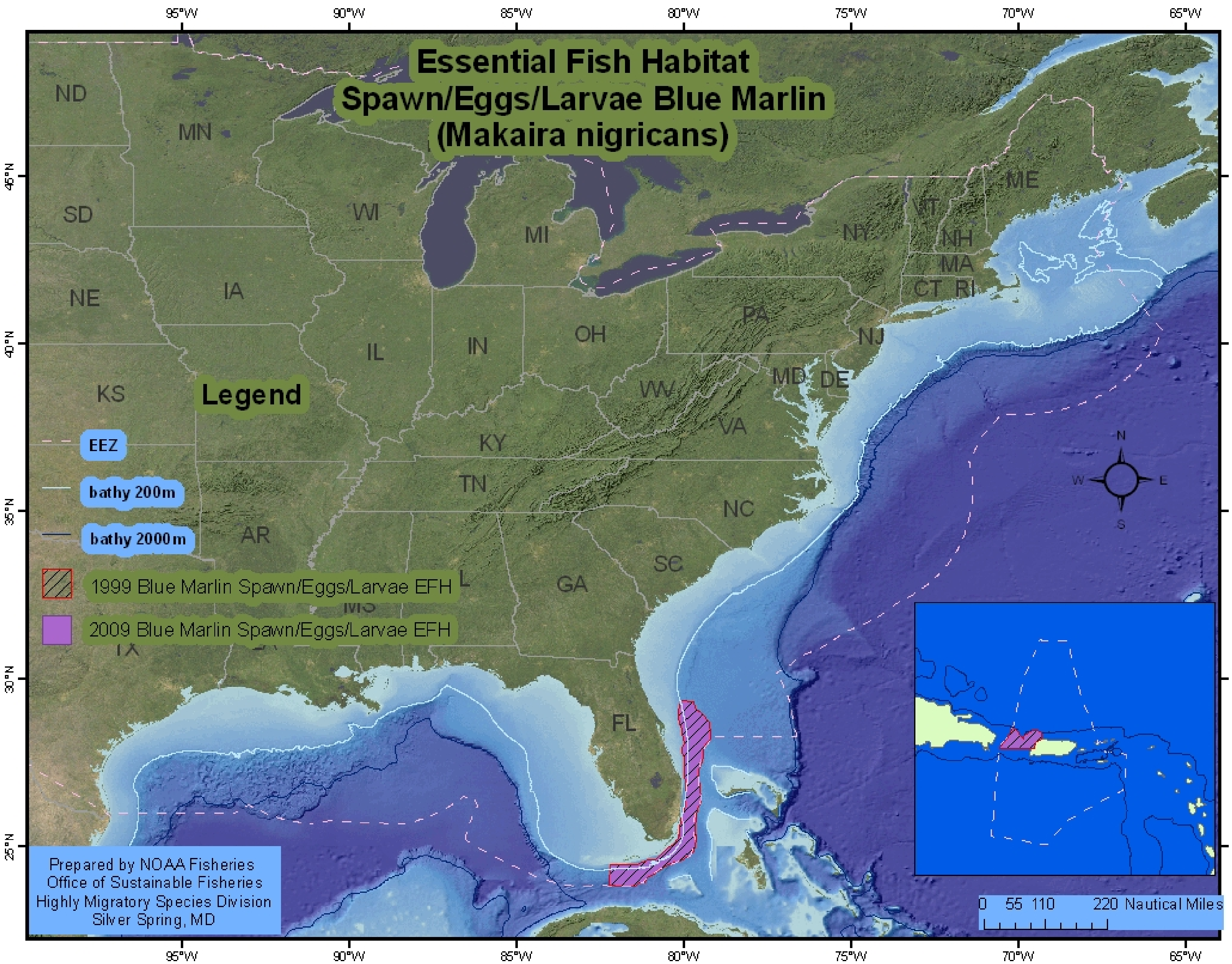

Figure 5.17 Blue Marlin: Spawning, Eggs, and Larvae. No changes have been made to the 1999 boundary.

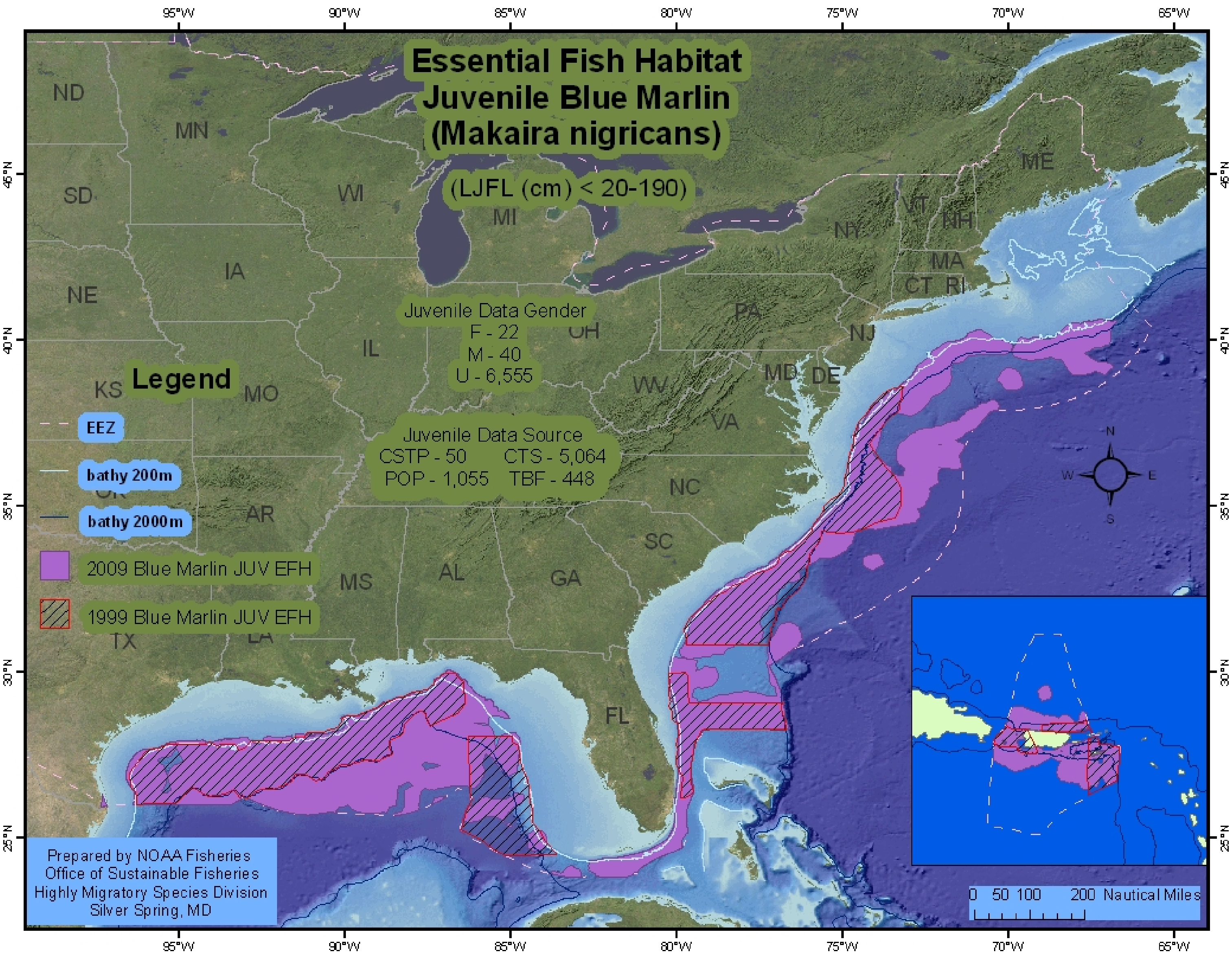

Figure 5.18 **Blue Marlin: Juvenile.**

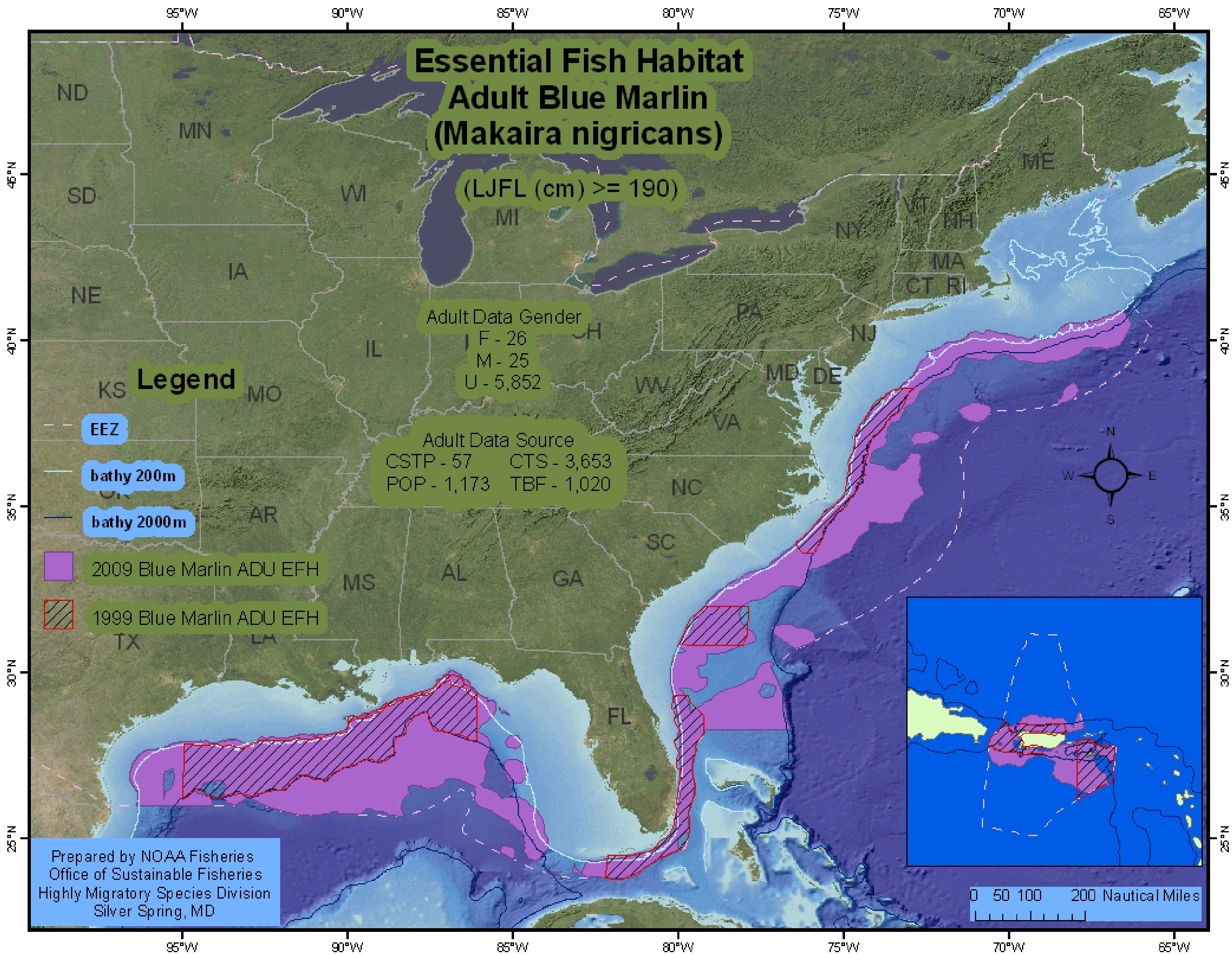

Figure 5.19 Blue Marlin: Adult.

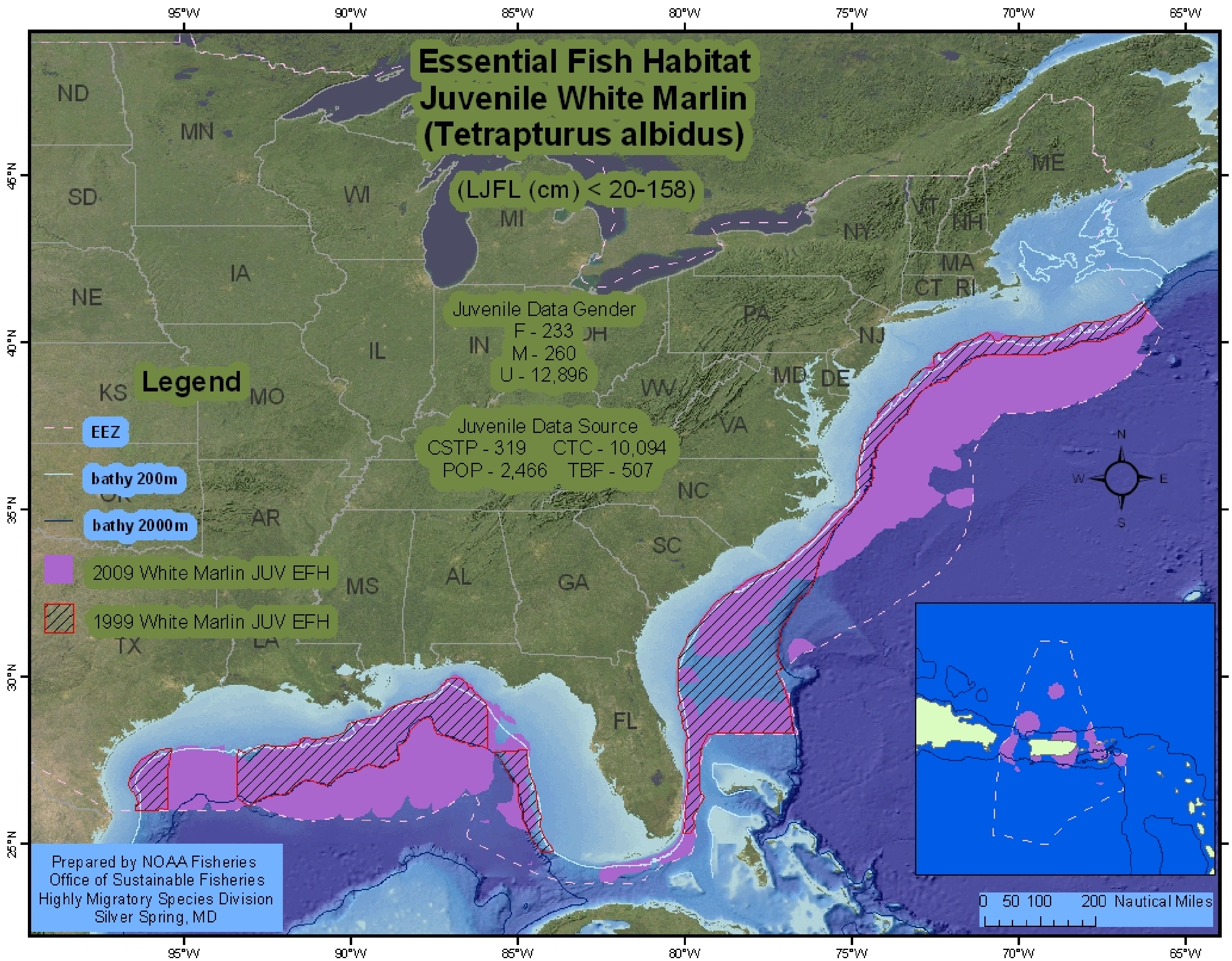

Figure 5.20 **White Marlin: Juvenile.**

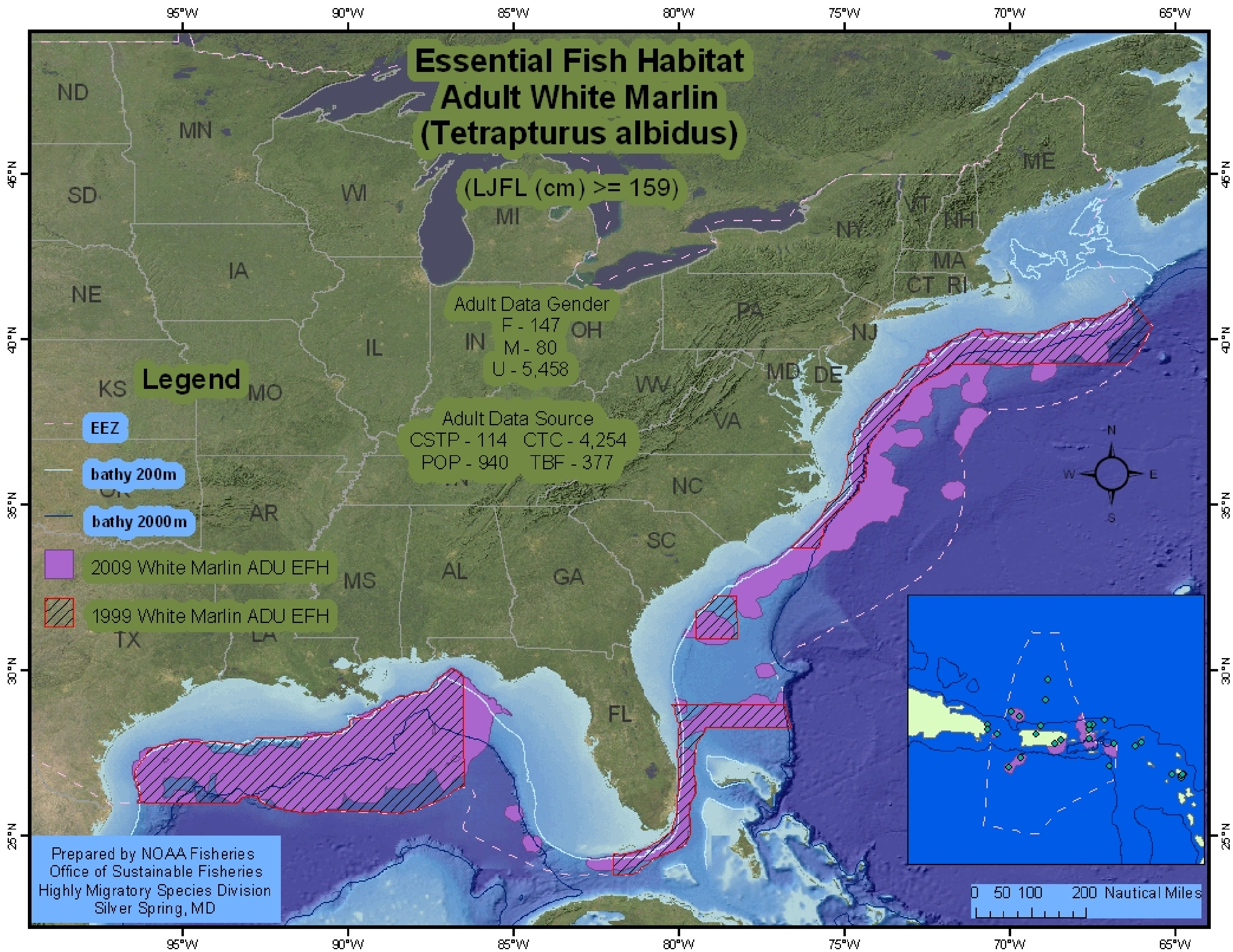

Figure 5.21 White Marlin: Adult.

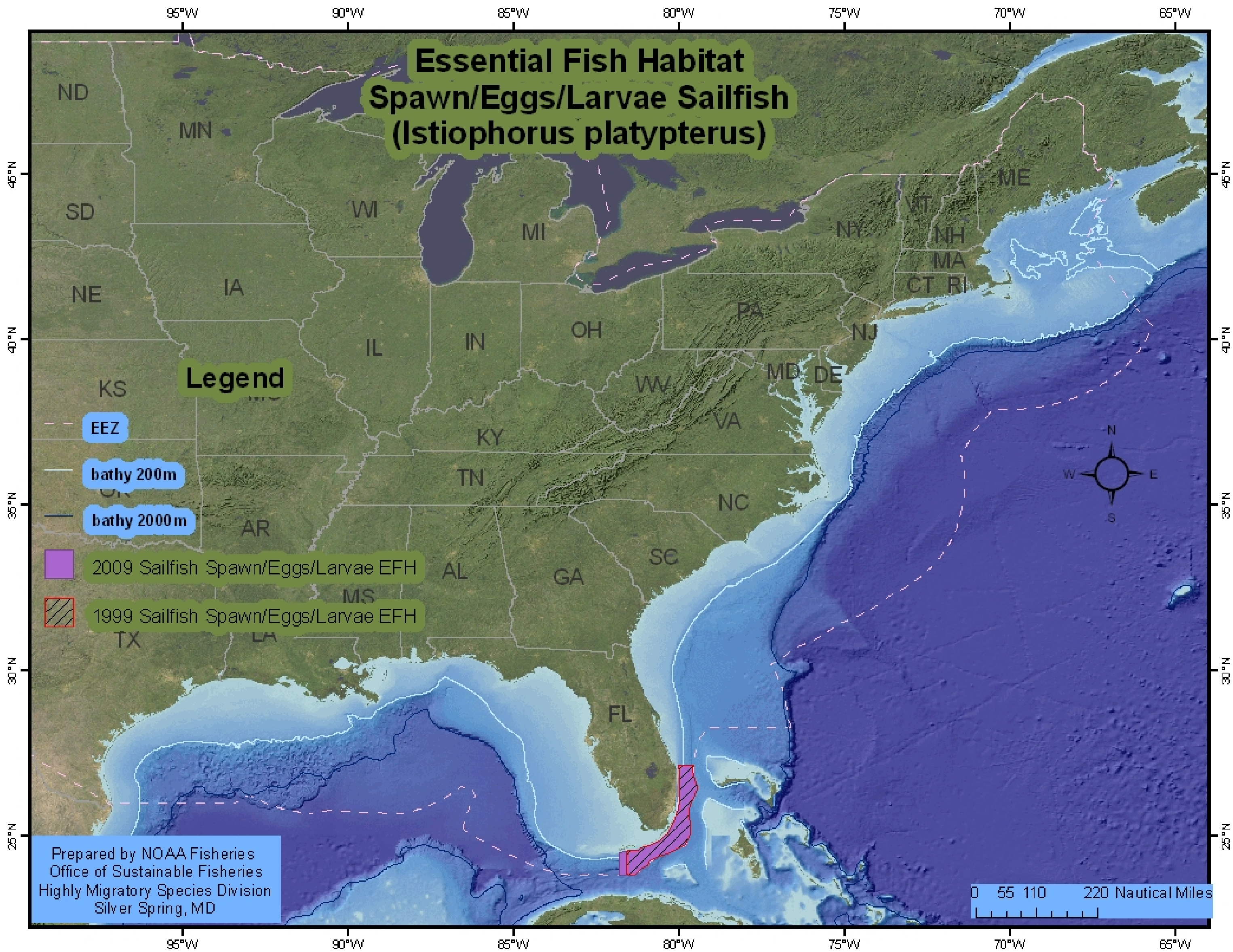

Figure 5.22 **Sailfish: Spawning, Eggs, and Larvae.**

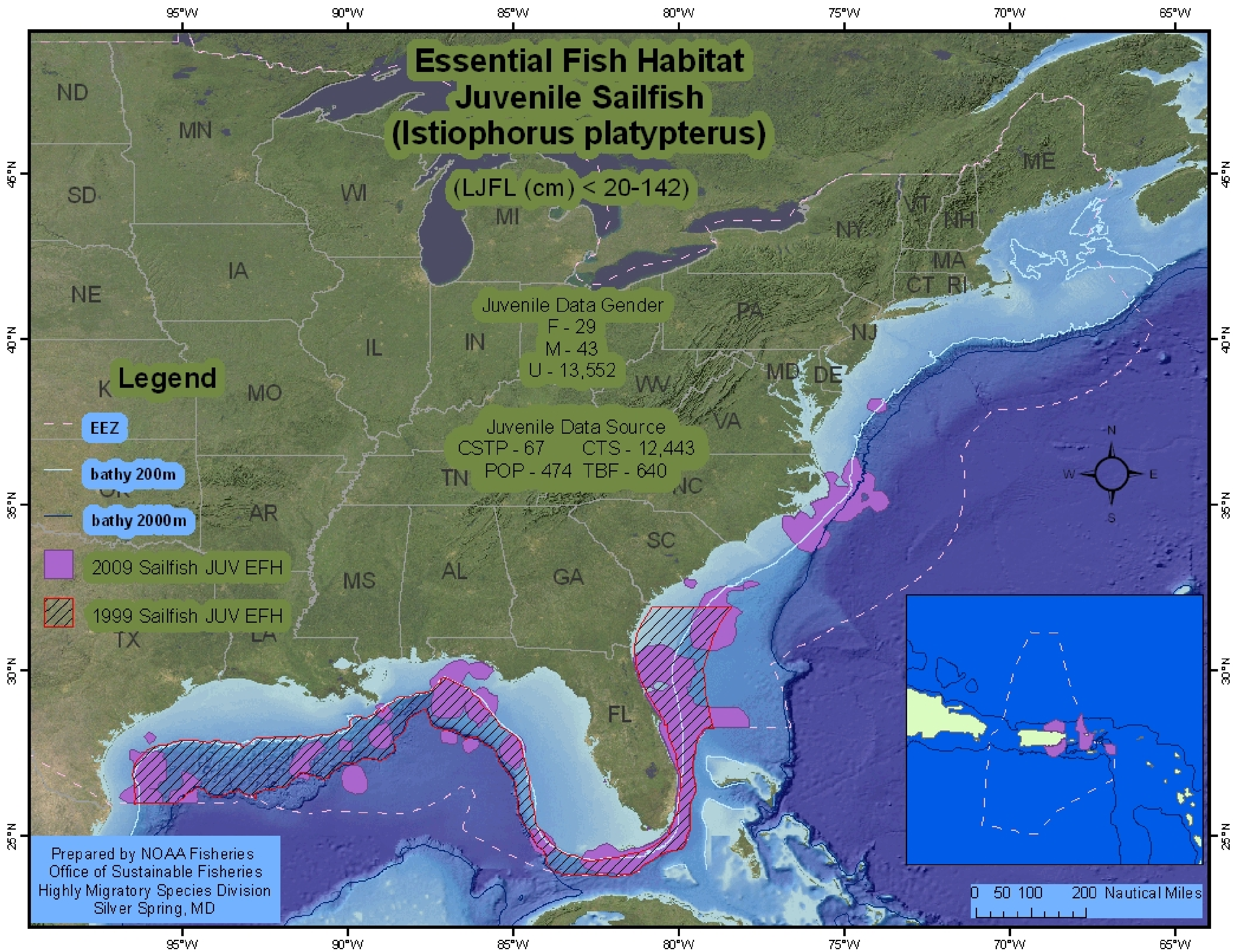

Figure 5.23 **Sailfish: Juvenile.**

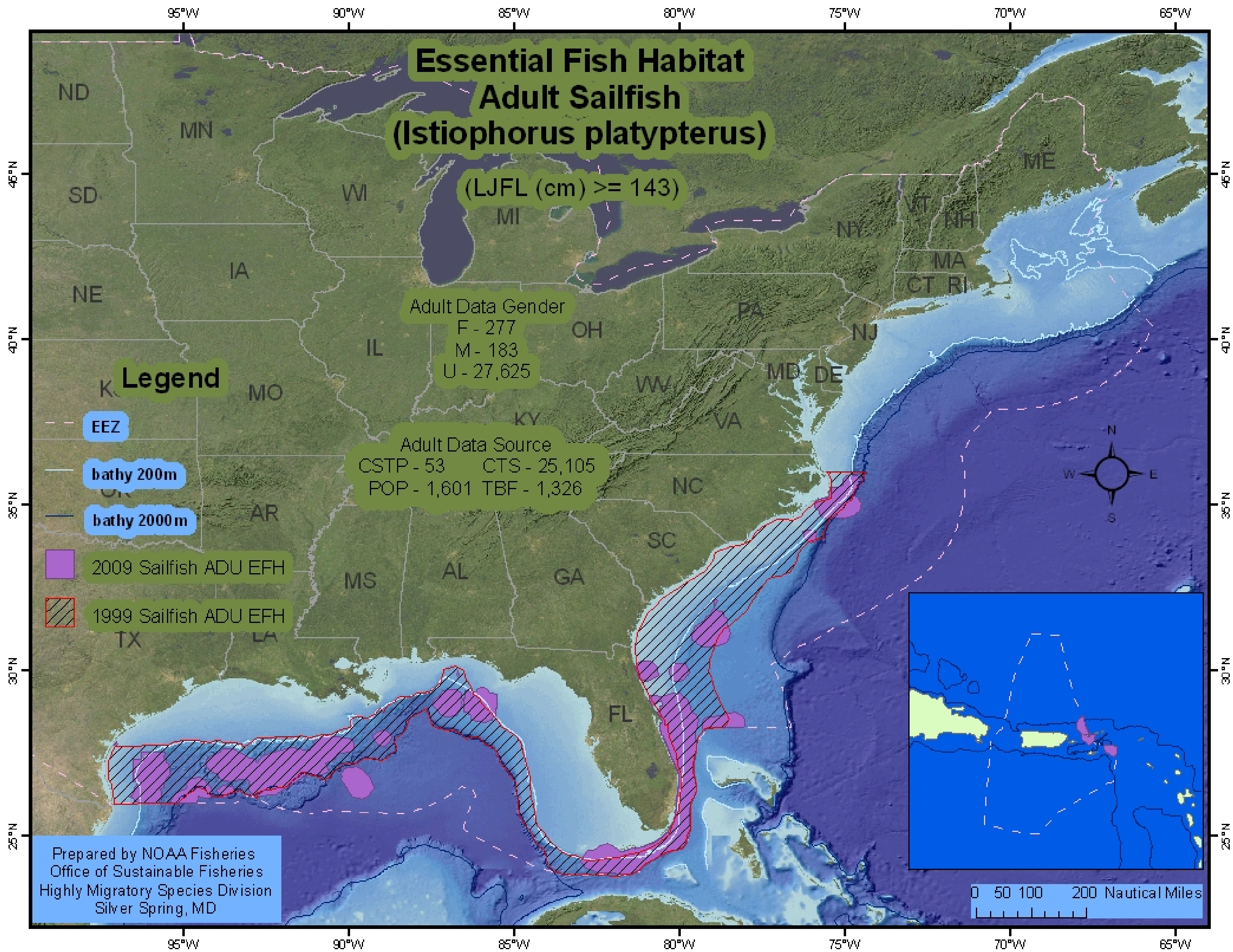

Figure 5.24 Sailfish: Adult.

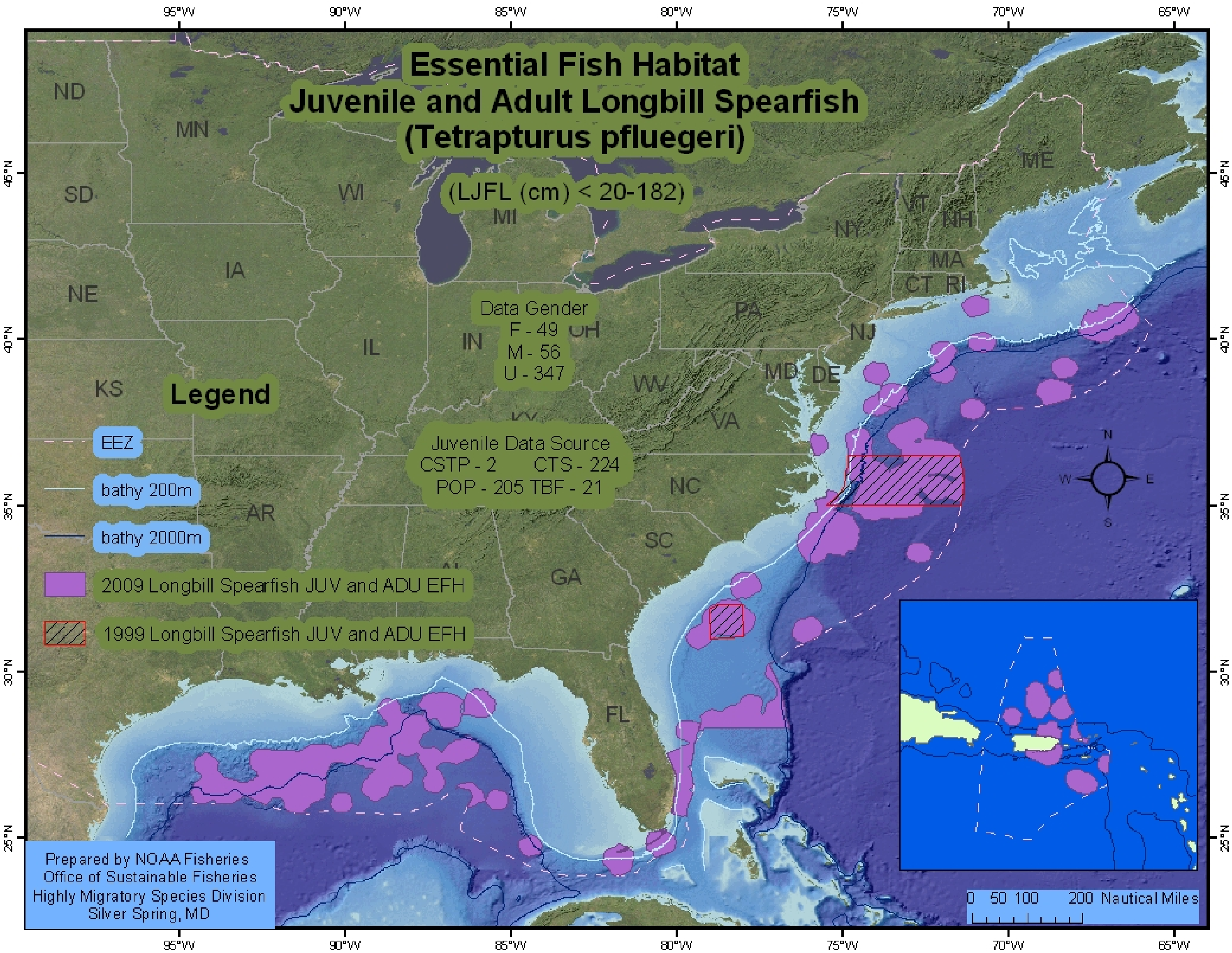

Figure 5.25 **Longbill Spearfish: Juvenile and Adult Combined.**

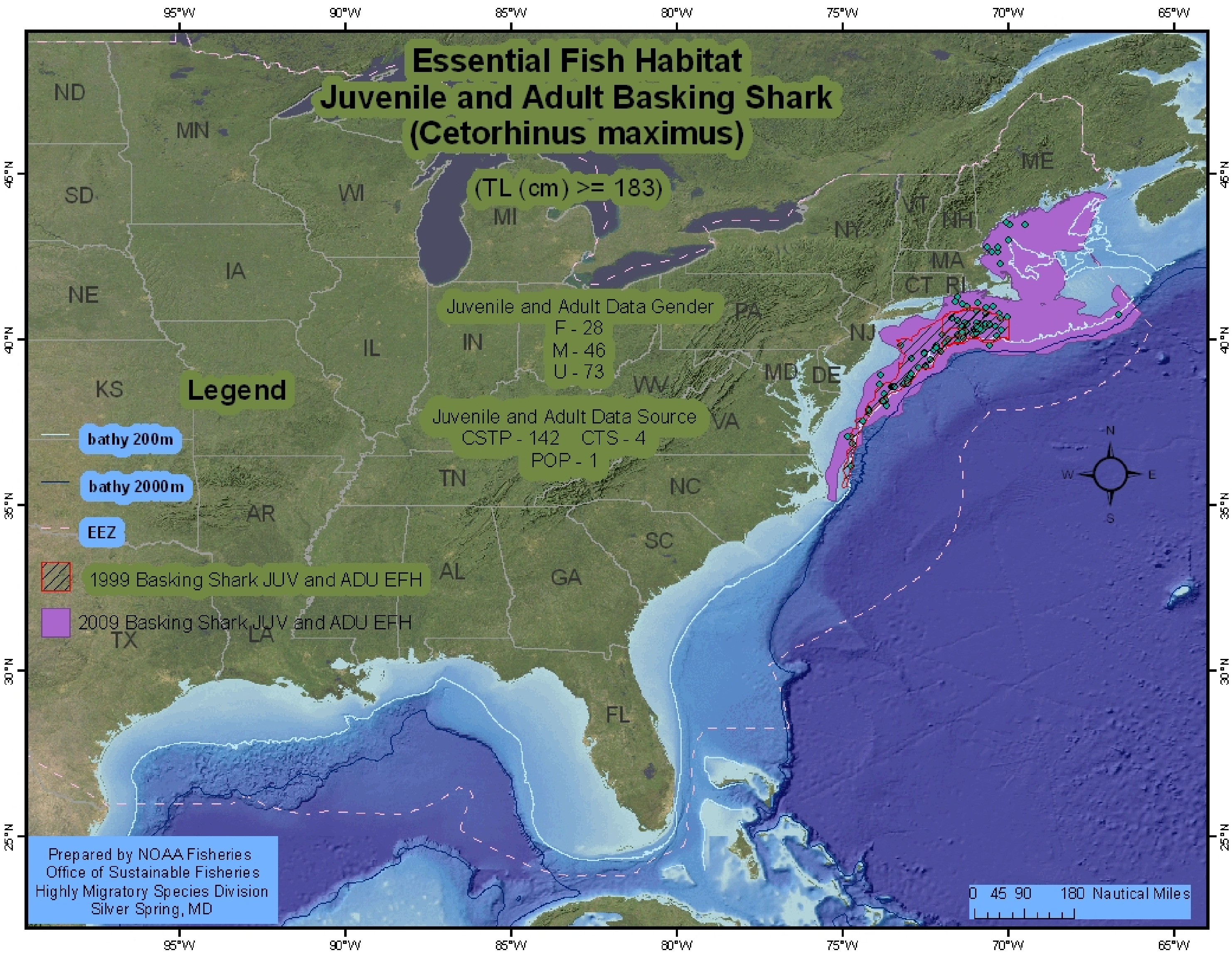

Figure 5.26 **Basking Shark: Juvenile and Adult Combined.**

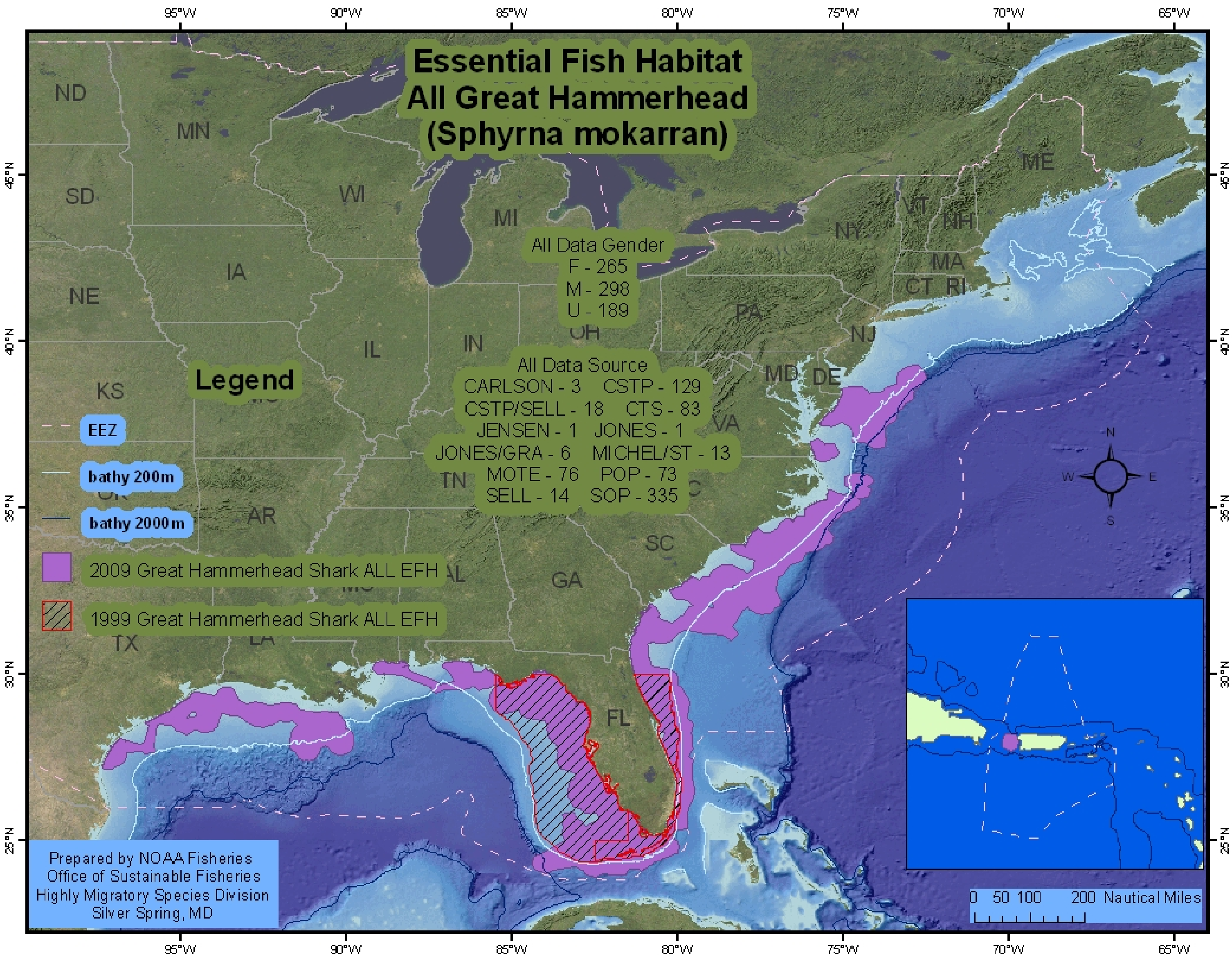

Figure 5.27 Great Hammerhead Shark: All Life Stages Combined.

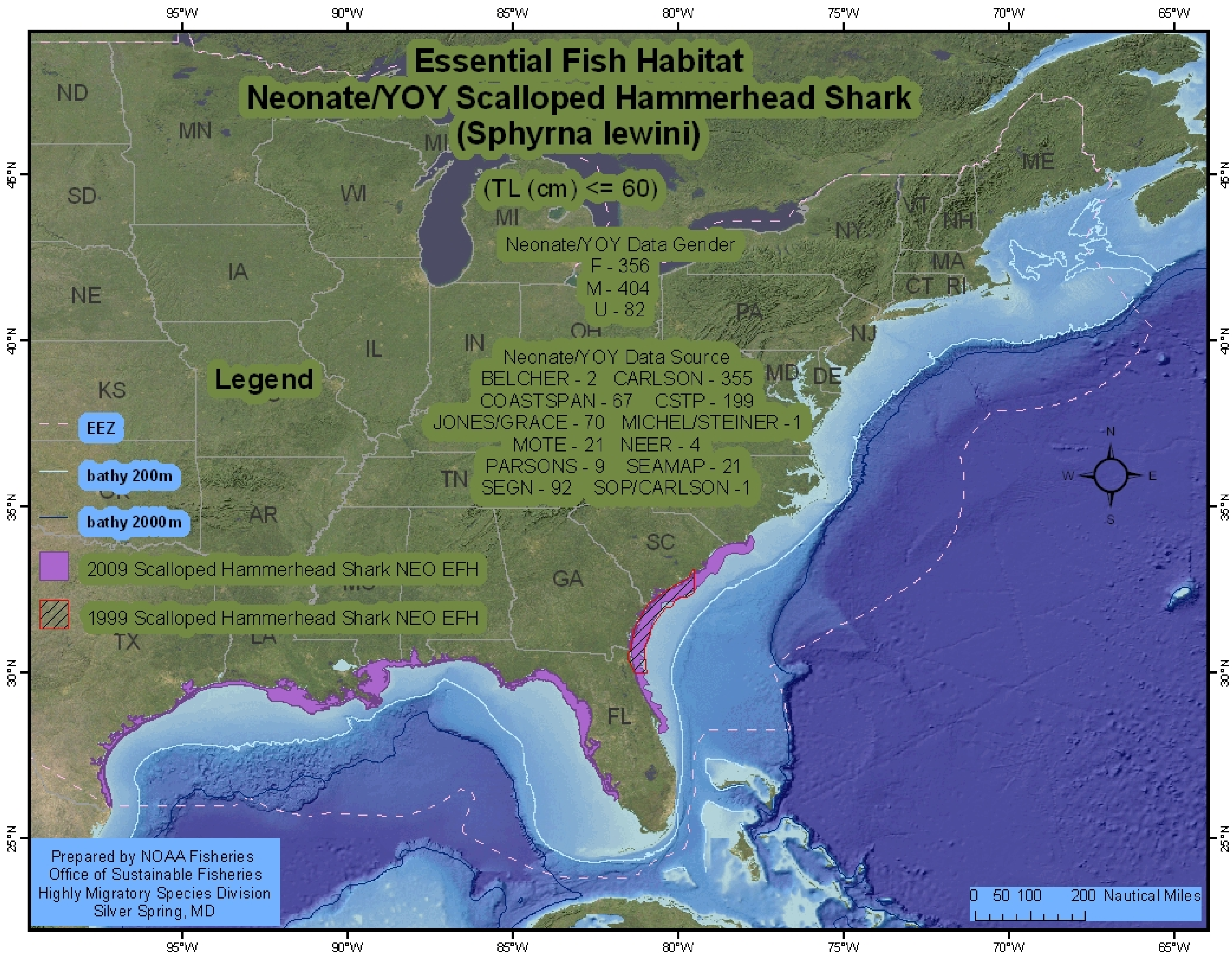

Figure 5.28 **Scalloped Hammerhead Shark: Neonate.**

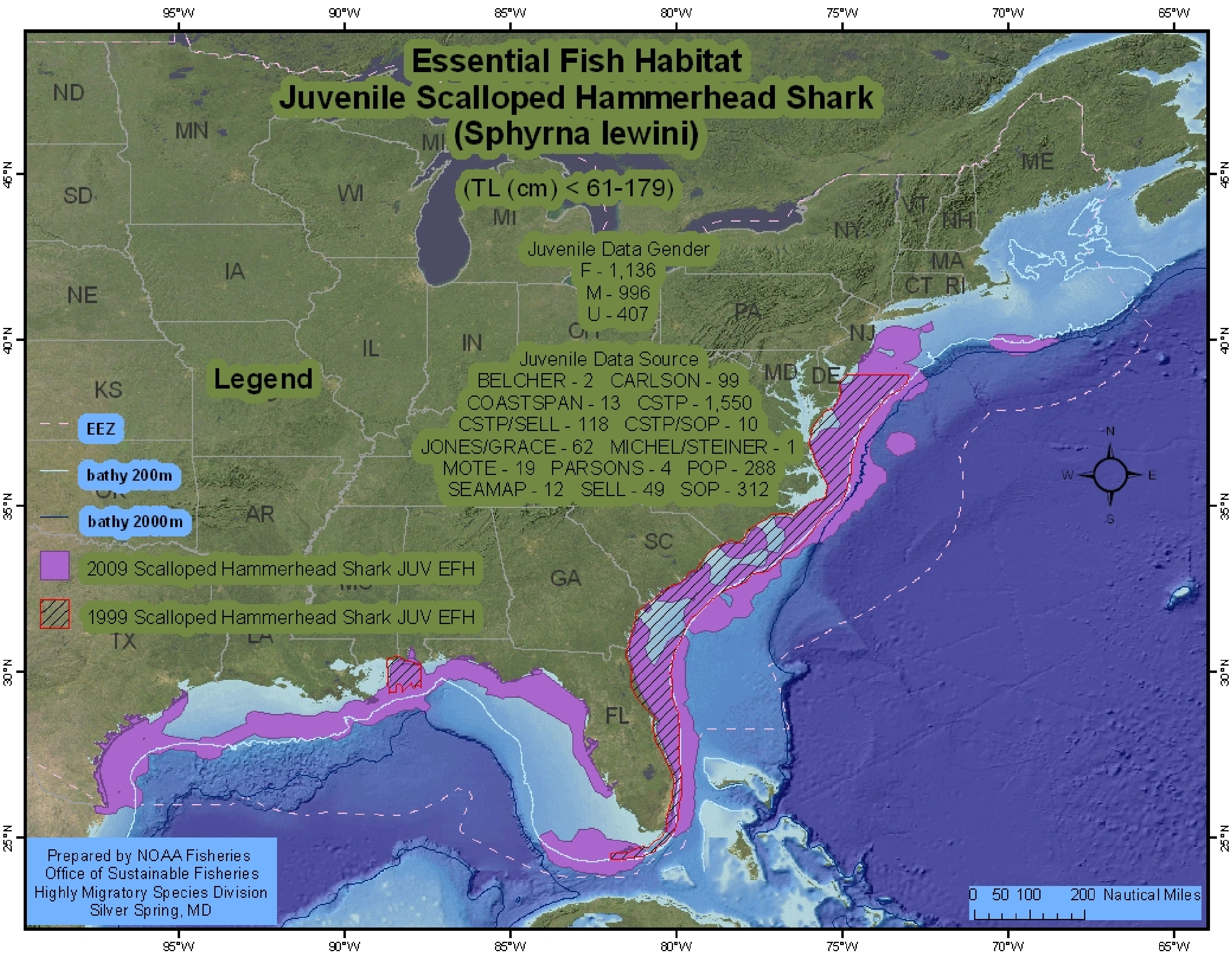

Figure 5.29 Scalloped Hammerhead Shark: Juvenile.

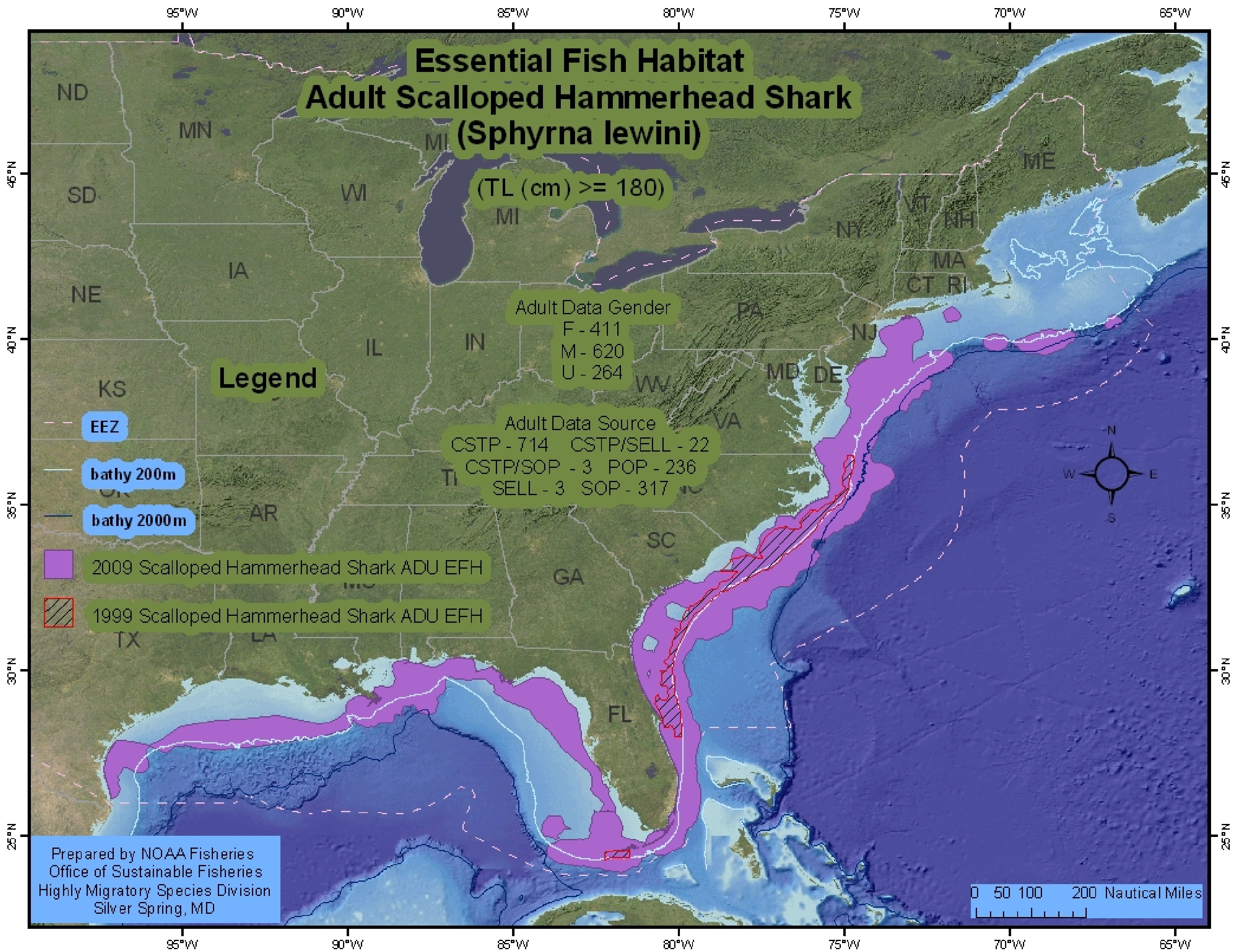

Figure 5.30 Scalloped Hammerhead Shark: Adult.

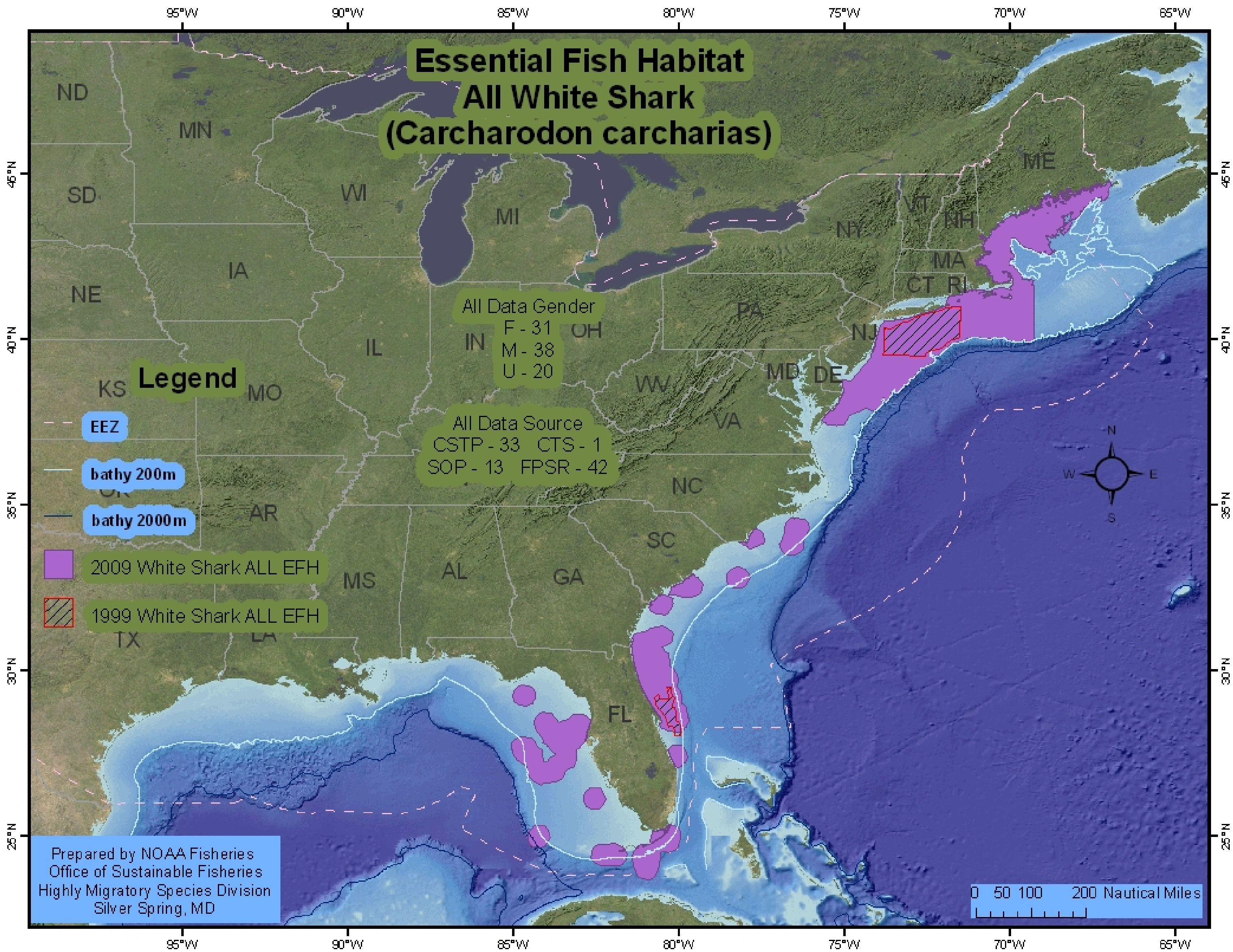

Figure 5.31 White Shark: All Life Stages Combined.

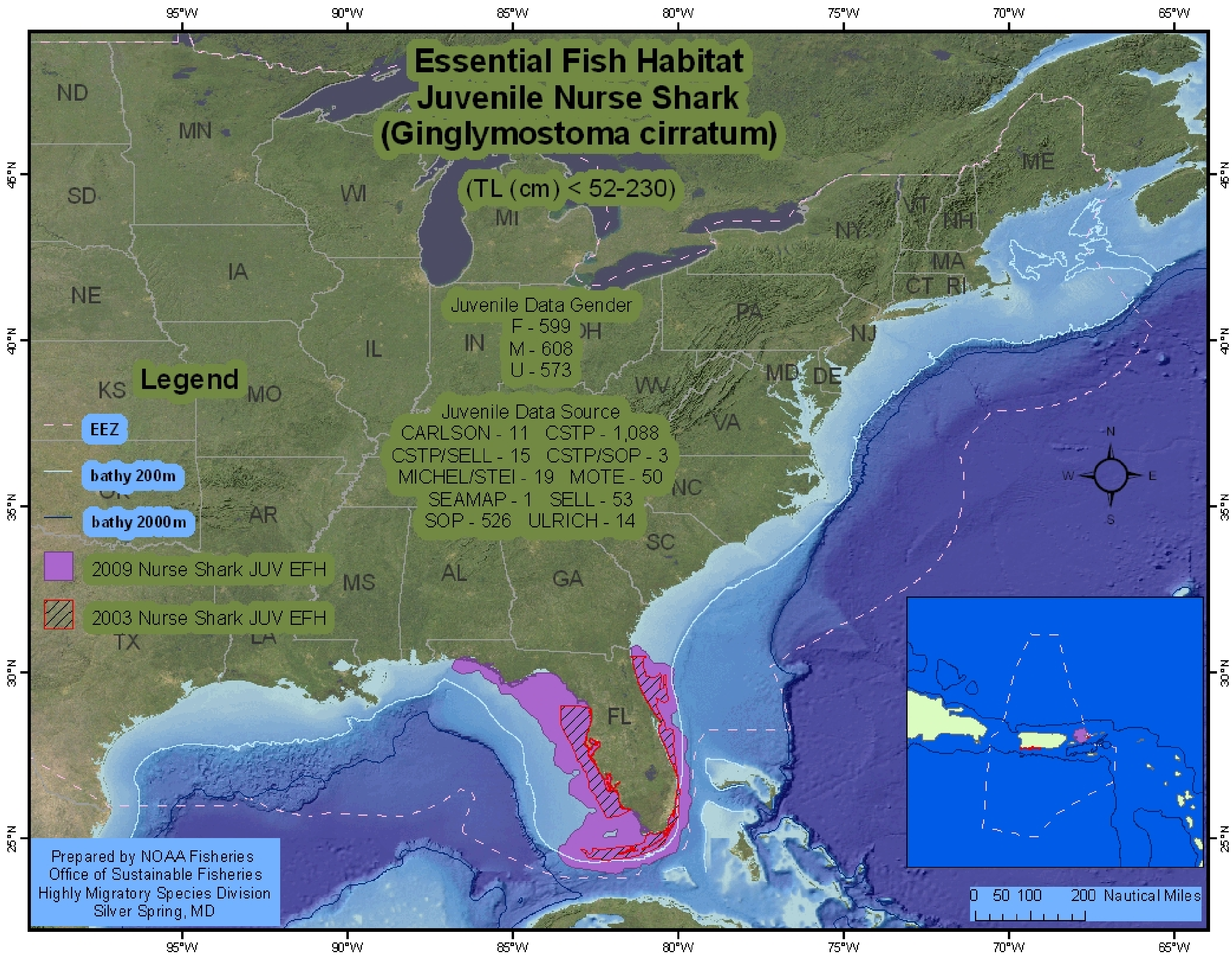

Figure 5.32 **Nurse Shark: Juvenile.**

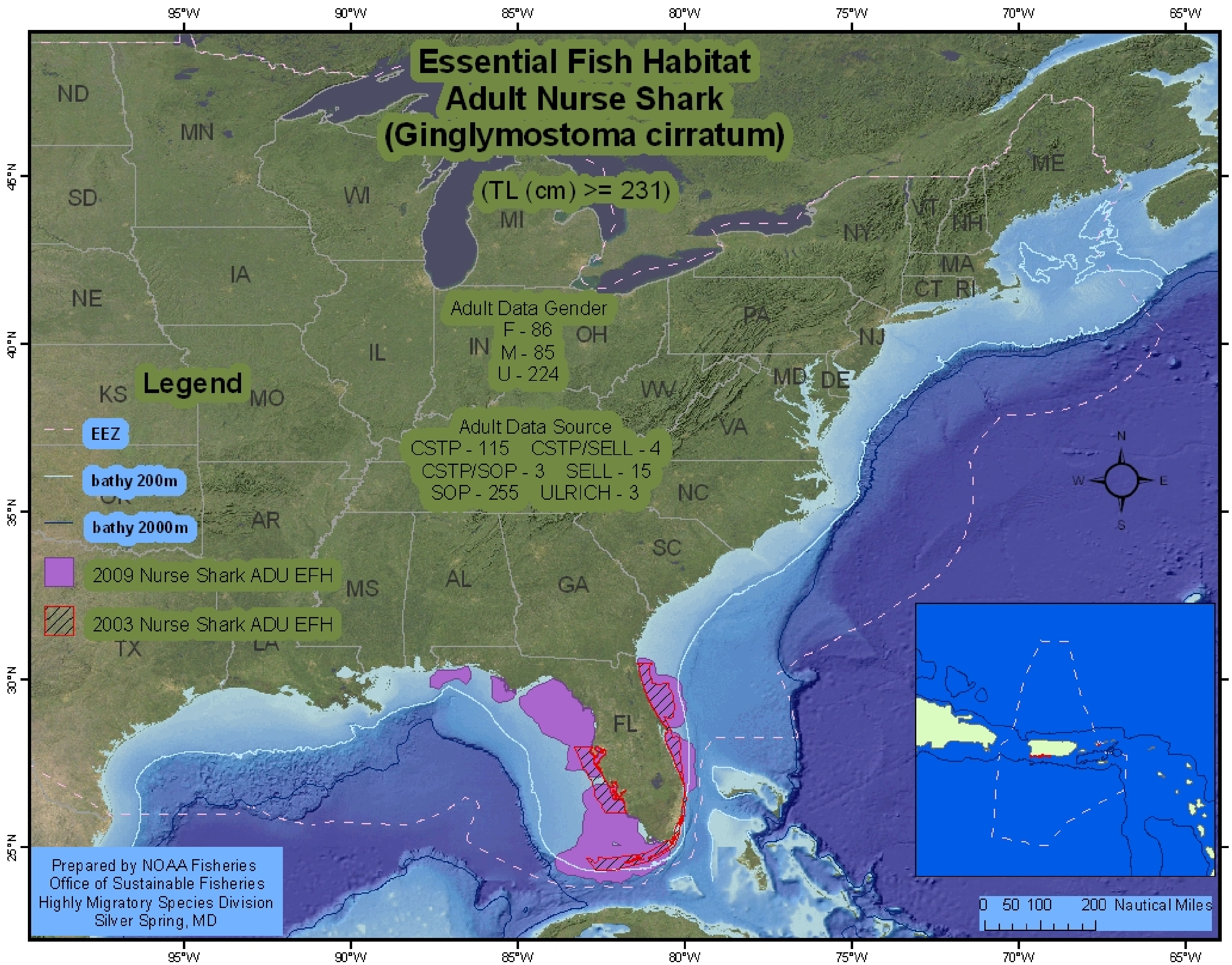

Figure 5.33 **Nurse Shark: Adult.**

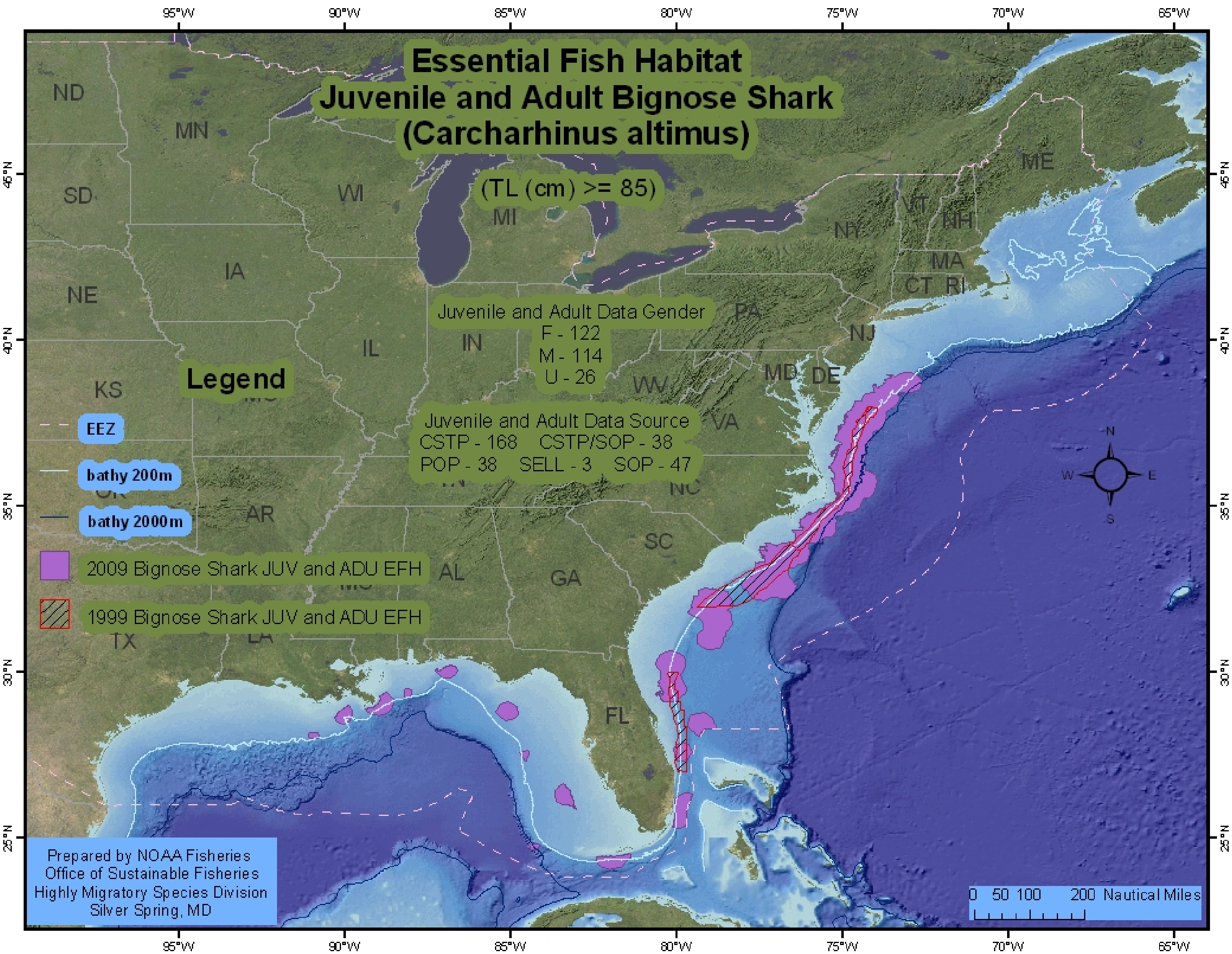

Figure 5.34 **Bignose Shark: Juvenile and Adult Combined.**

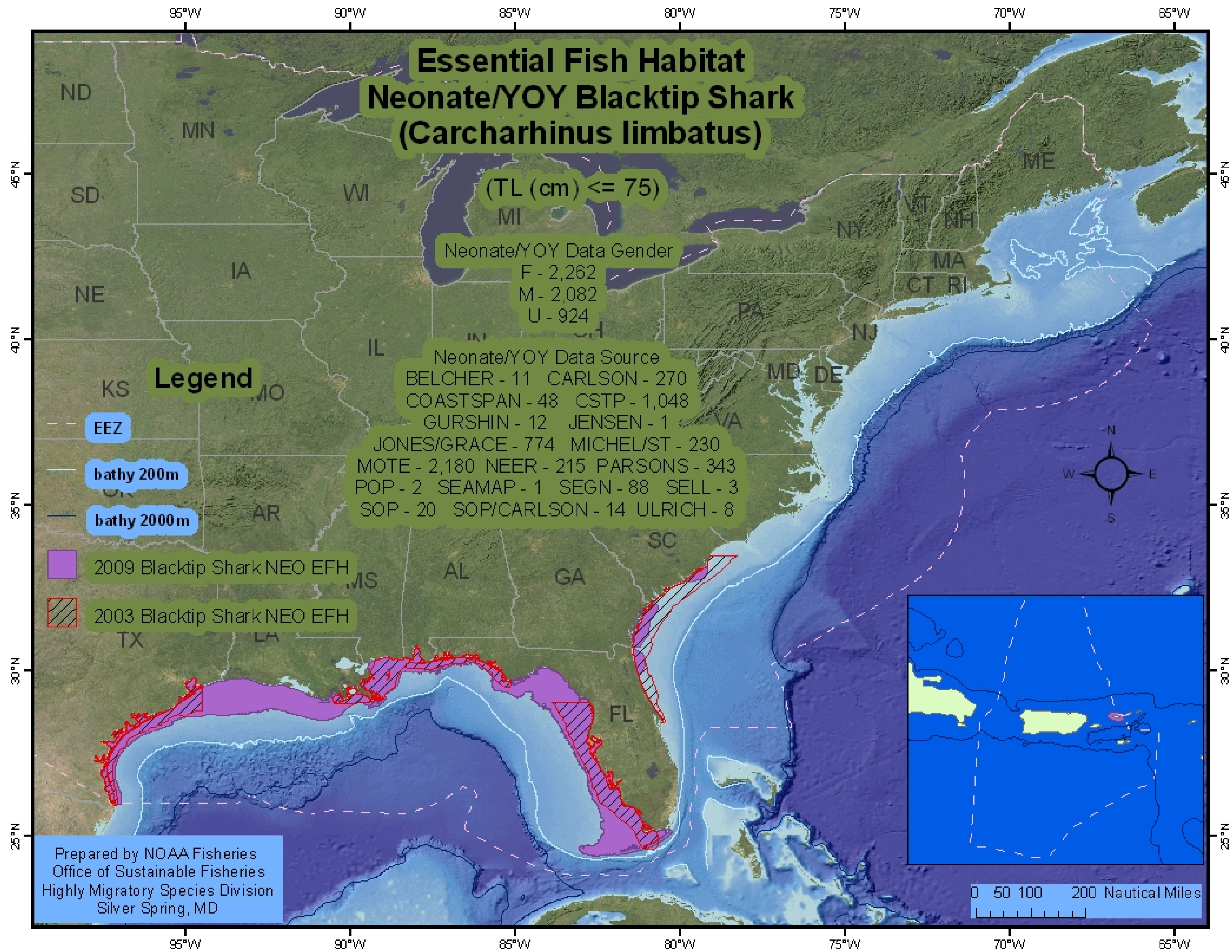

Figure 5.35 **Blacktip Shark: Neonate.**

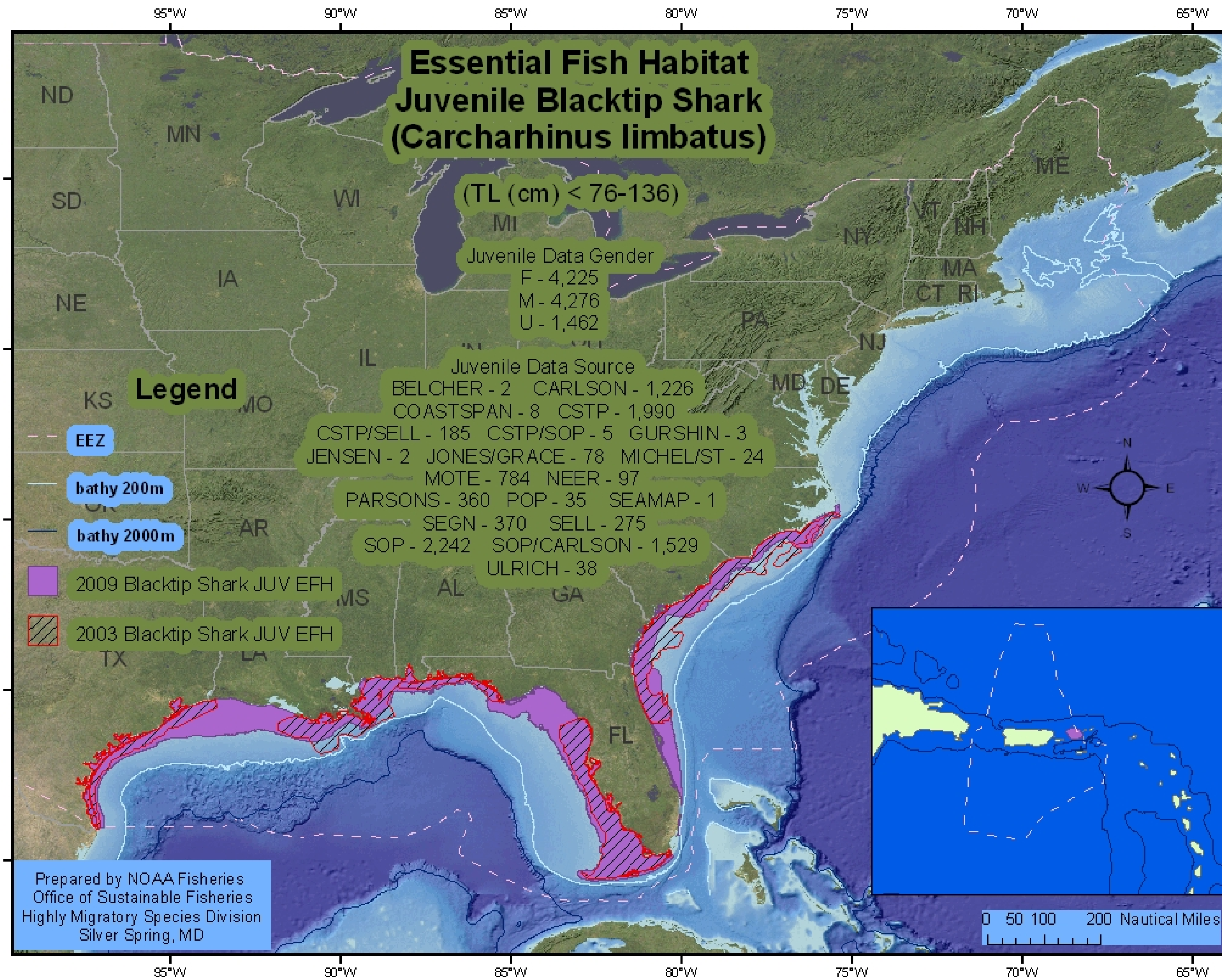

Figure 5.36 Blacktip Shark: Juvenile.

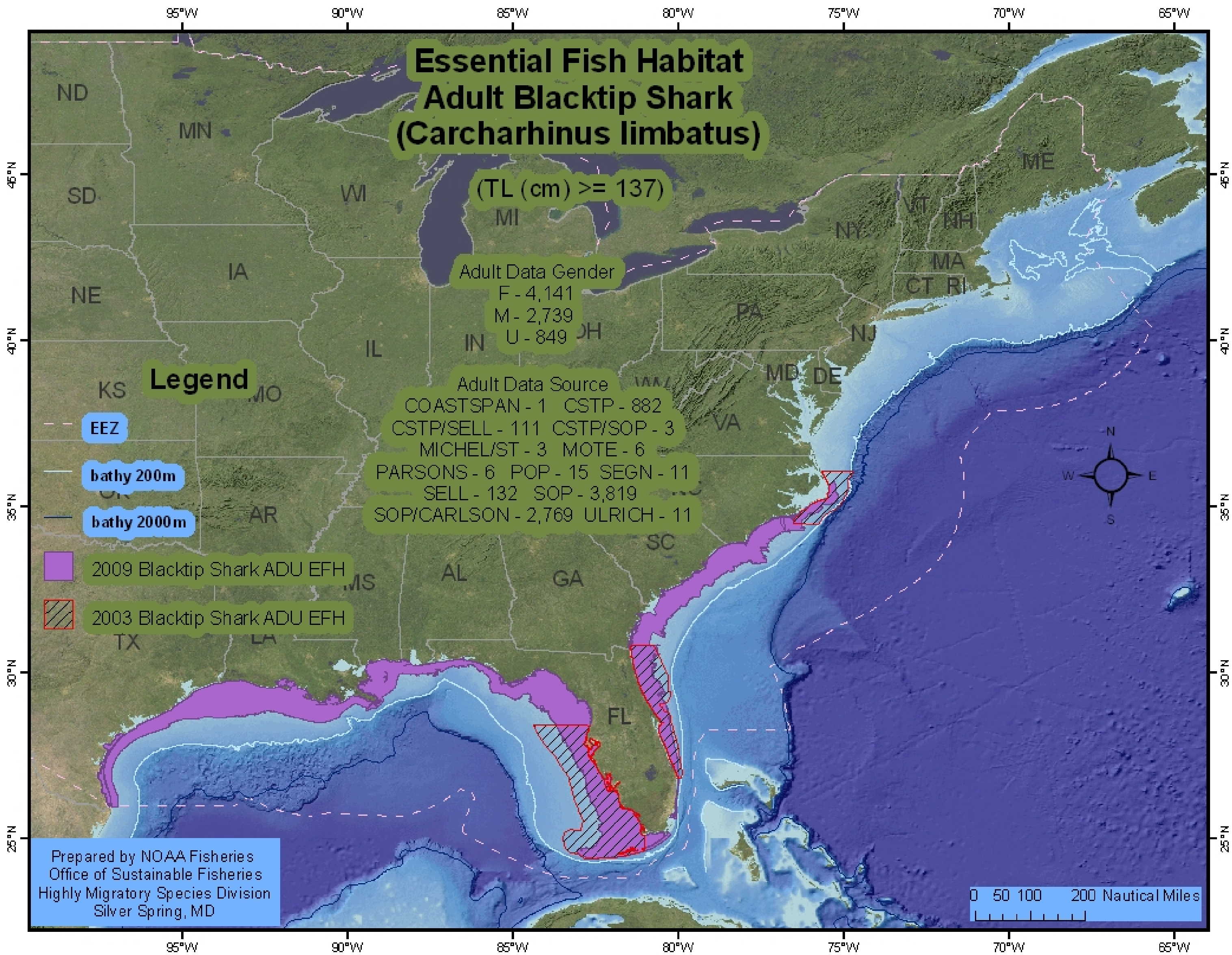

Figure 5.37 Blacktip Shark: Adult.

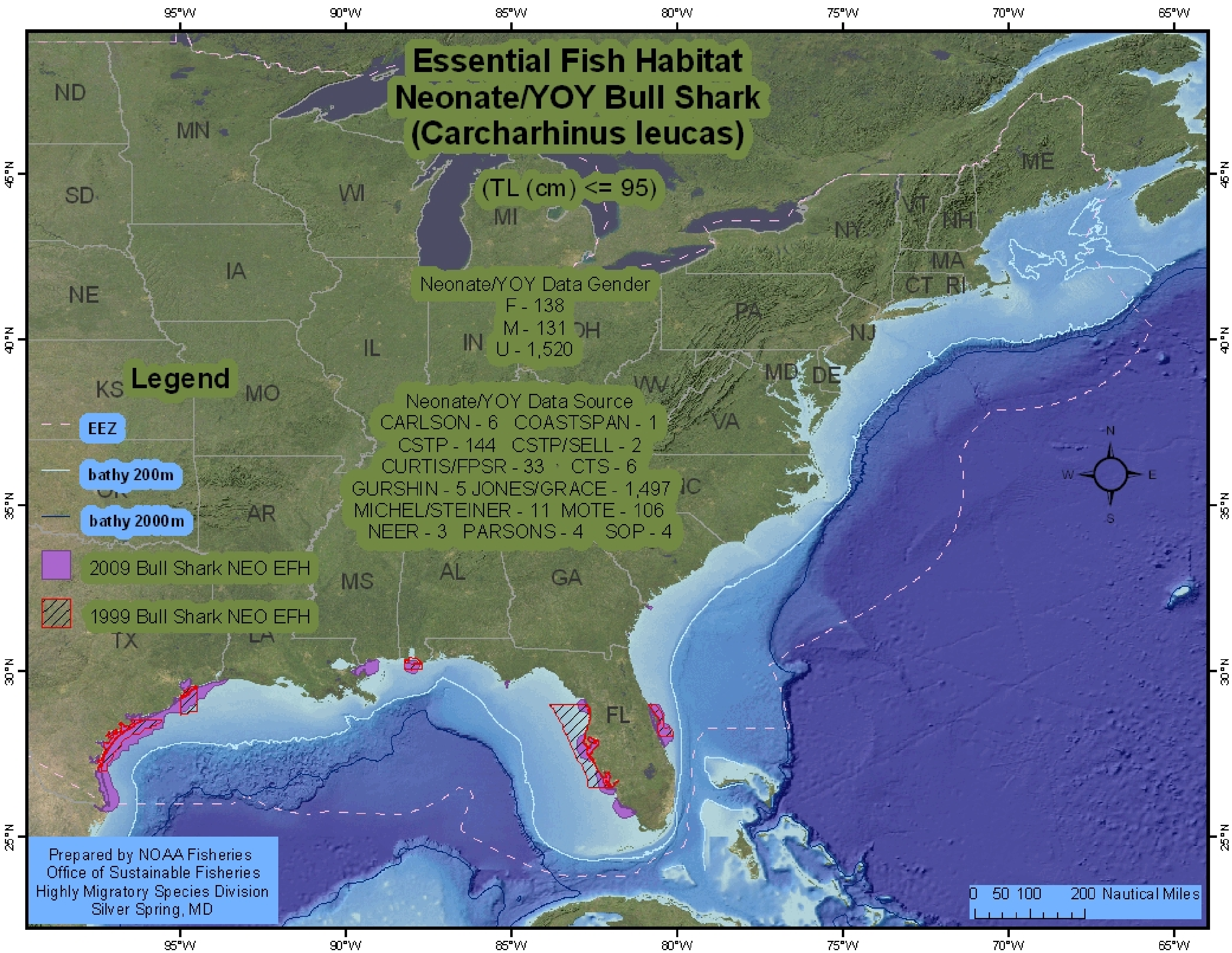

Figure 5.38 Bull Shark: Neonate.

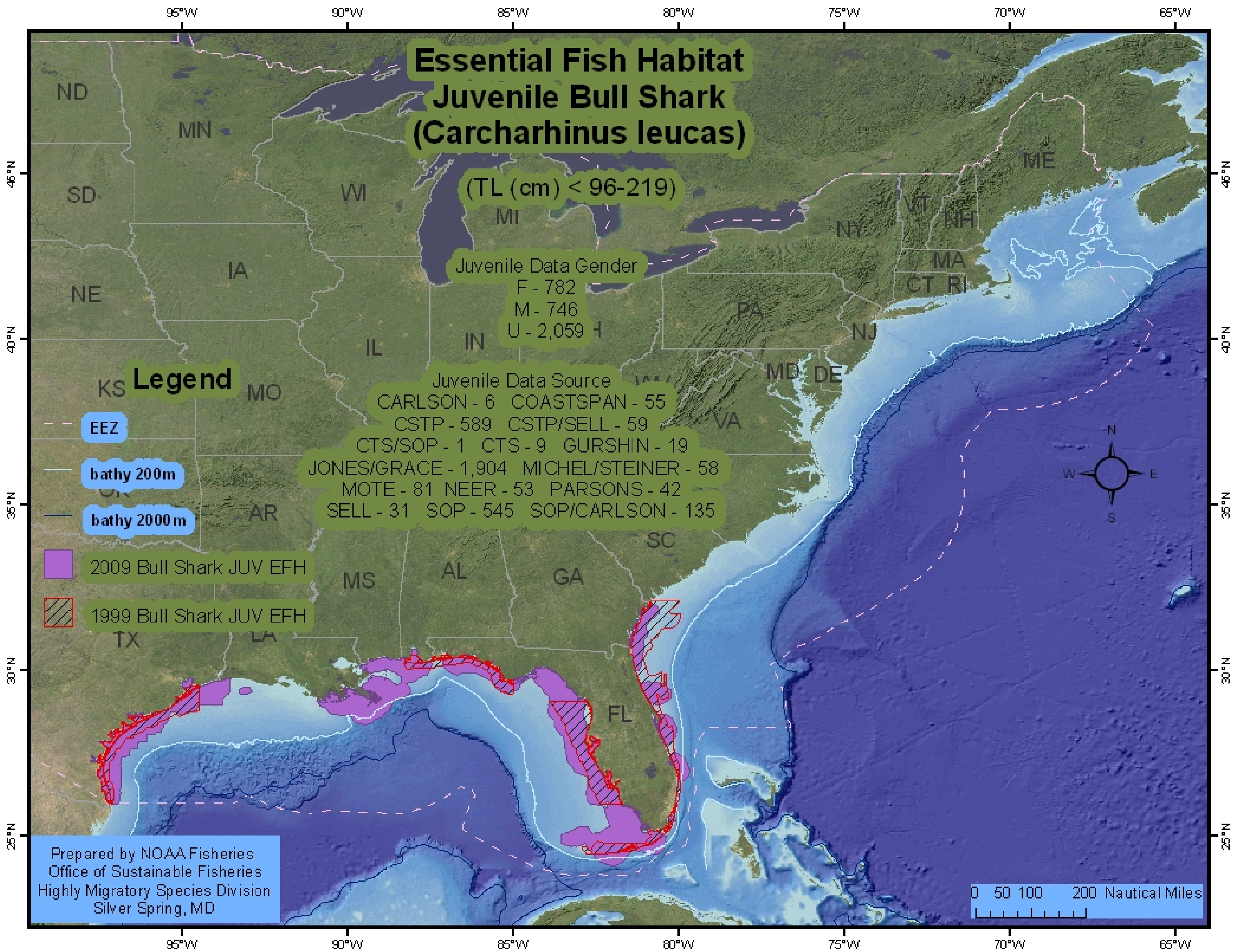

Figure 5.39 **Bull Shark: Juvenile.**

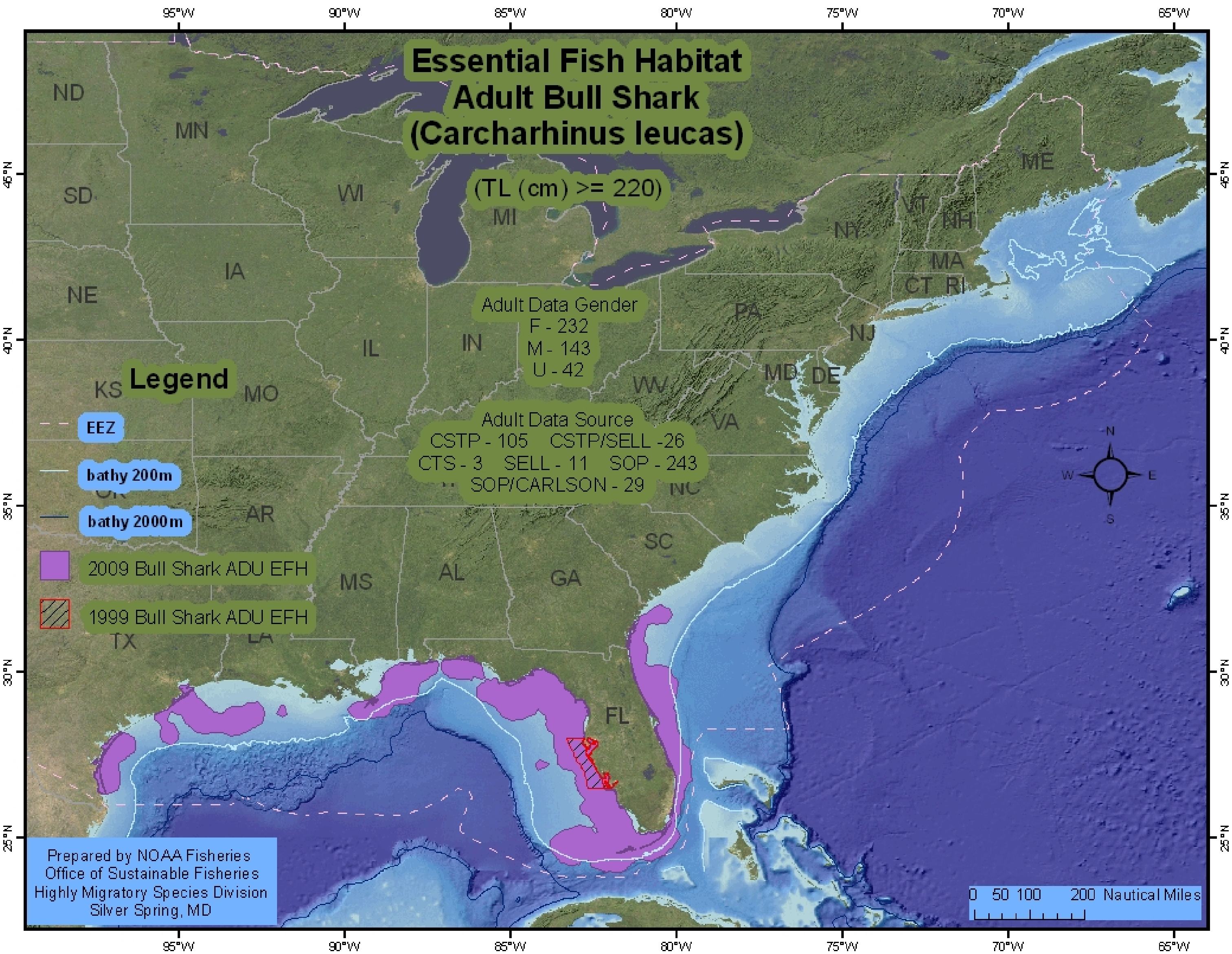

Figure 5.40 **Bull Shark: Adult.**

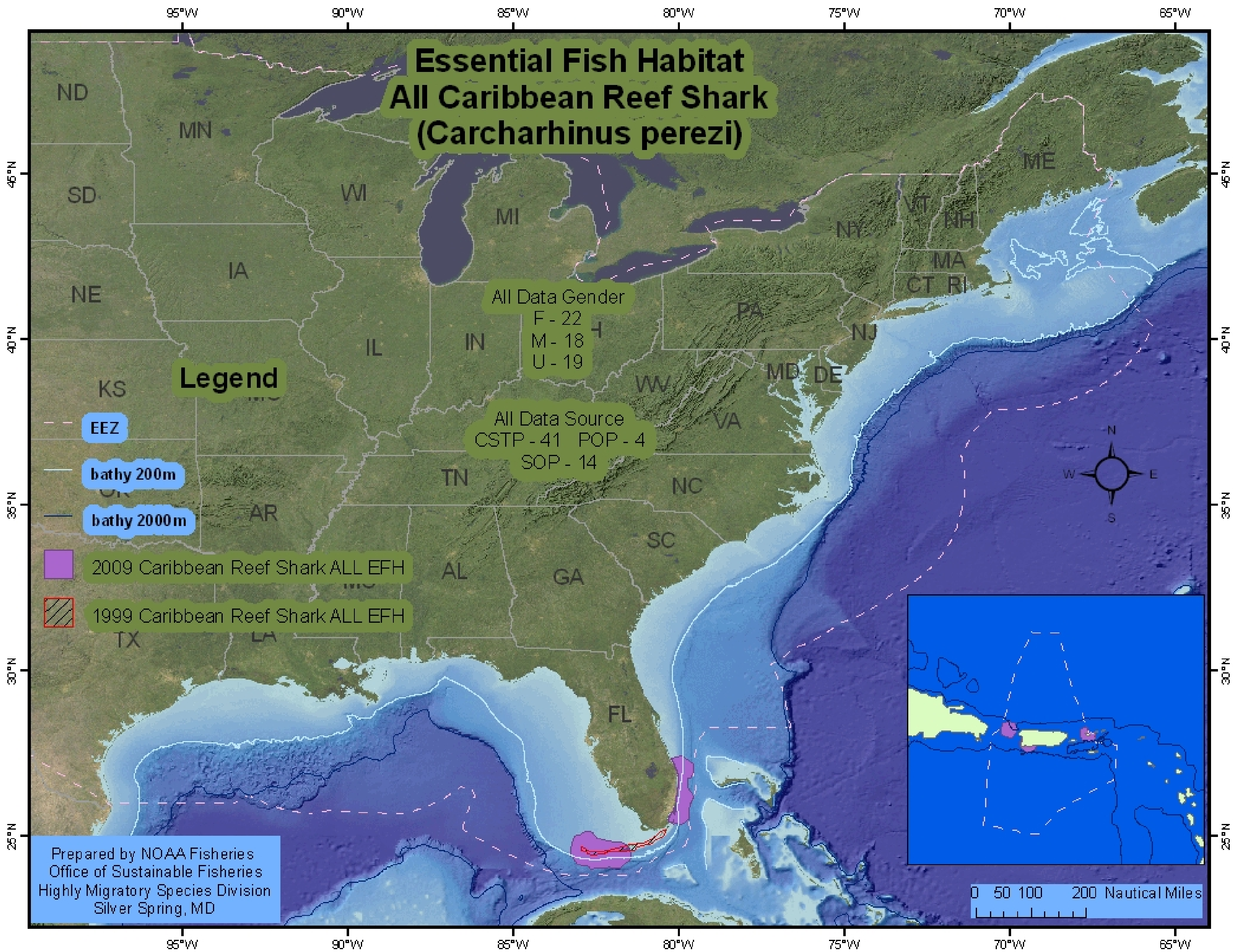

Figure 5.41 **Caribbean Reef Shark: All Life Stages Combined.**

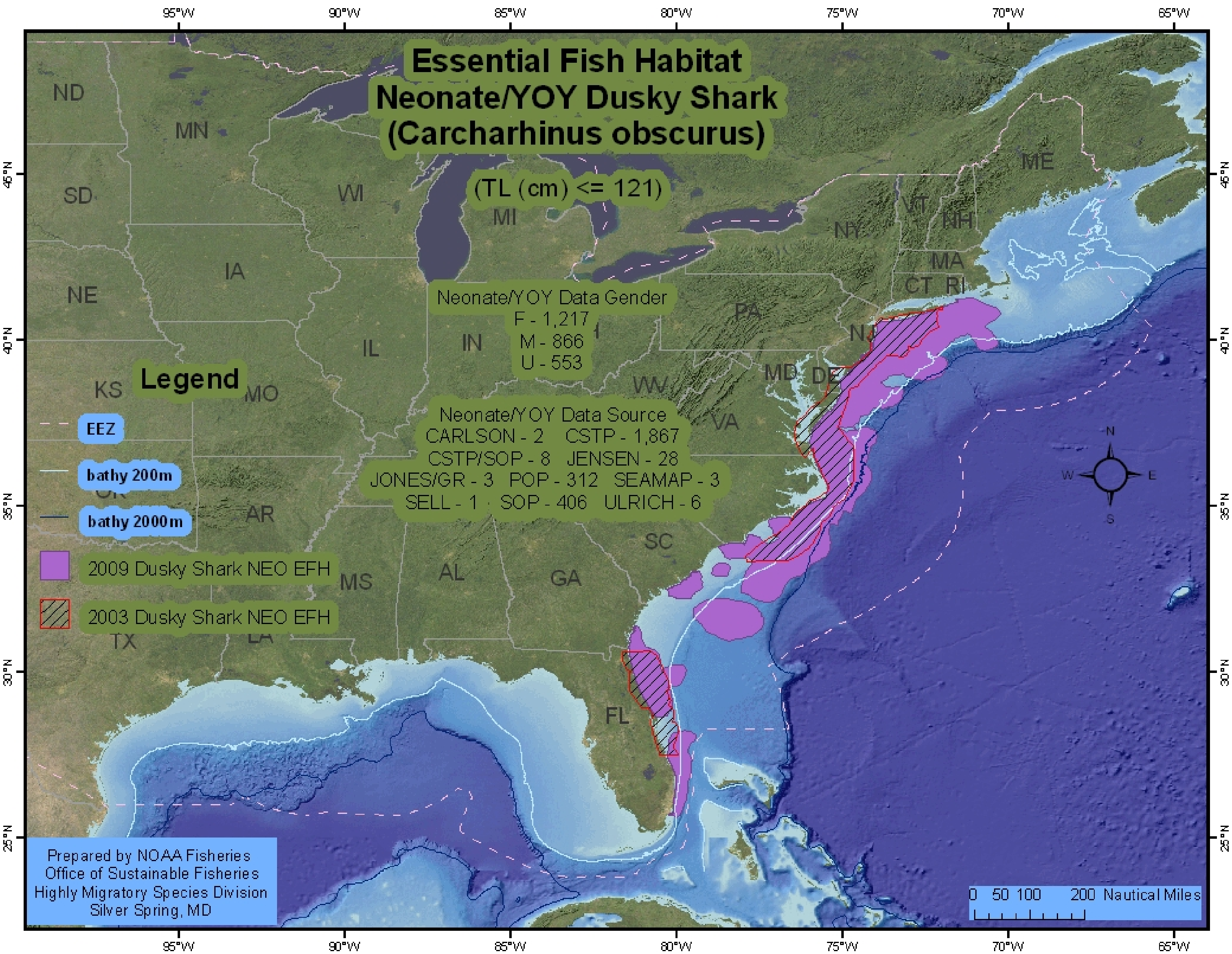

Figure 5.42 **Dusky Shark: Neonate.**

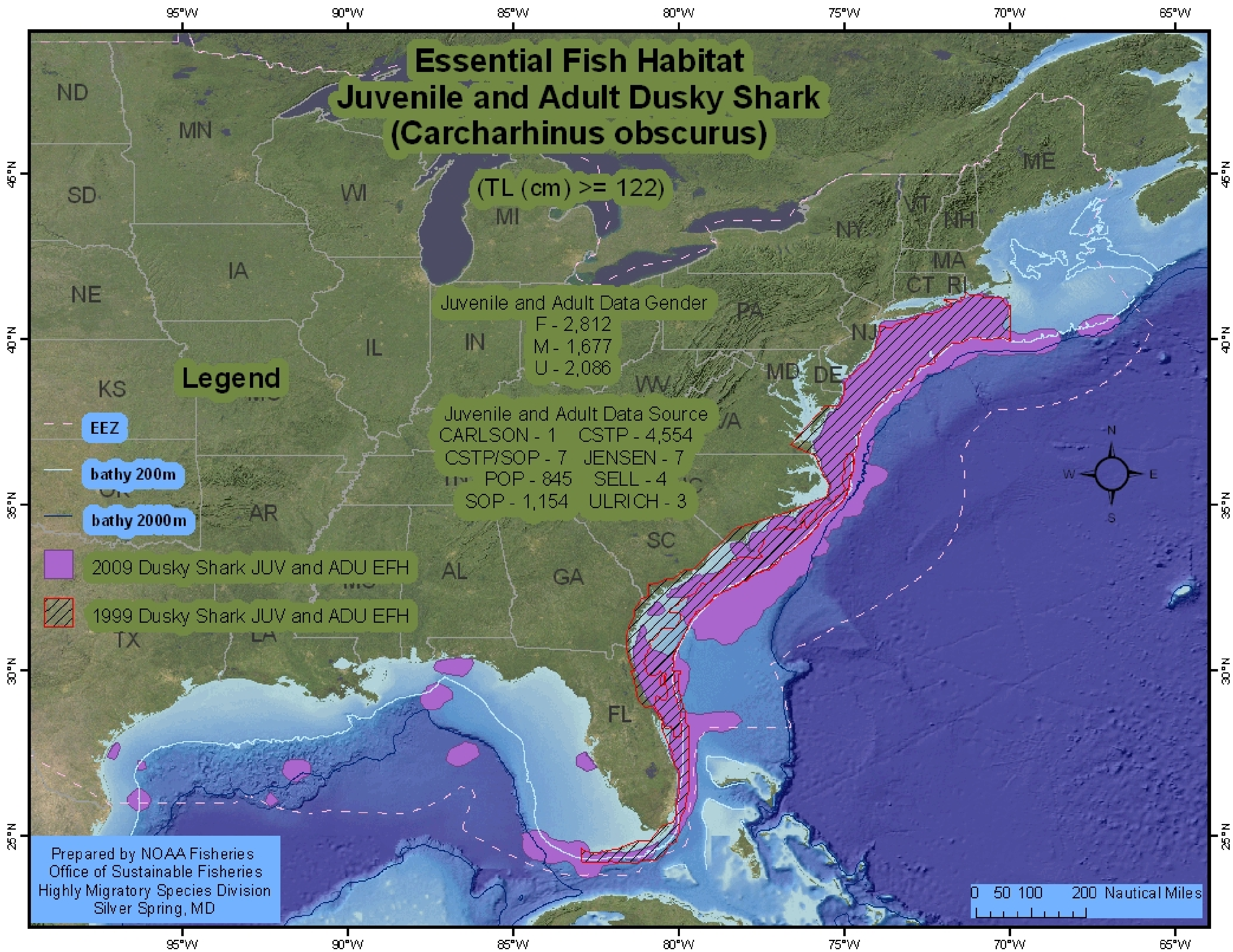

Figure 5.43 Dusky Shark: Juvenile and Adult Combined.

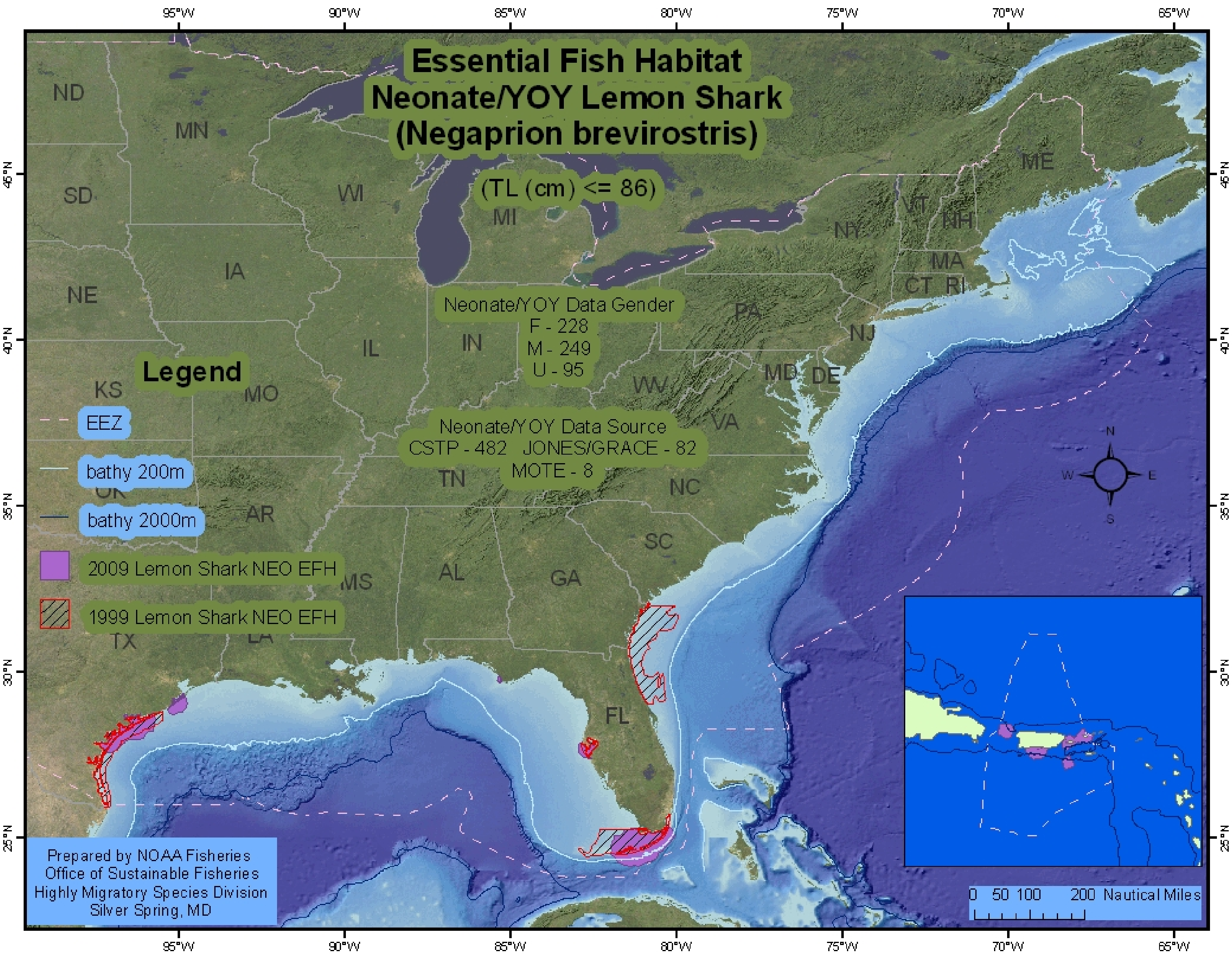

Figure 5.44 Lemon Shark: Neonate.

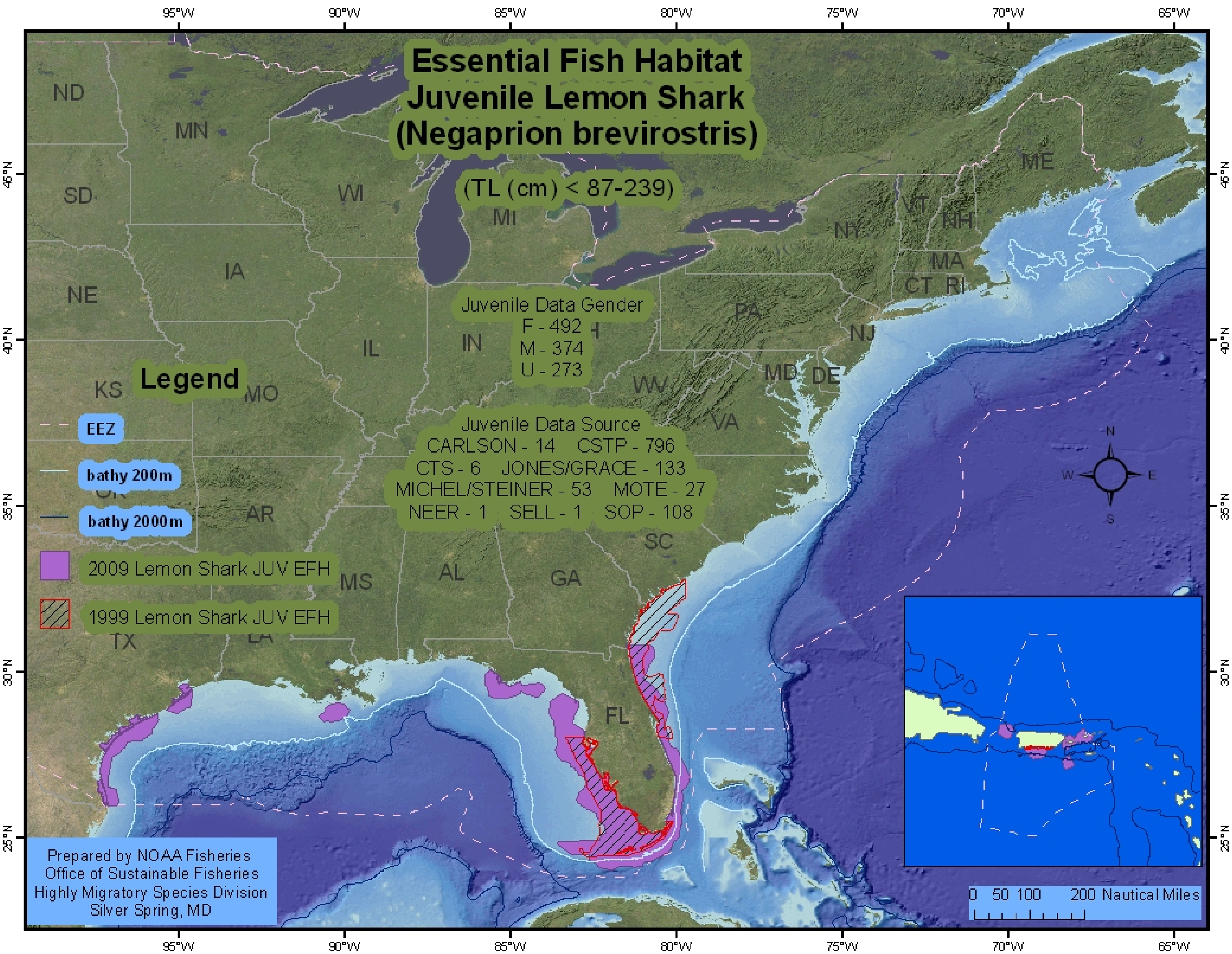

Figure 5.45 Lemon Shark: Juvenile.

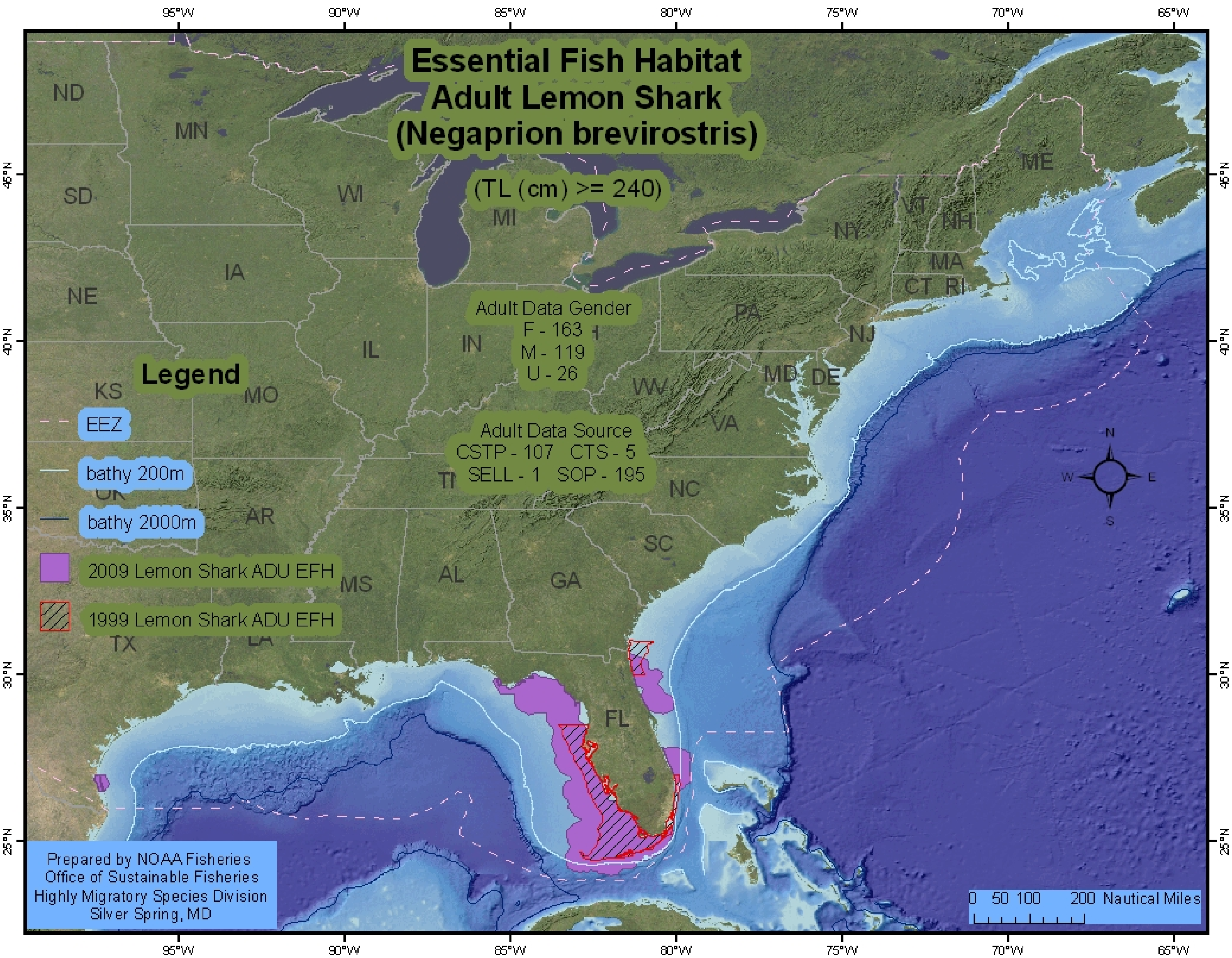

Figure 5.46 Lemon Shark: Adult.

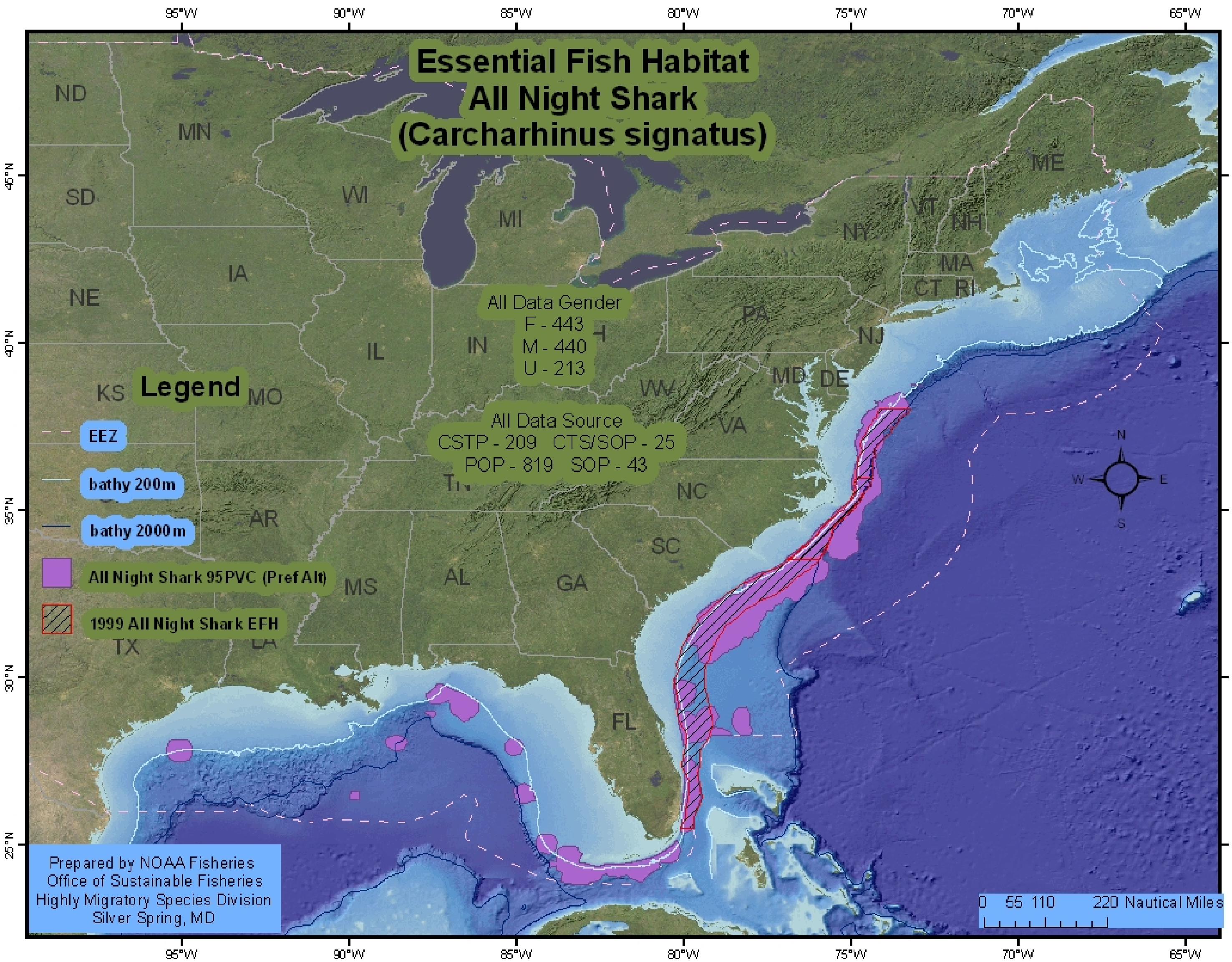

Figure 5.47 **Night Shark: All Life Stages Combined.**

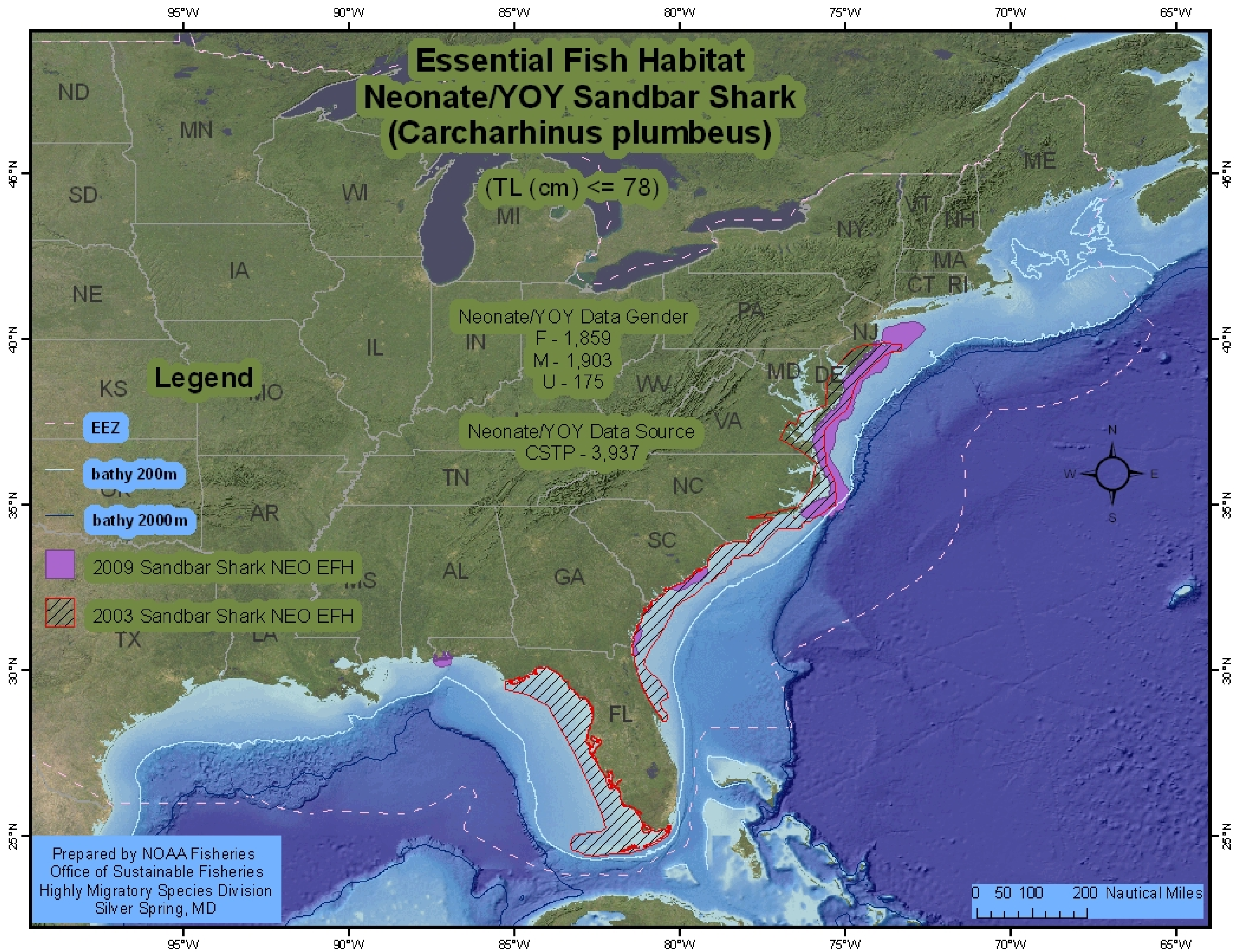

Figure 5.48 Sandbar Shark: Neonate.

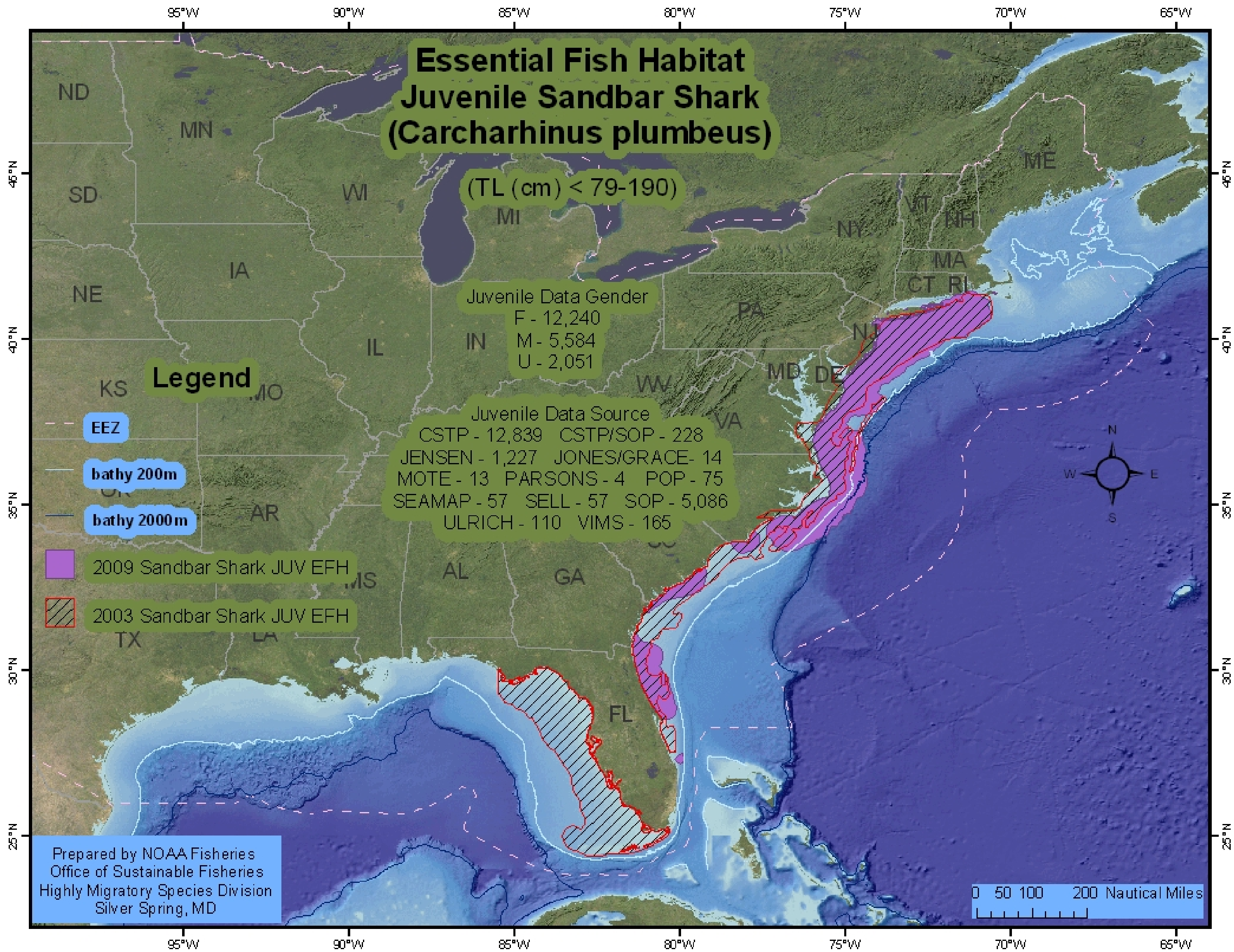

Figure 5.49 Sandbar Shark: Juvenile.

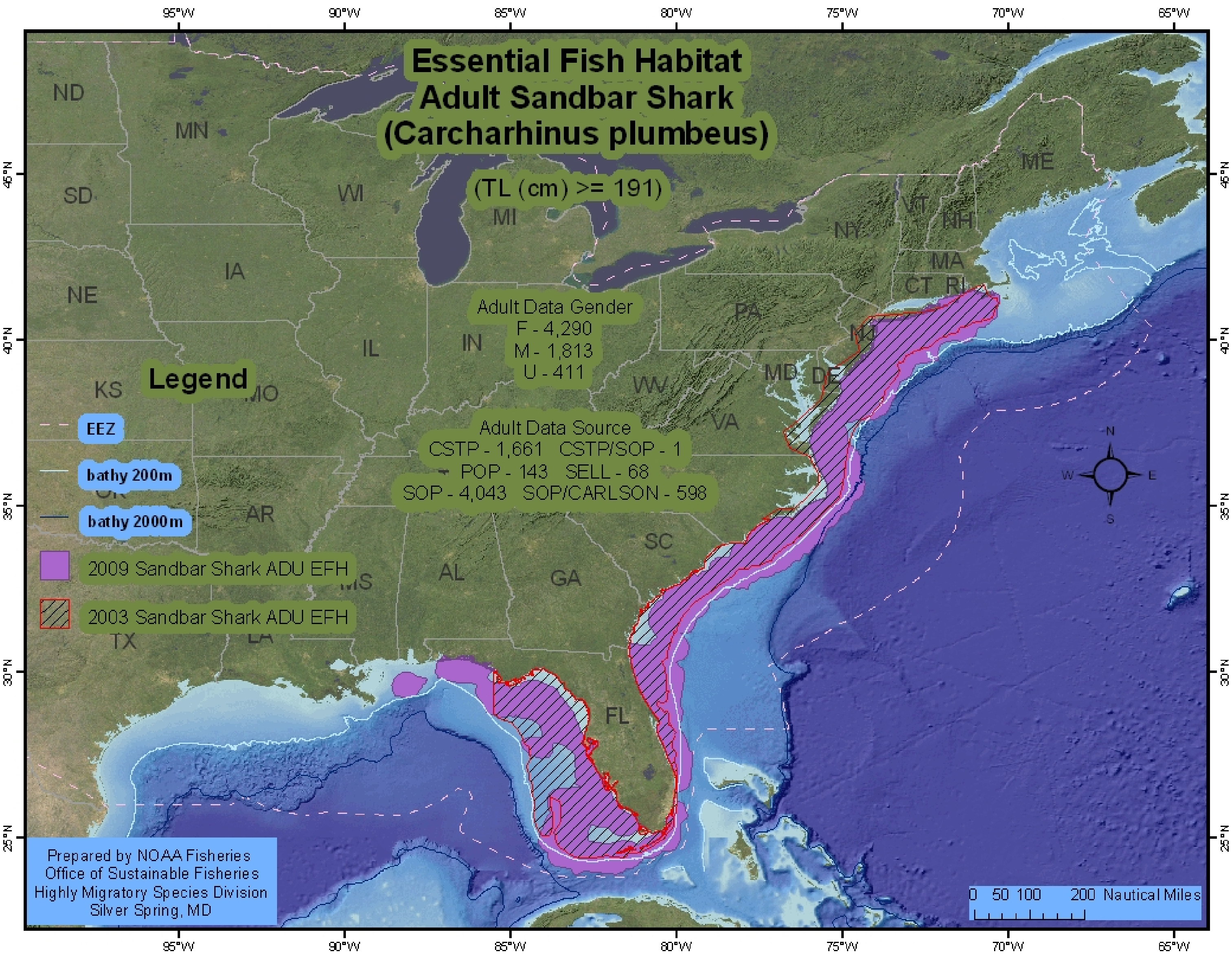

Figure 5.50 **Sandbar Shark: Adult.**

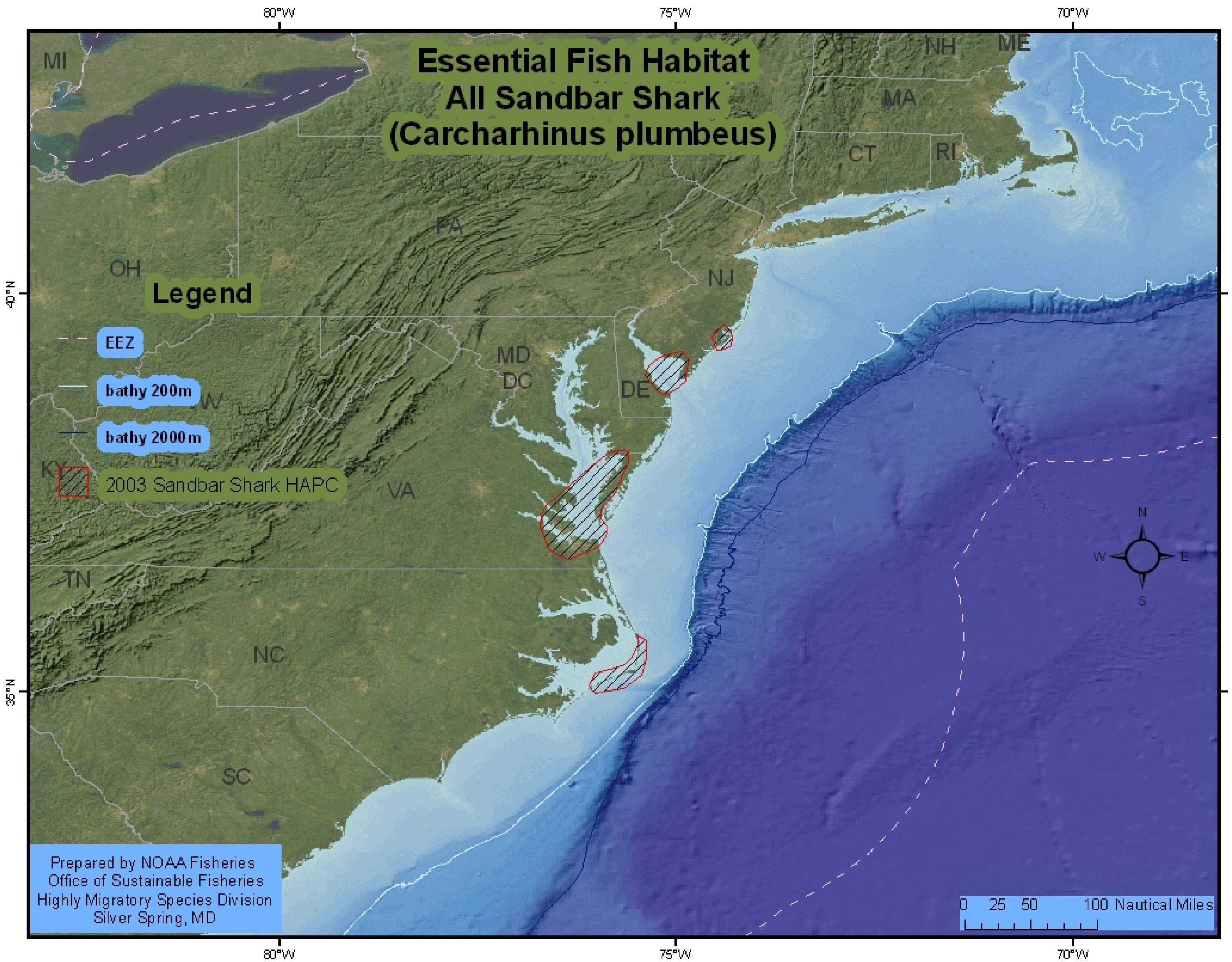

Figure 5.51 Sandbar Shark Habitat Area of Particular Concern.

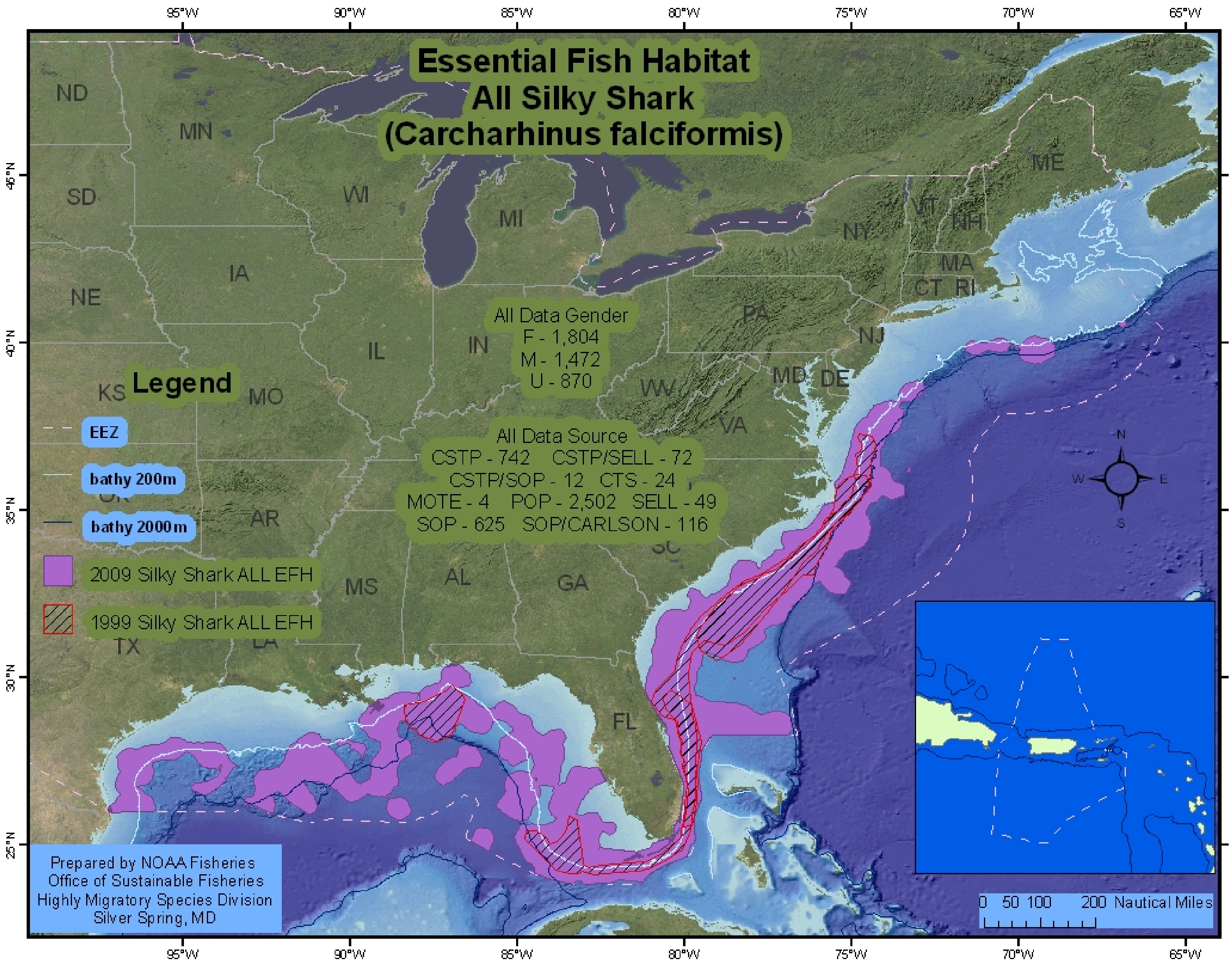

Figure 5.52 Silky Shark: All Life Stages Combined.

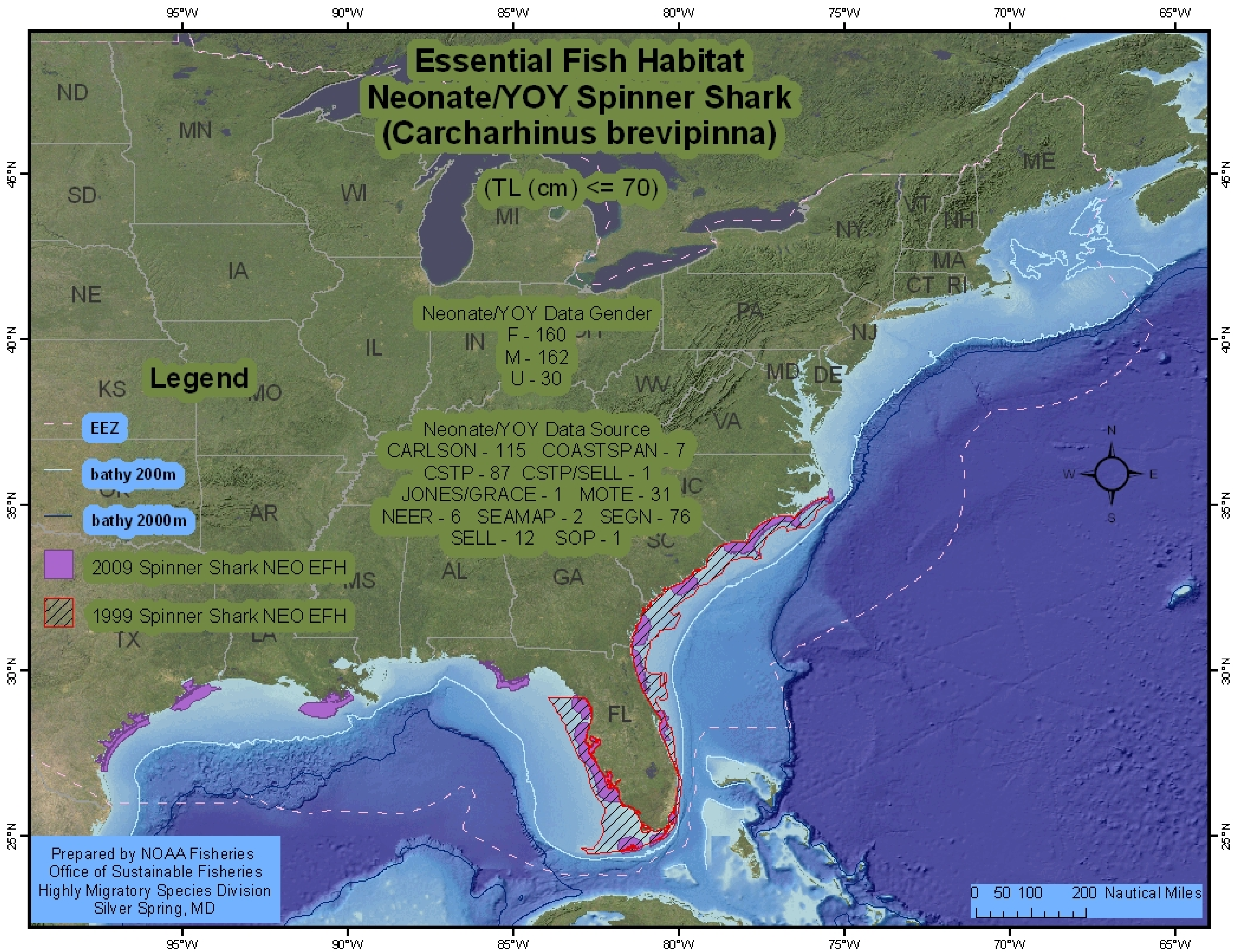

Figure 5.53 **Spinner Shark: Neonate.**

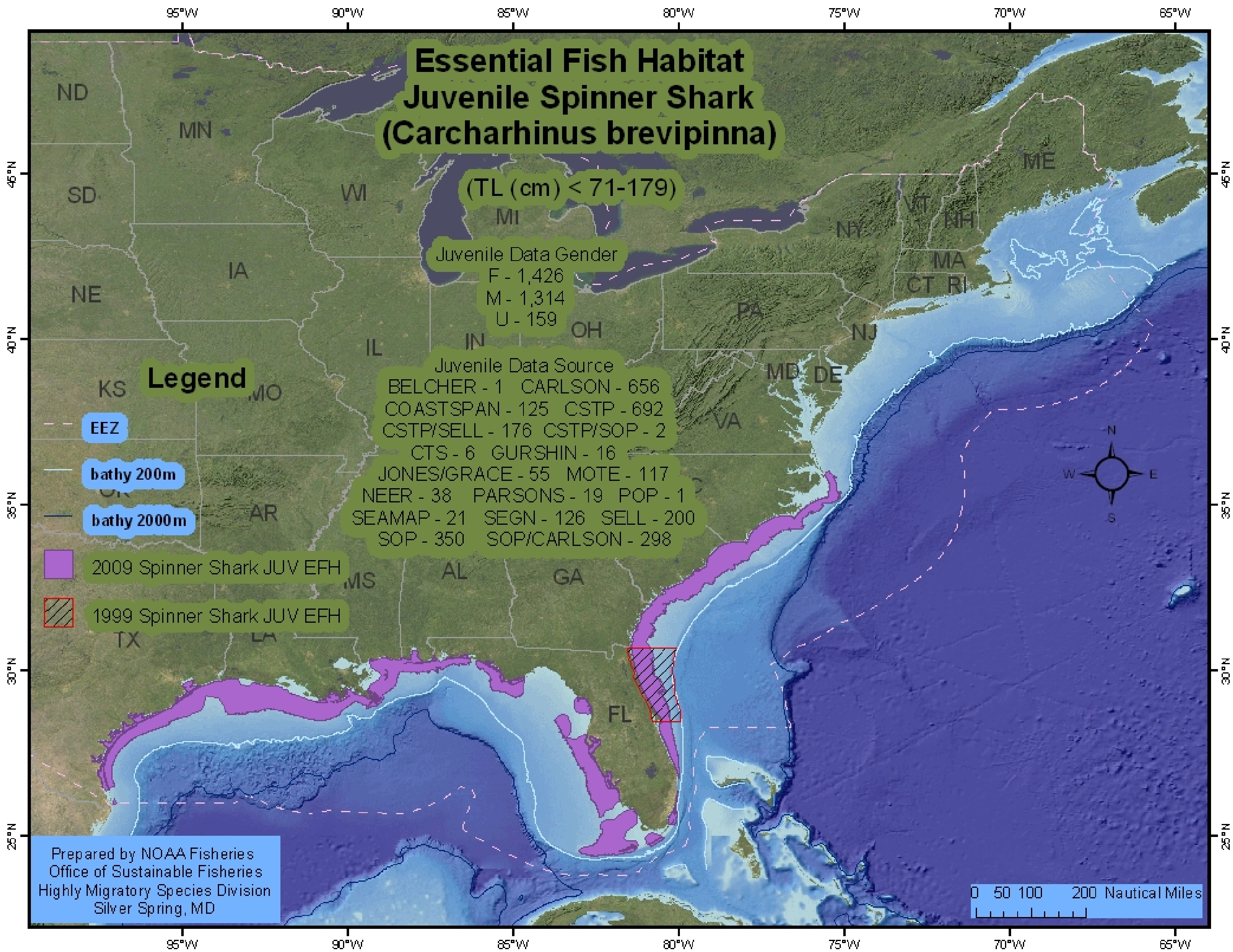

Figure 5.54 **Spinner Shark: Juvenile.**

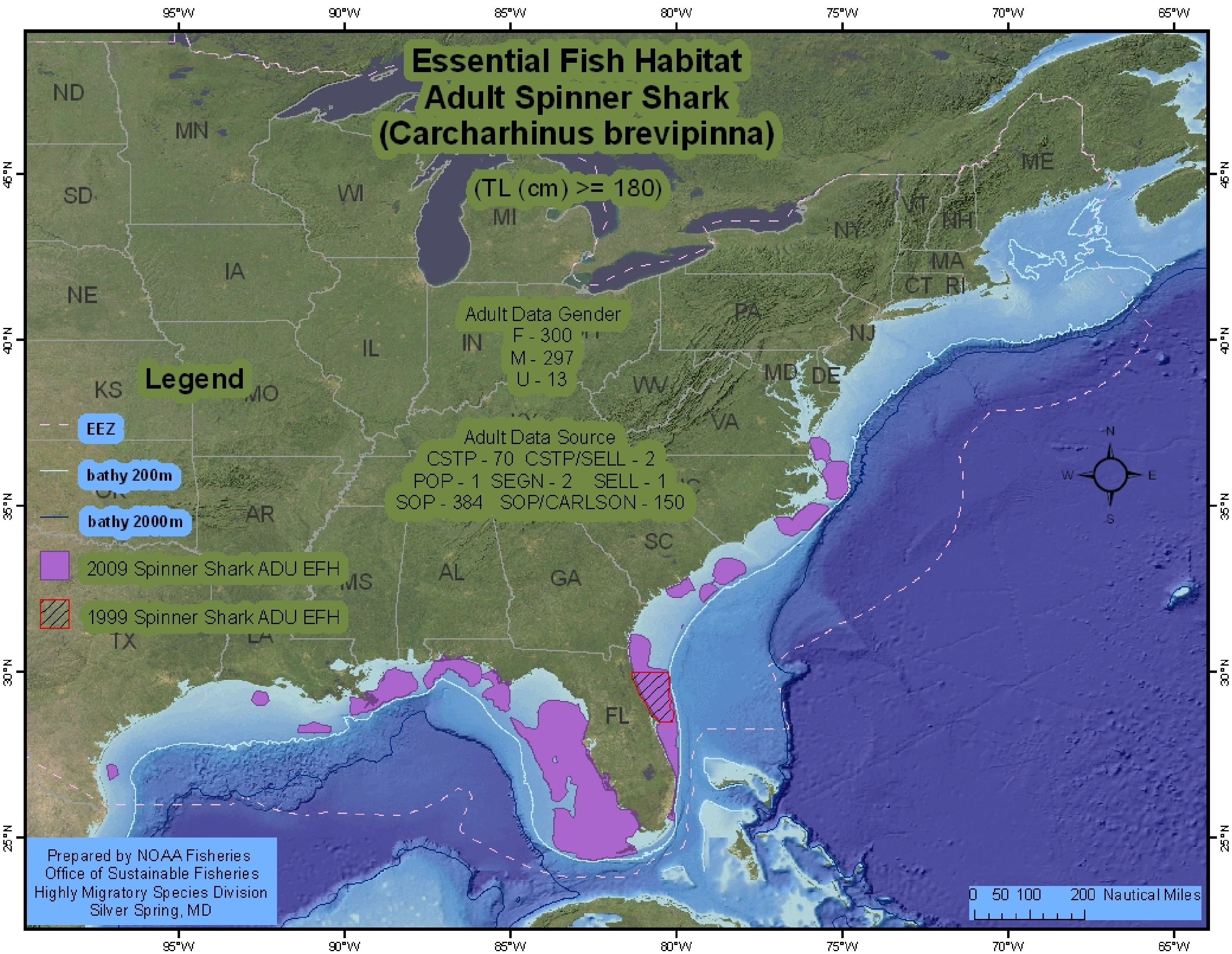

Figure 5.55 Spinner Shark: Adult.

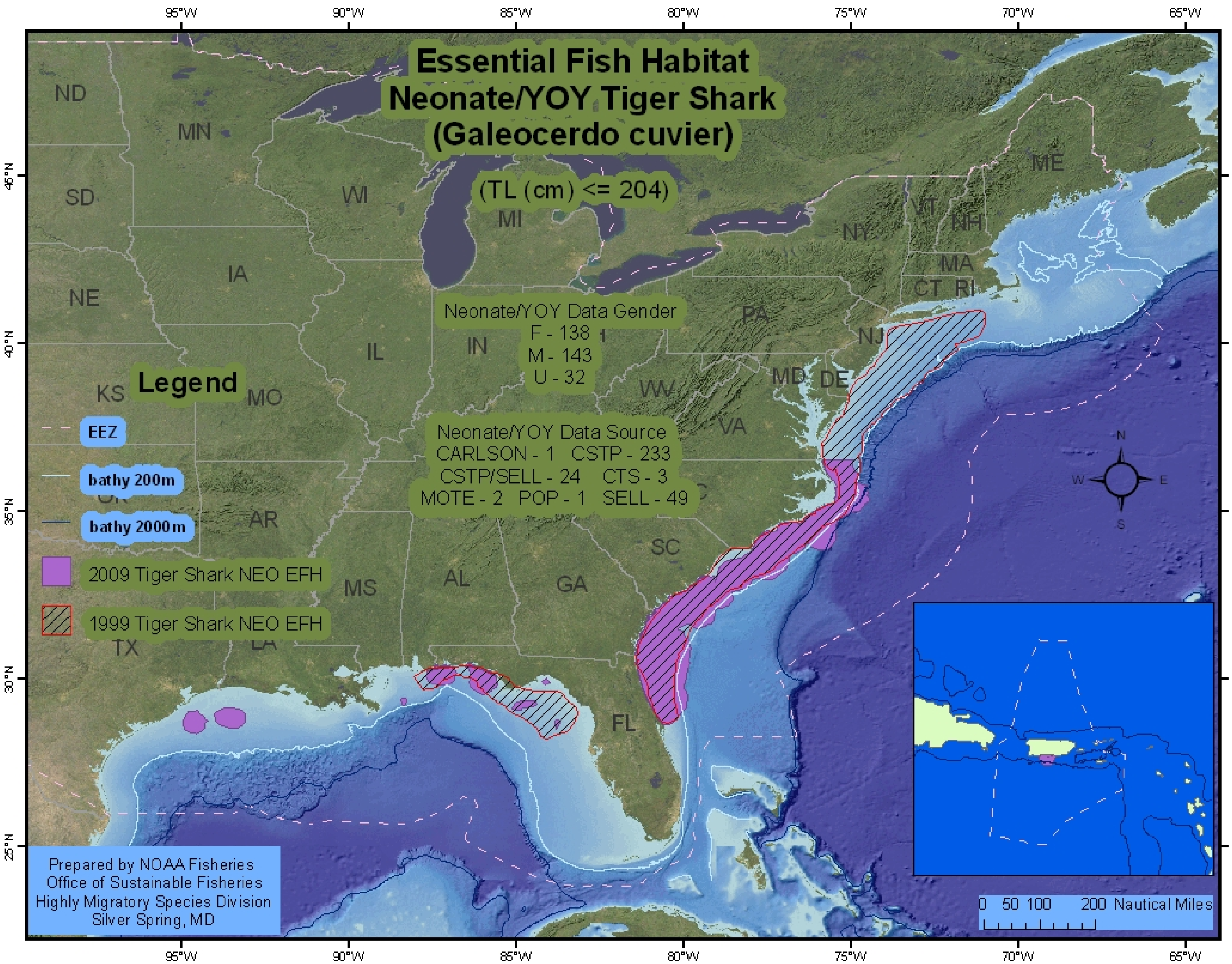

Figure 5.56 **Tiger Shark: Neonate.**

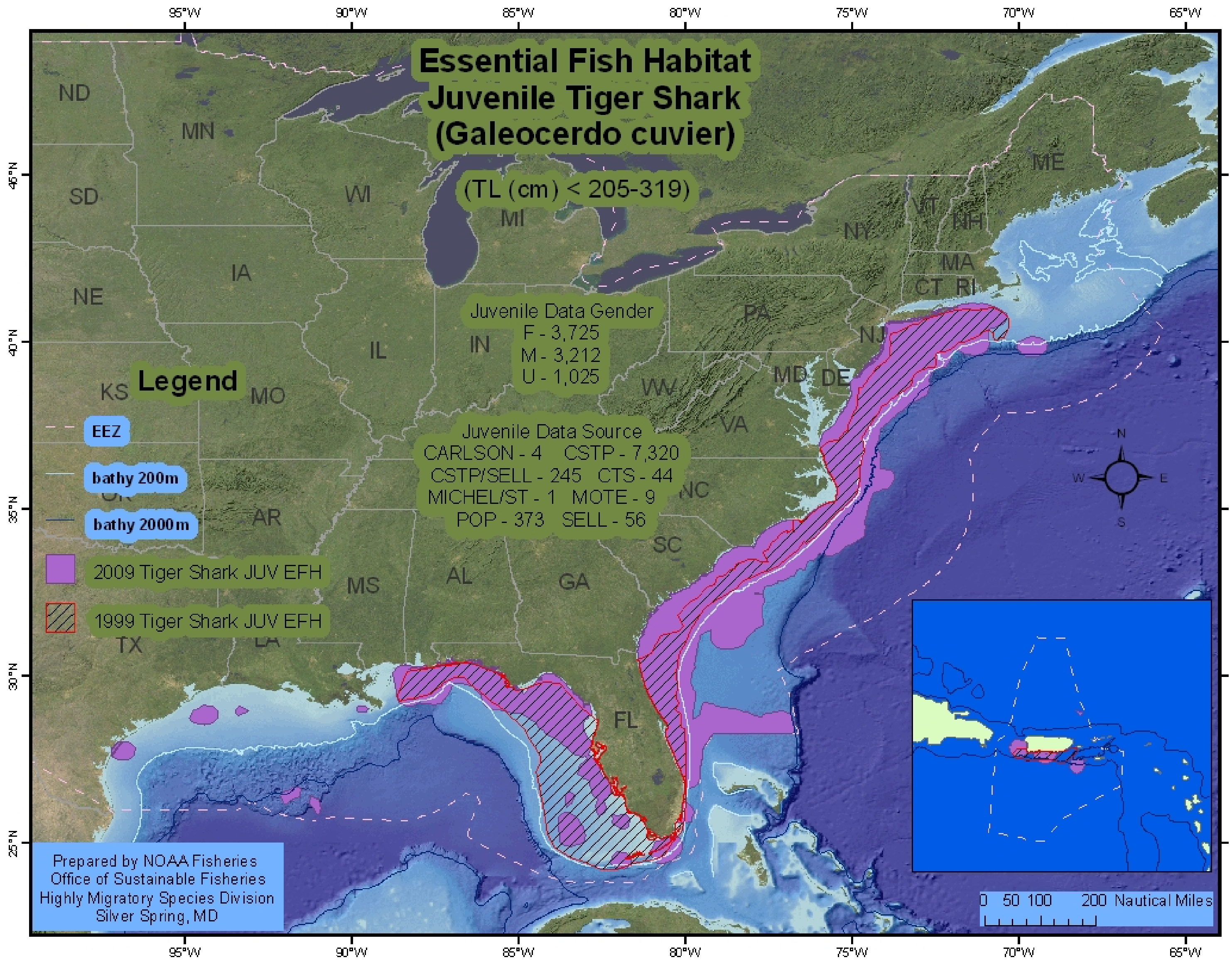

Figure 5.57 Tiger Shark: Juvenile.

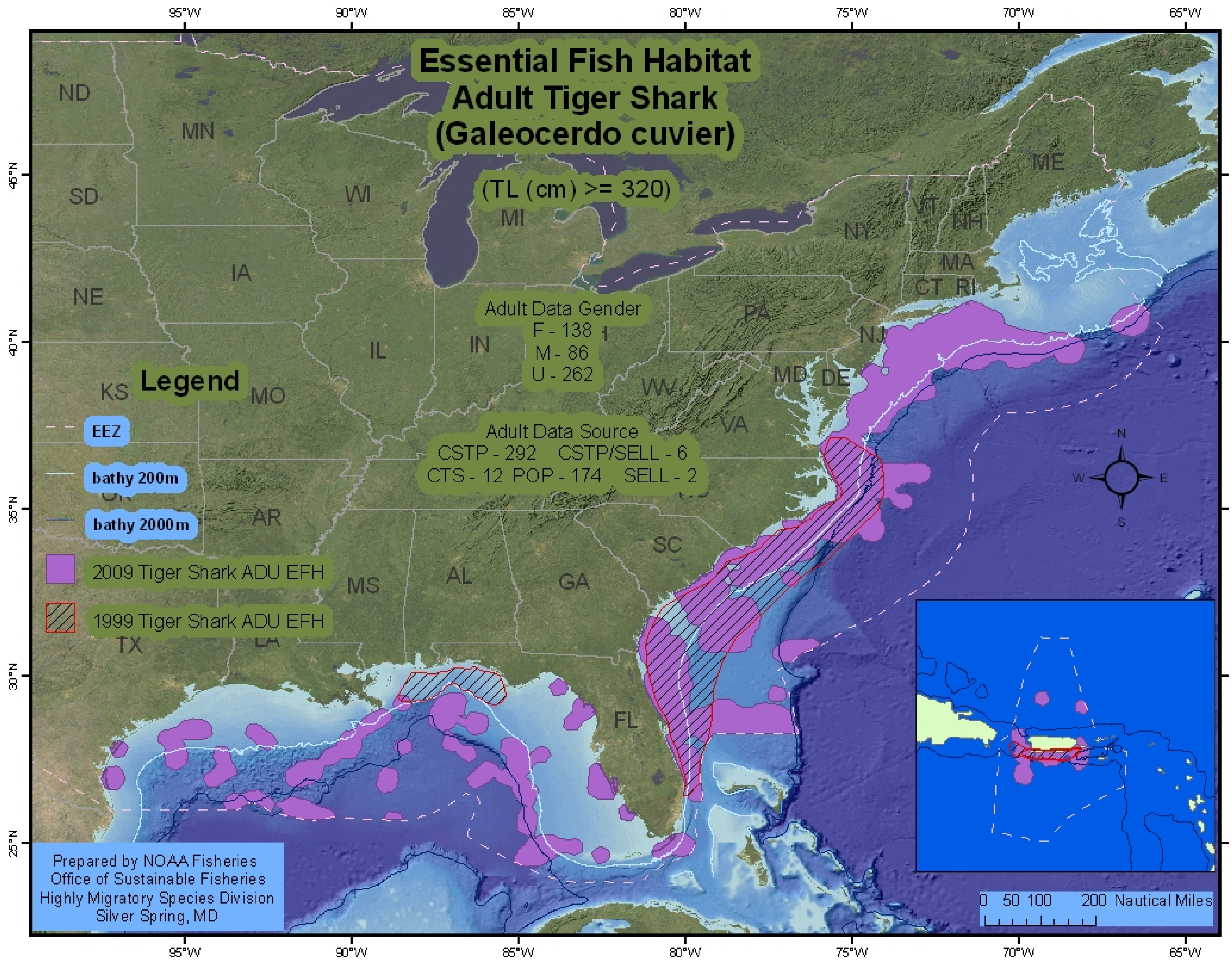

Figure 5.58 Tiger Shark: Adult.

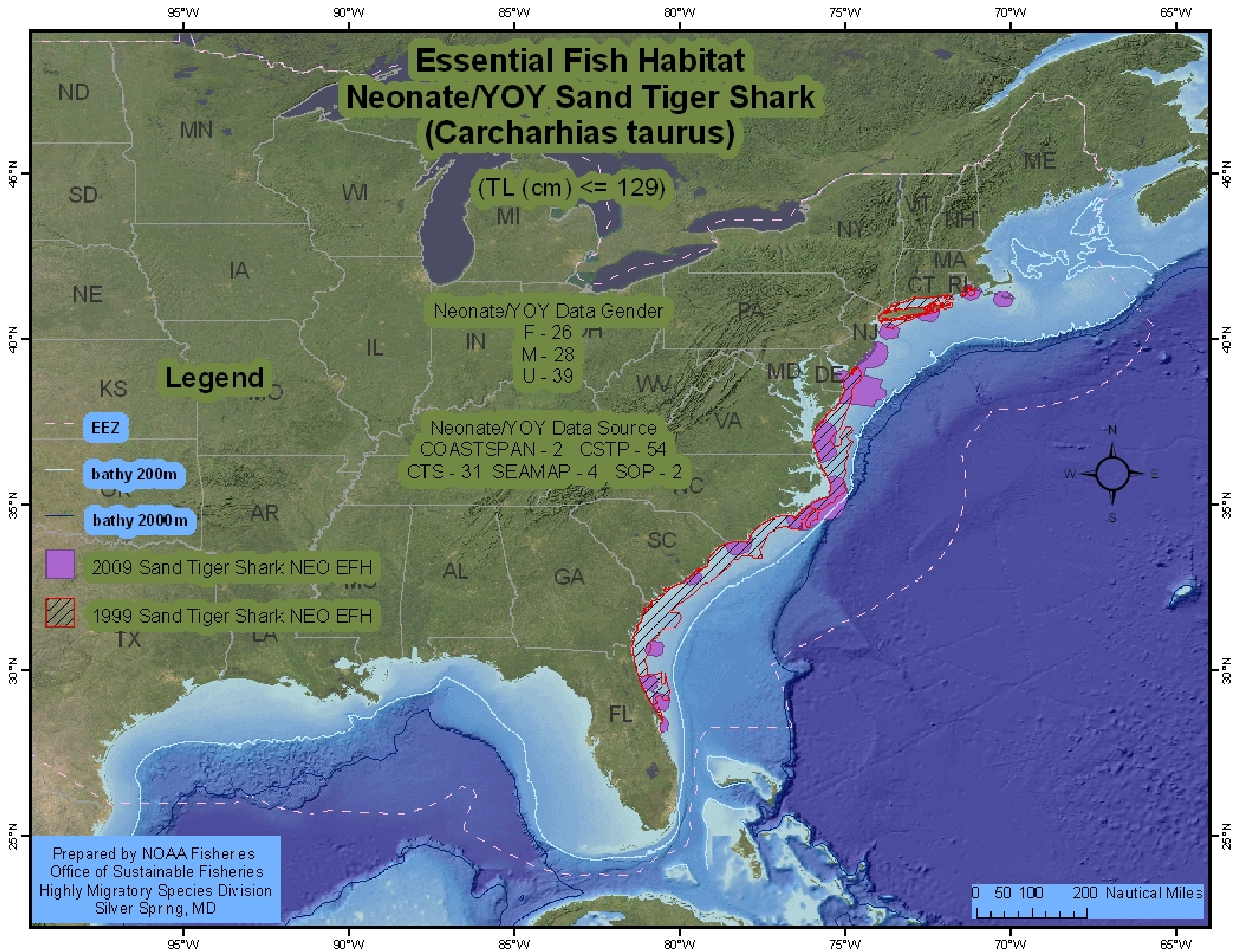

Figure 5.59 Sand Tiger Shark: Neonate.

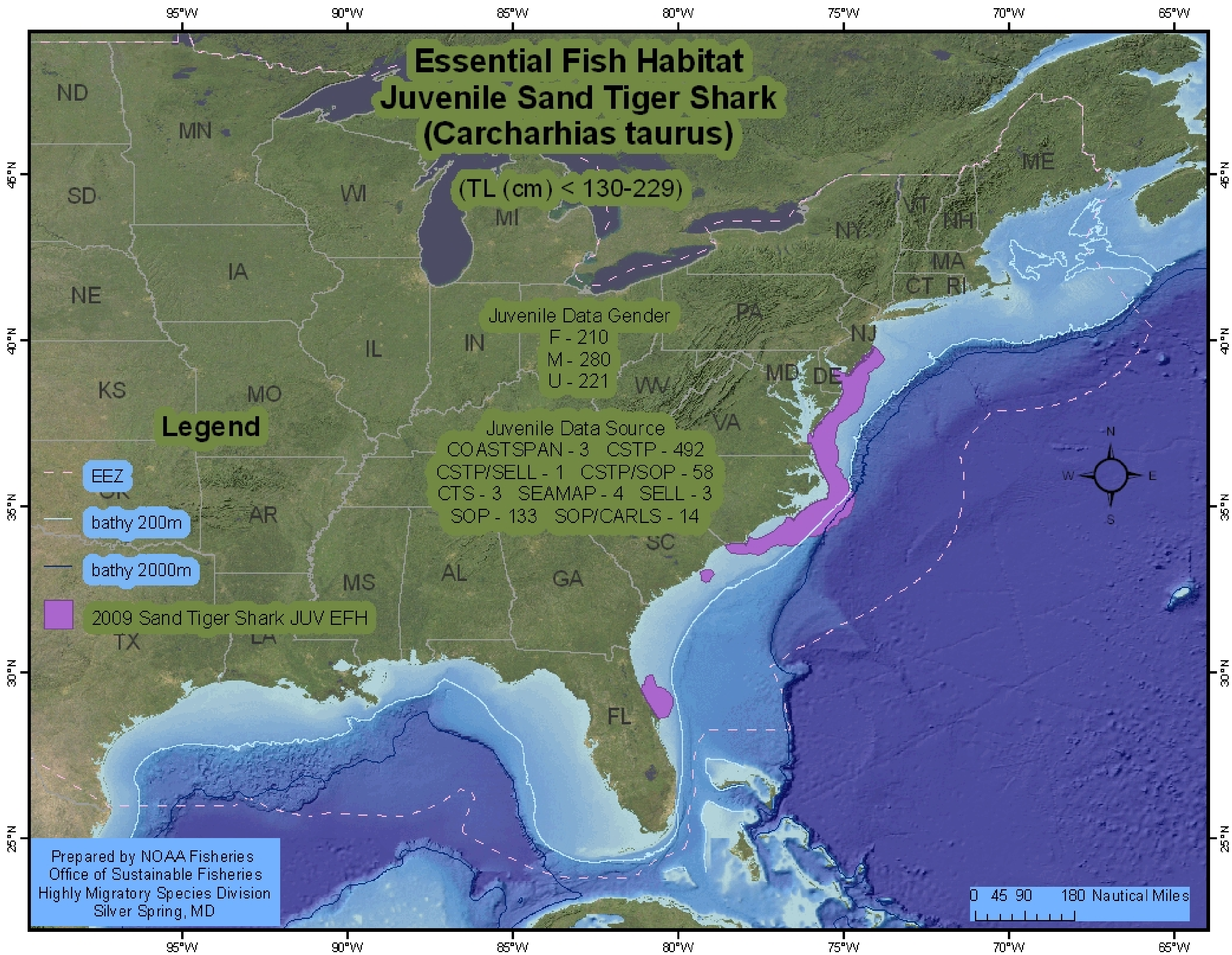

Figure 5.60 Sand Tiger Shark: Juvenile.

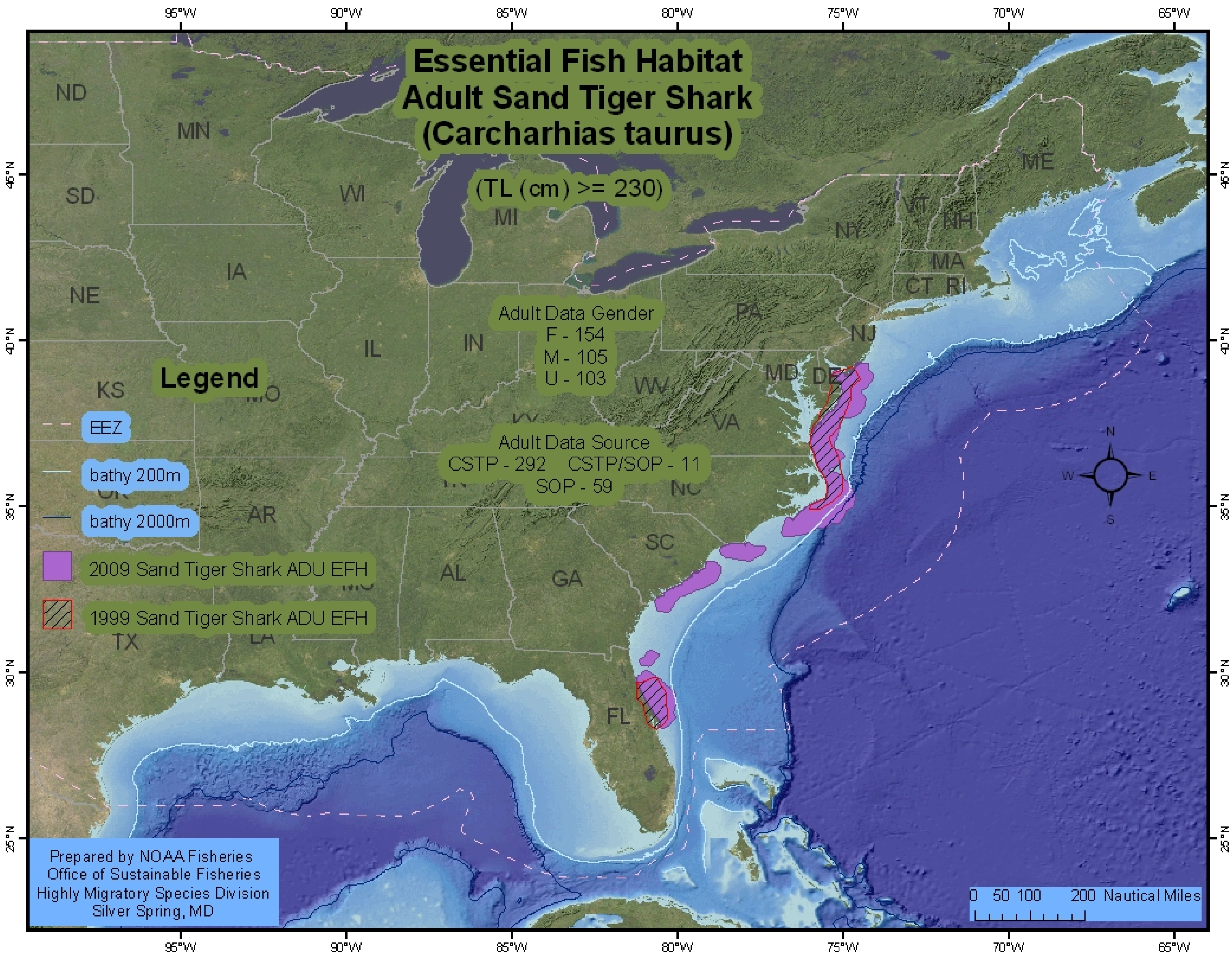

Figure 5.61 **Sand Tiger Shark: Adult.**

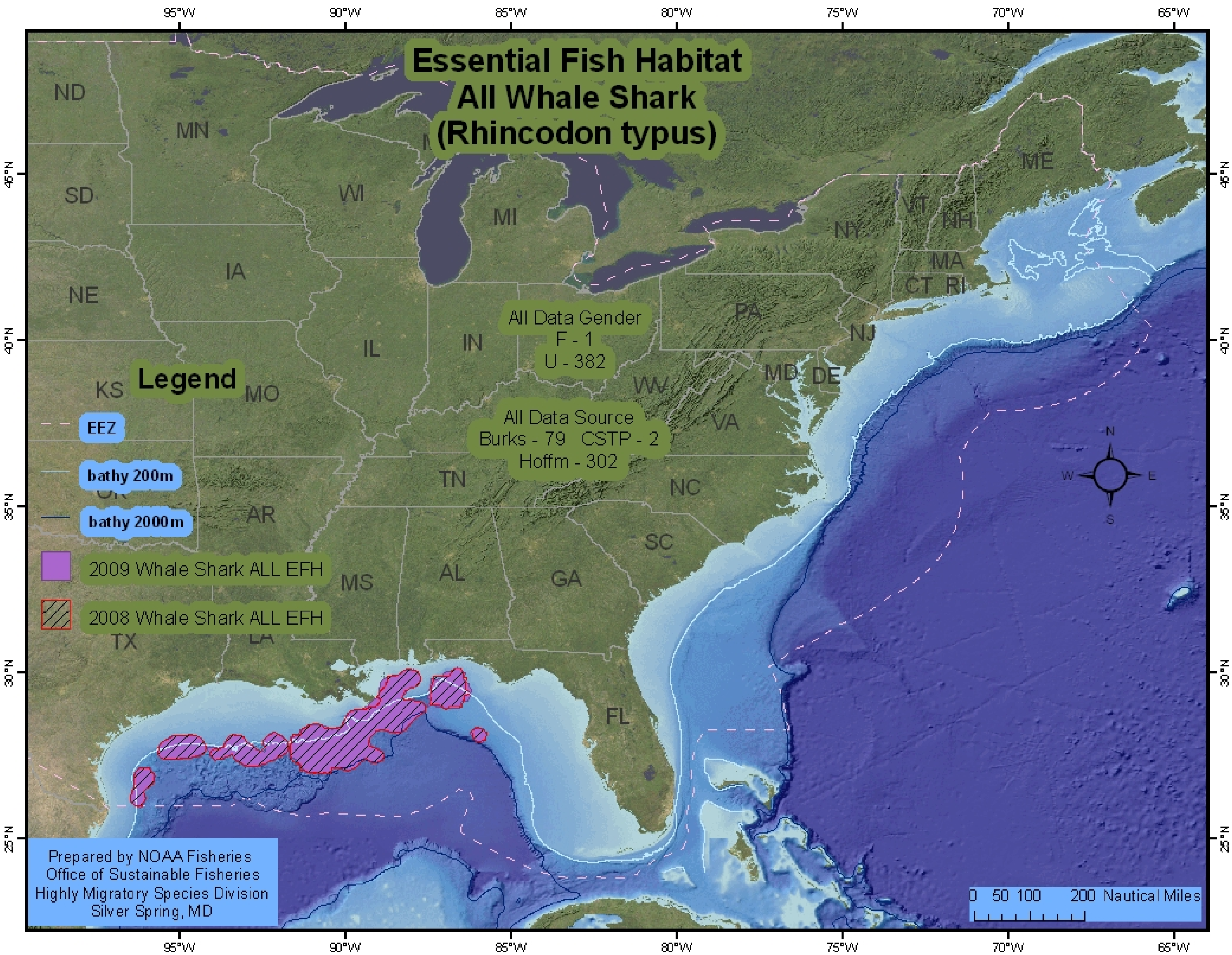

Figure 5.62 Whale Shark: All Life Stages Combined.

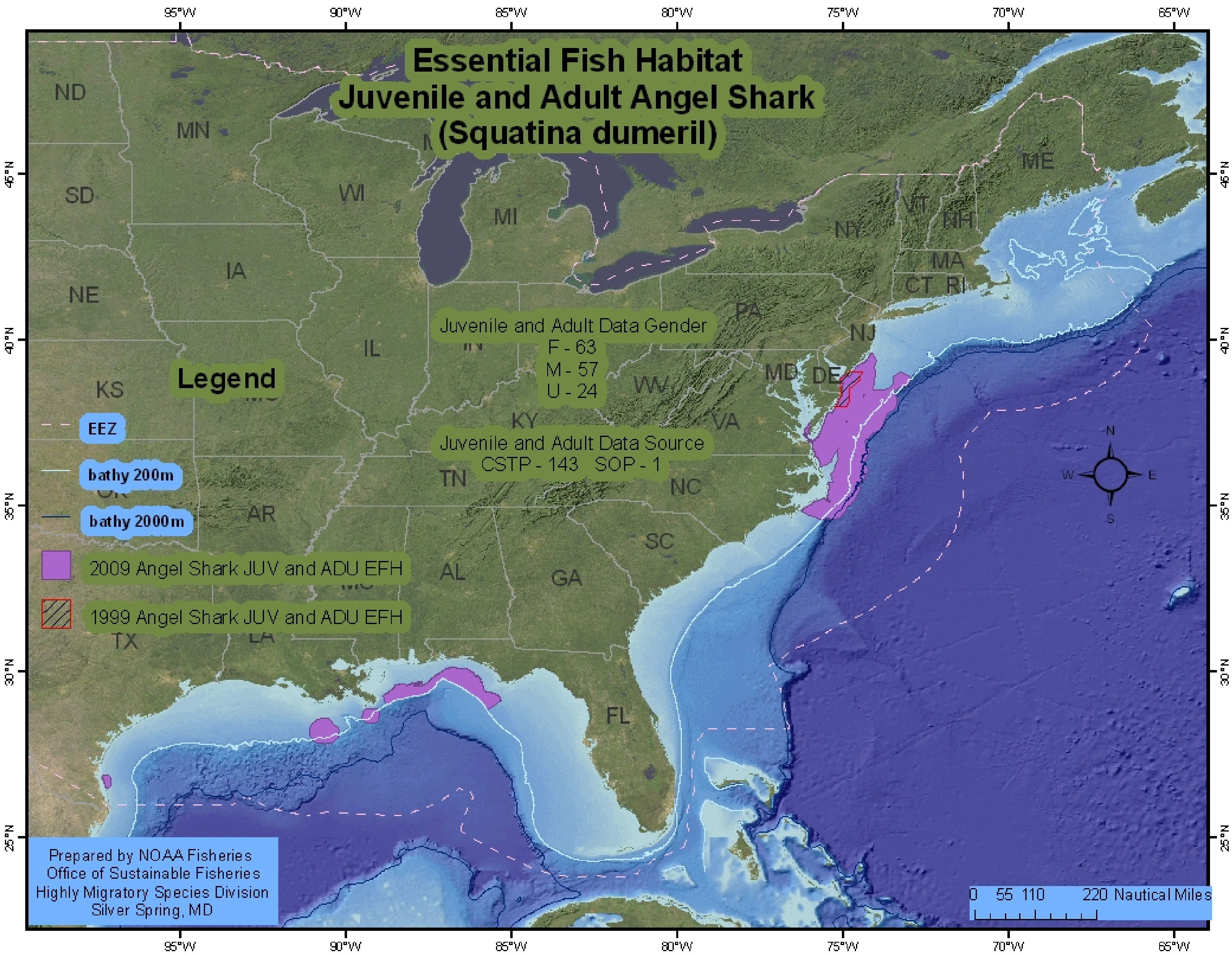

Figure 5.63 **Angel Shark: Juvenile and Adult Combined.**

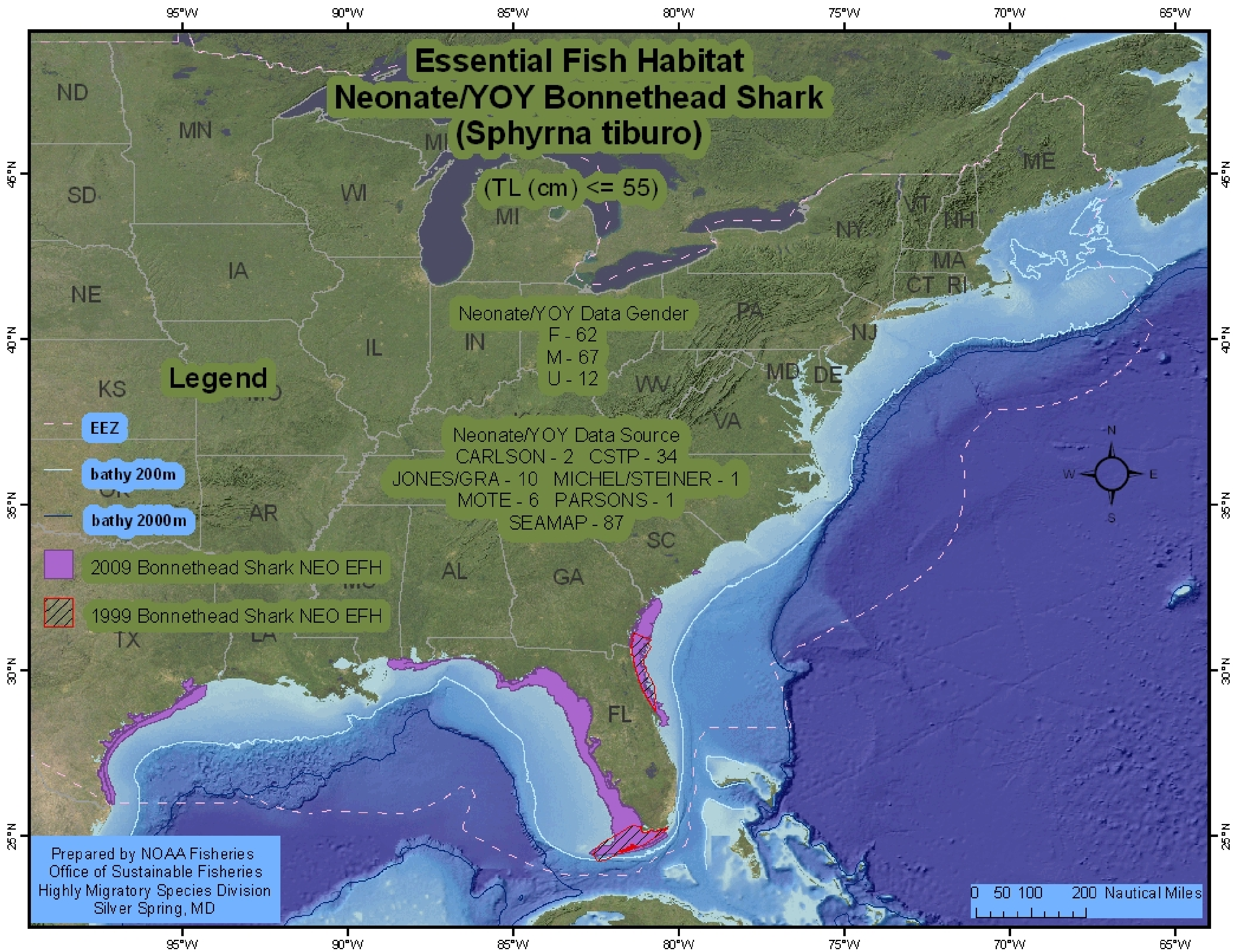

Figure 5.64 Bonnethead Shark: Neonate.

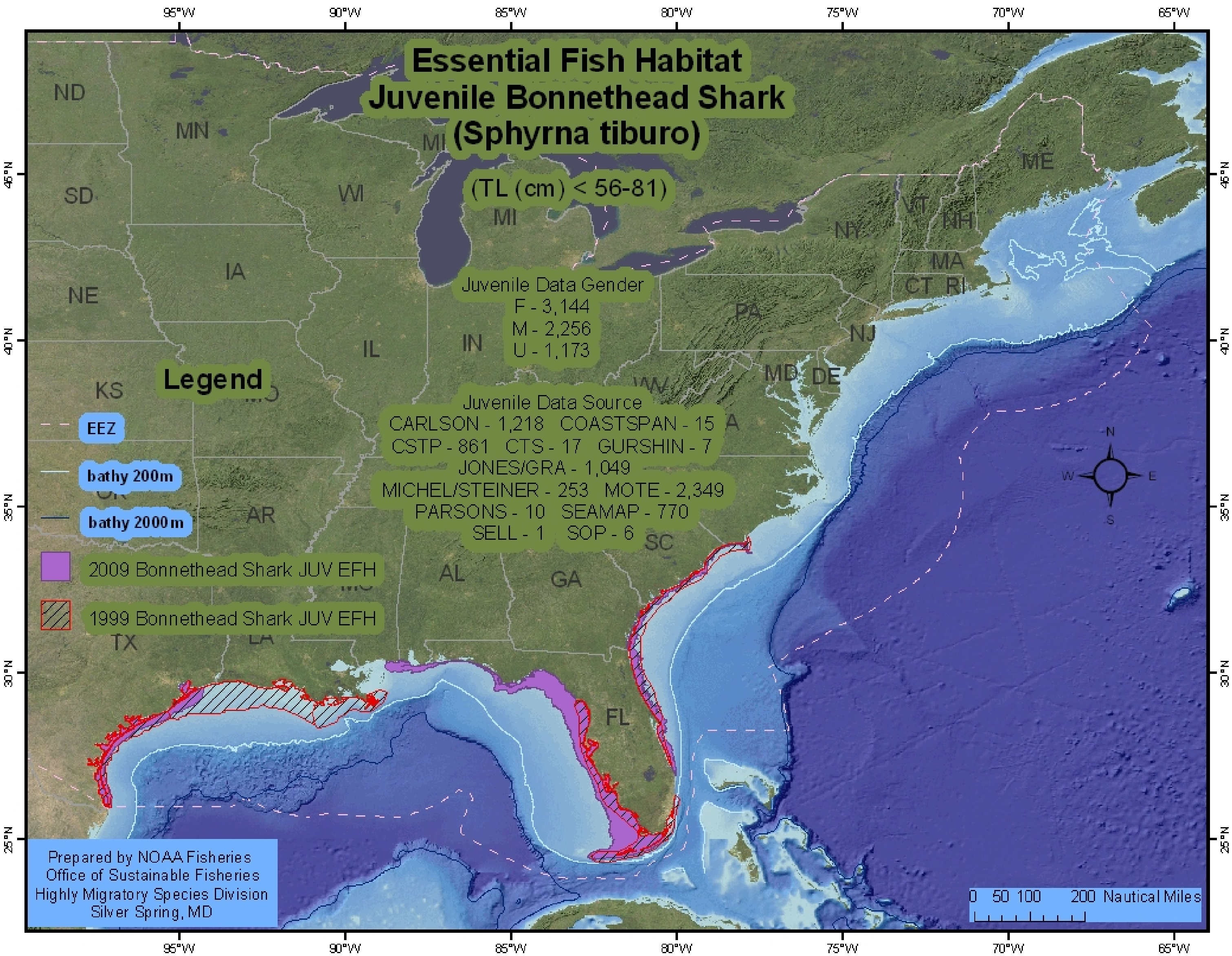

Figure 5.65 Bonnethead Shark: Juvenile.

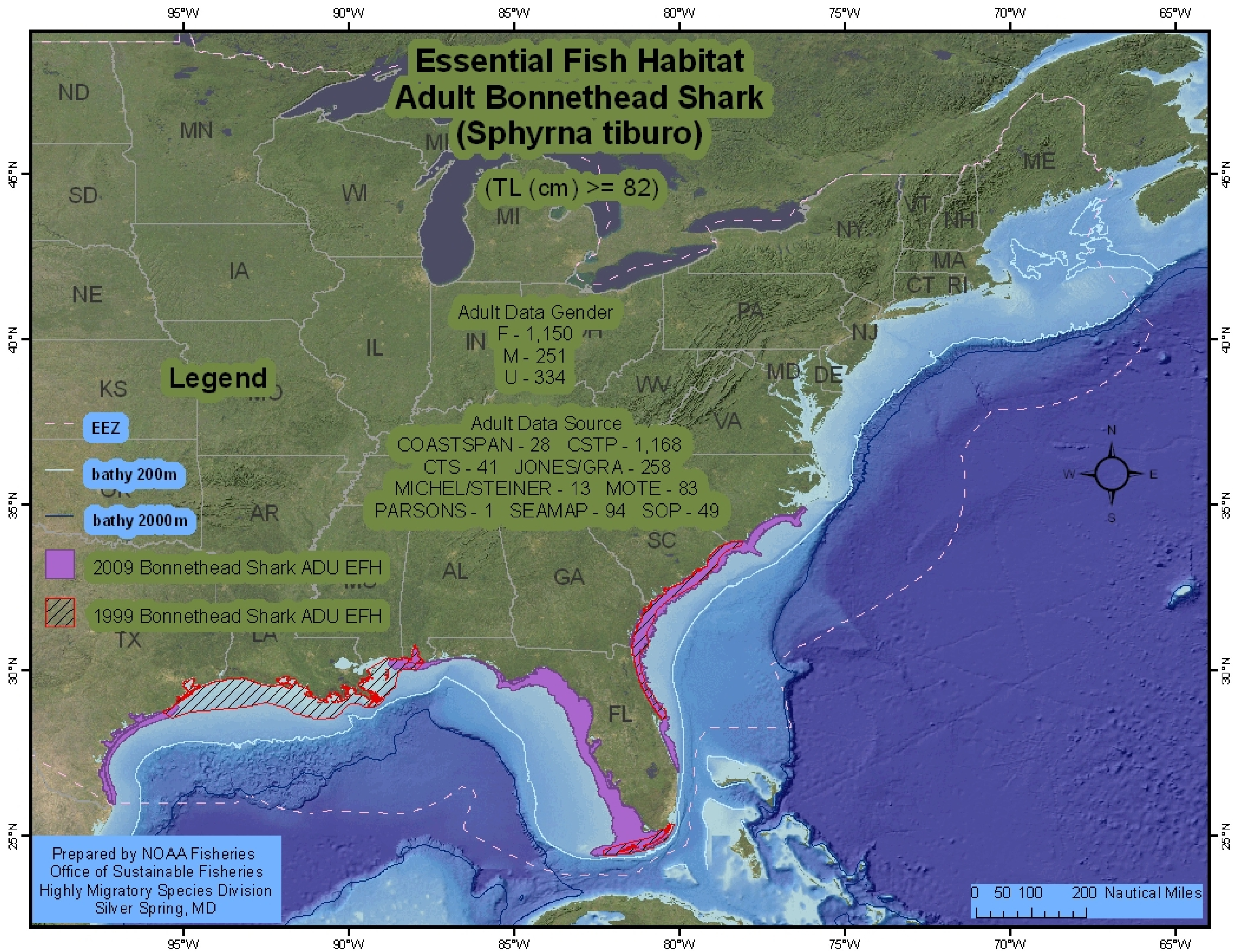

Figure 5.66 Bonnethead Shark: Adult.

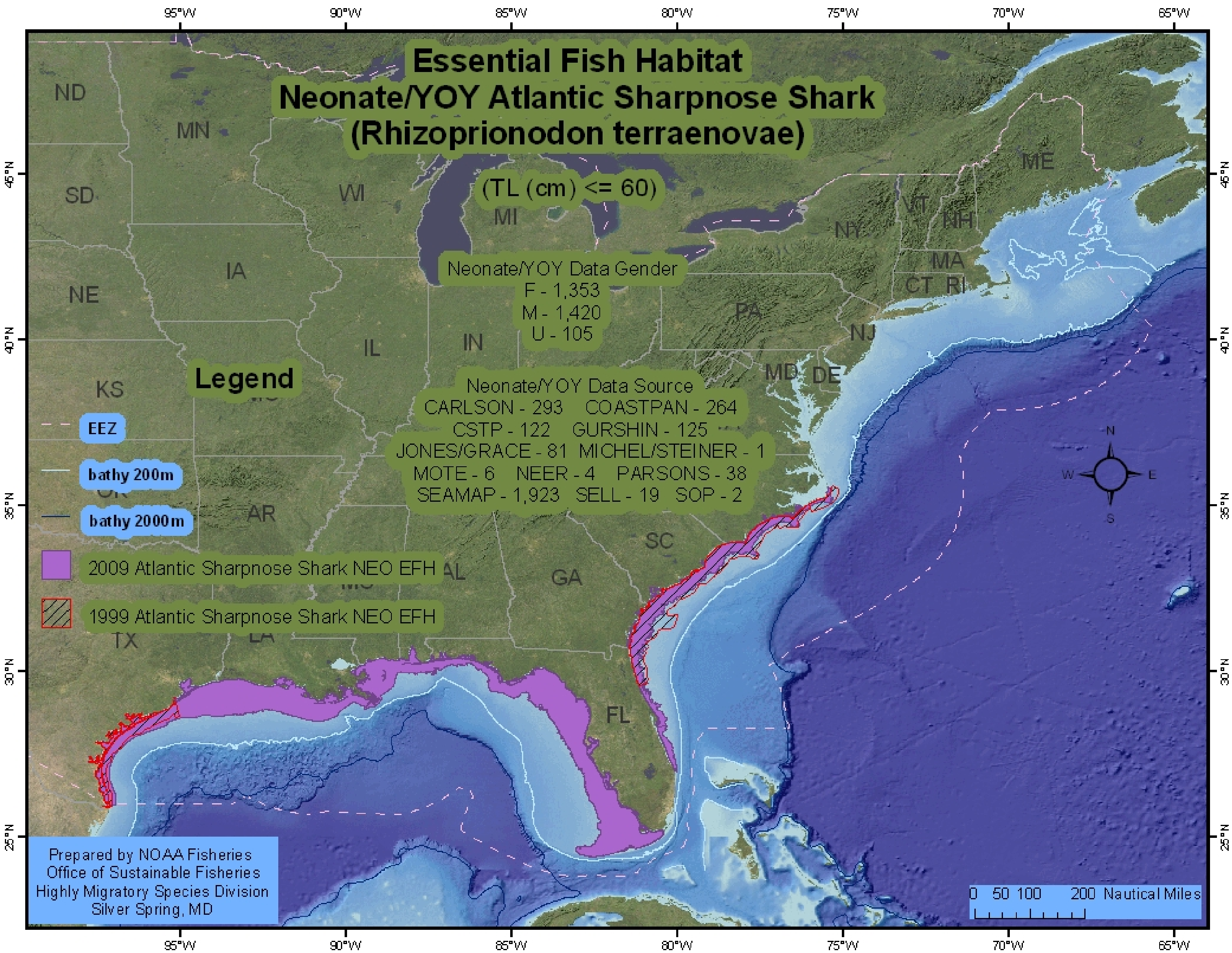

Figure 5.67 Altantic Sharpnose: Neonate.

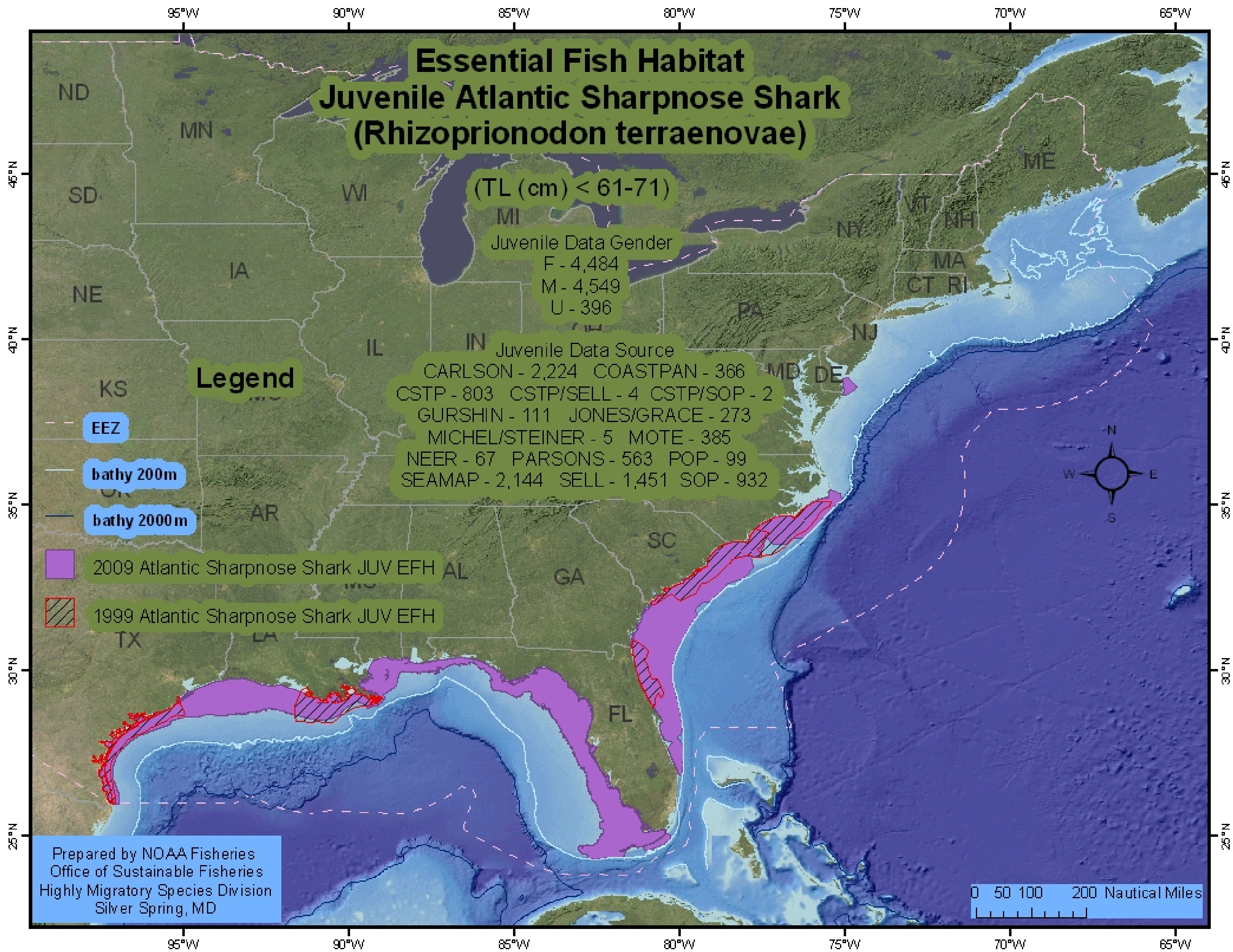

Figure 5.68 **Atlantic Sharpnose: Juvenile.**

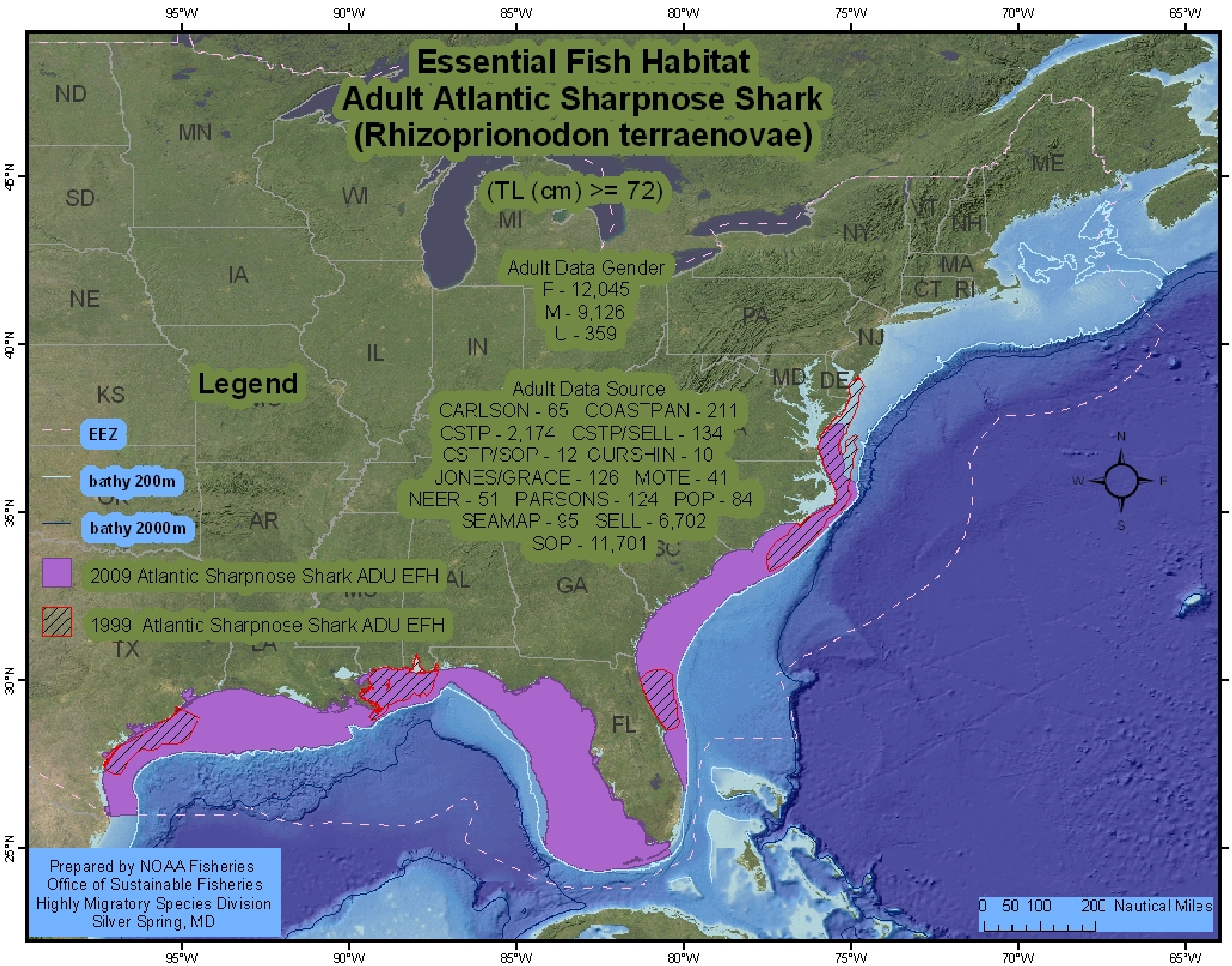

Figure 5.69 Atlantic Sharpnose Shark: Adult.

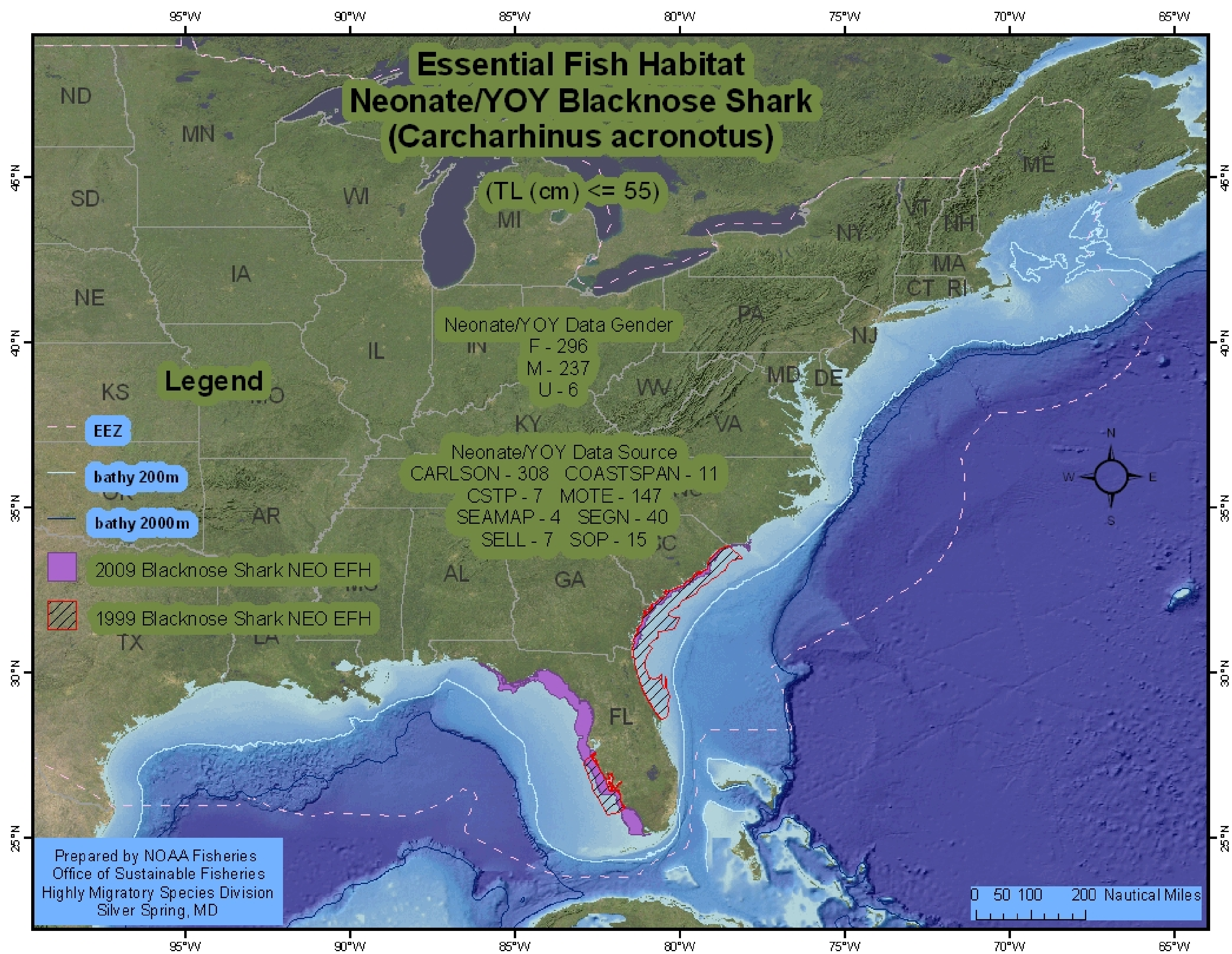

Figure 5.70 **Blacknose Shark: Neonoate.**

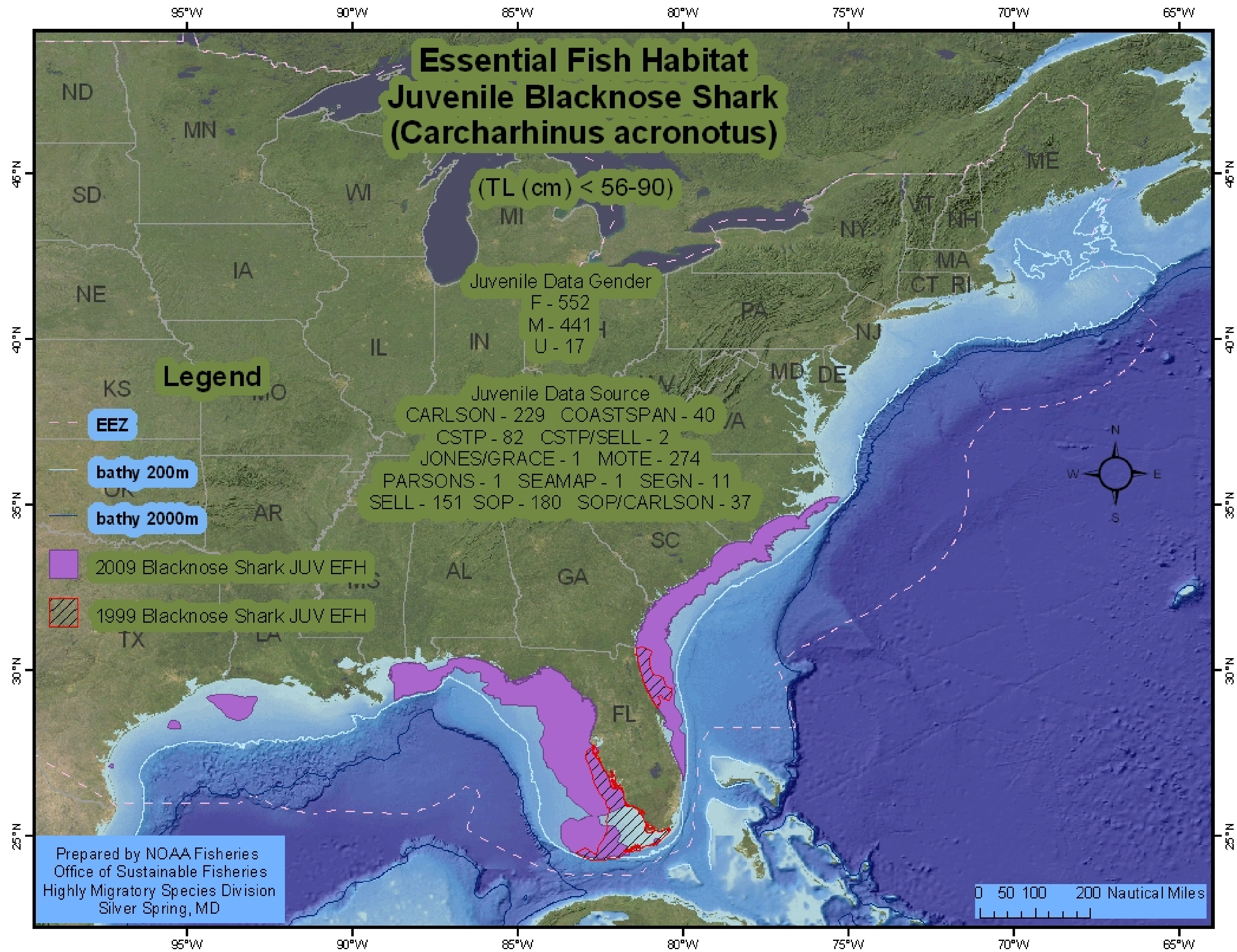

Figure 5.71 **Blacknose Shark: Juvenile.**

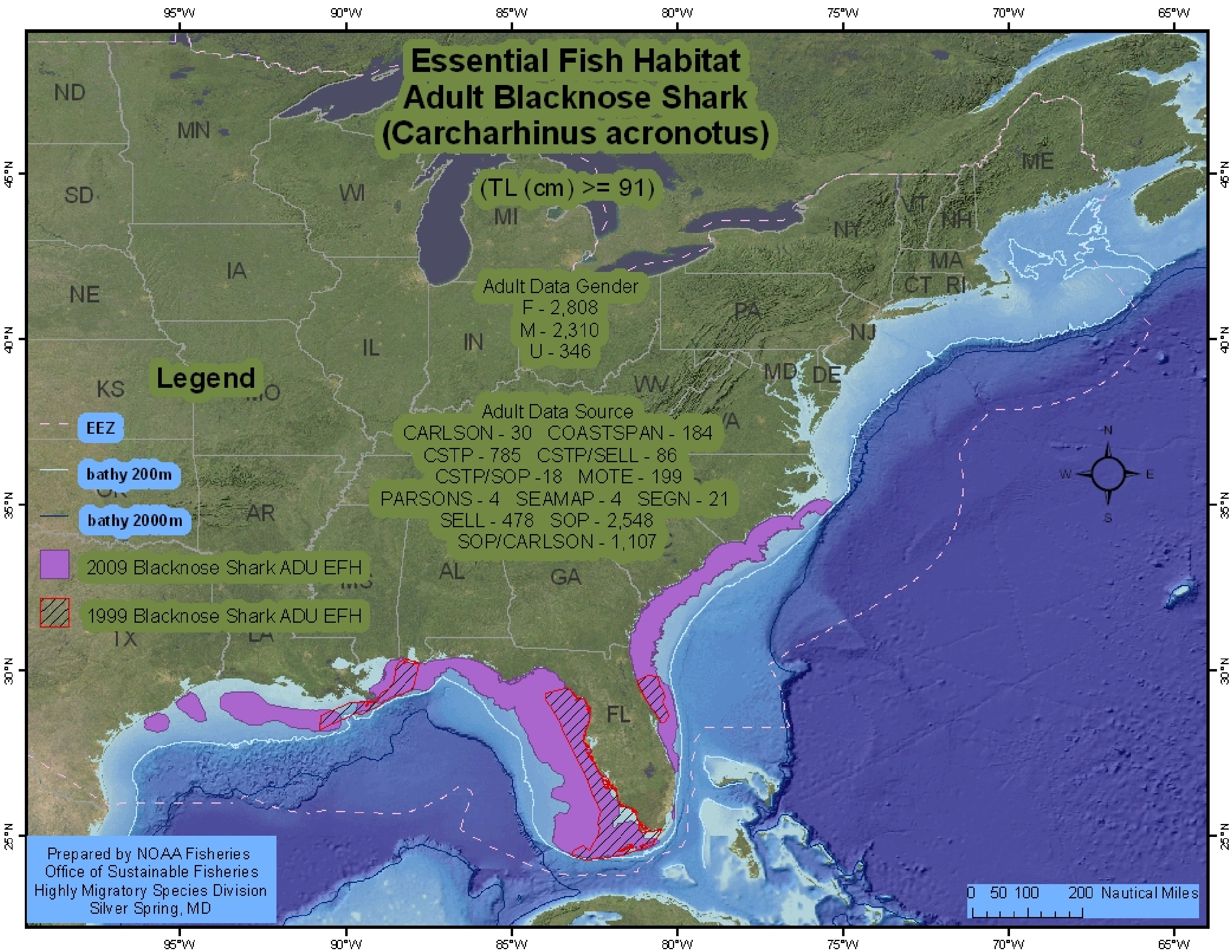

Figure 5.72 **Blacknose Shark: Adult.**

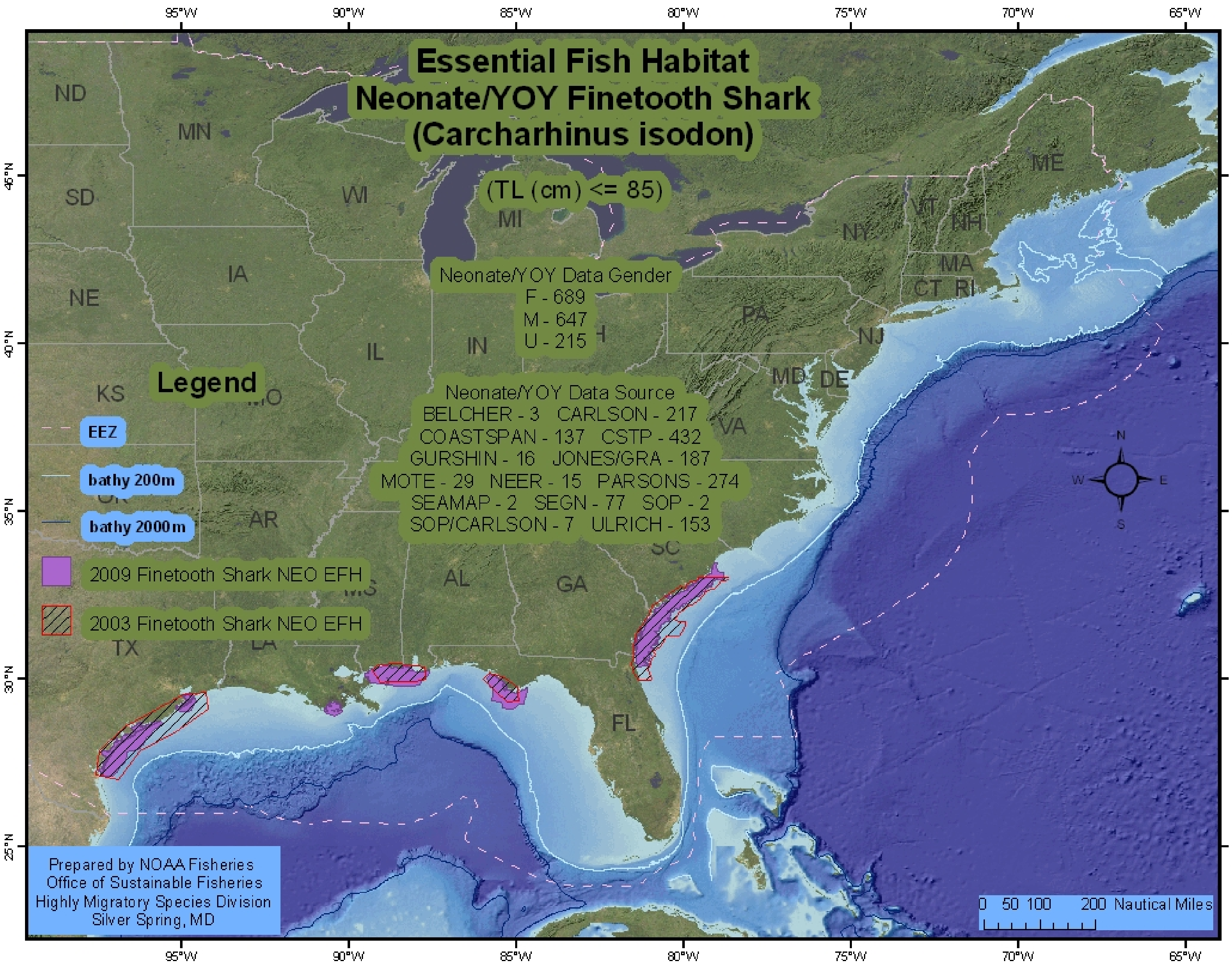

Figure 5.73 **Finetooth Shark: Neonate.**

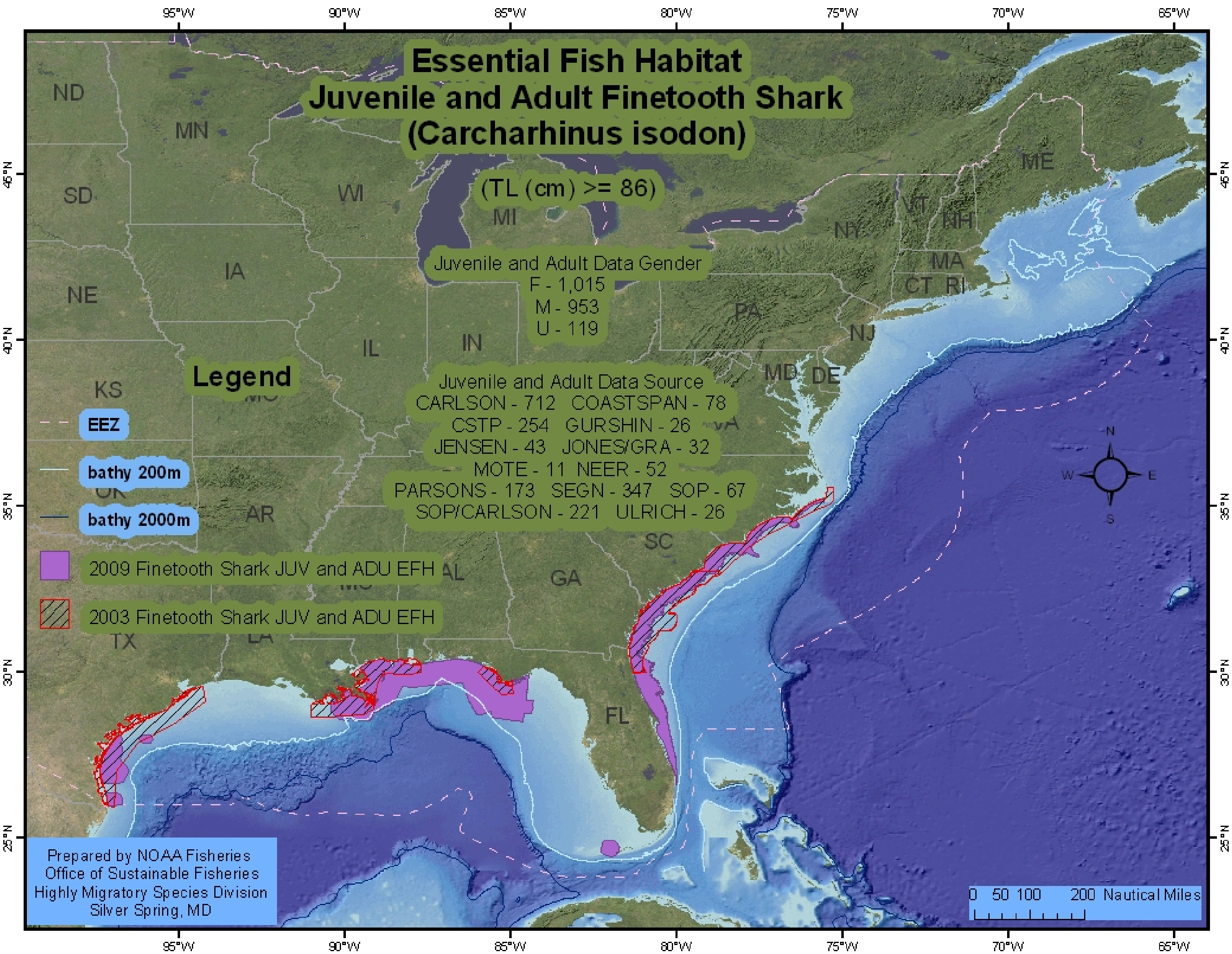

Figure 5.74 **Finetooth Shark: Juvenile and Adult Combined.**

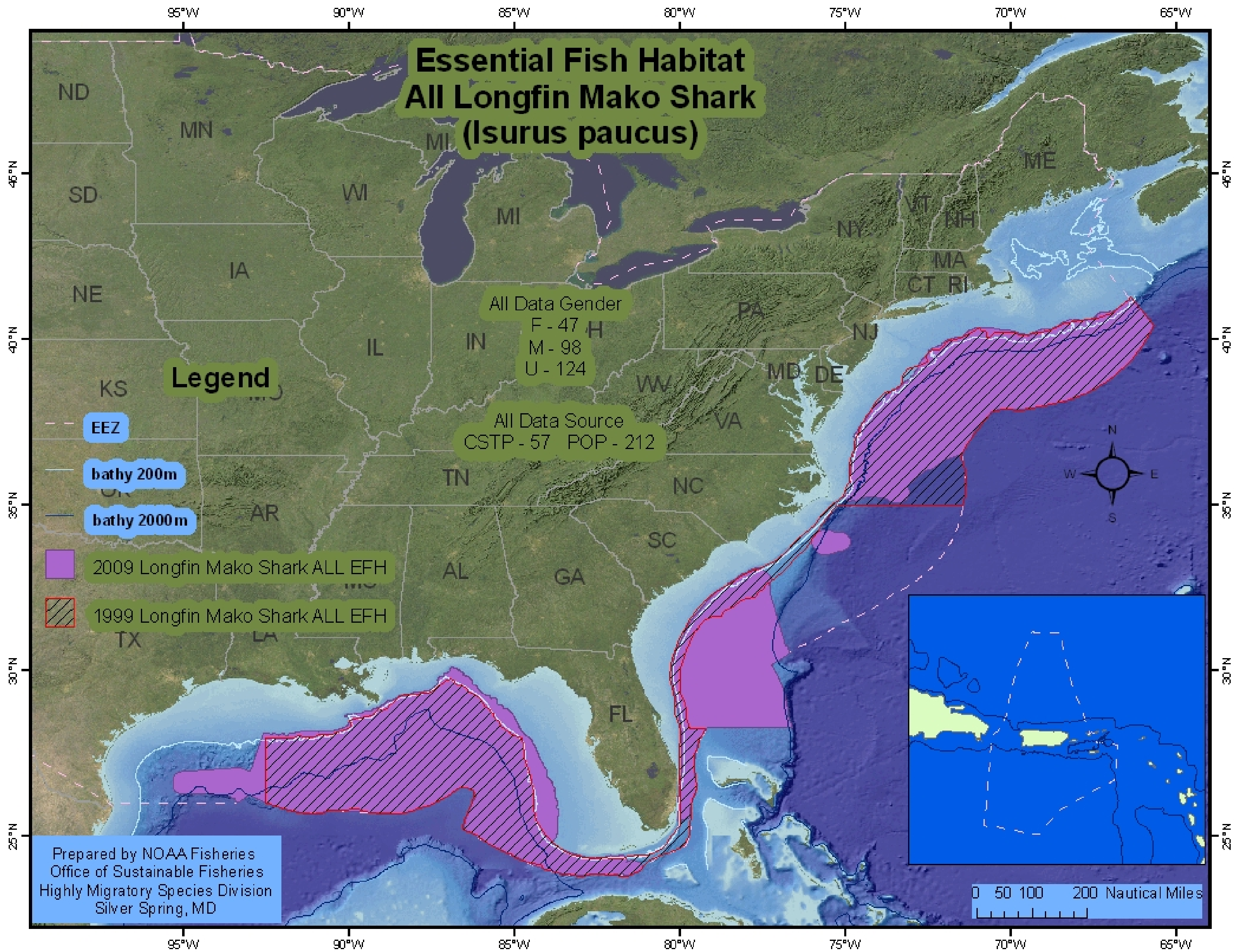

Figure 5.75 Longfin Mako Shark: All Life Stages Combined.

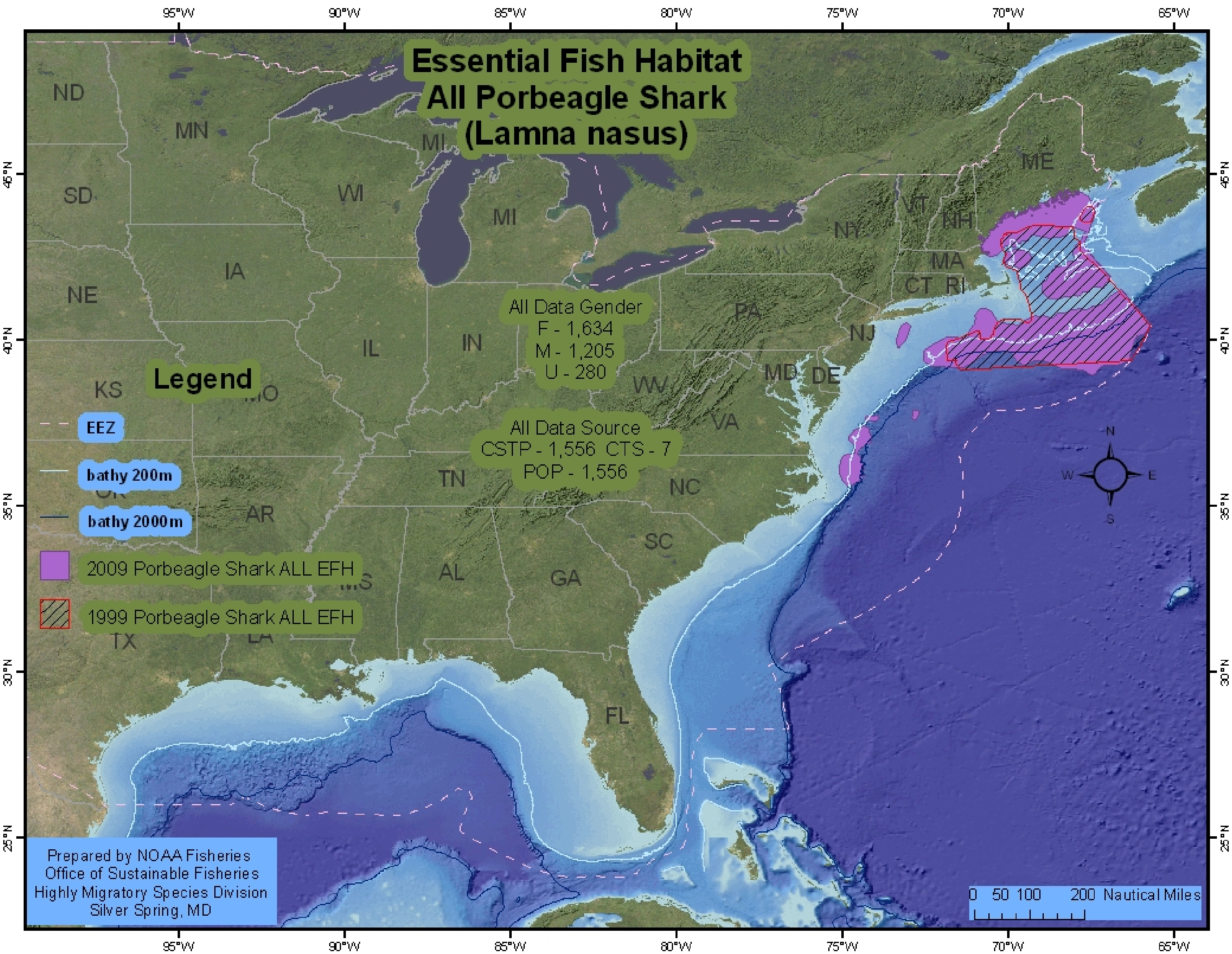

Figure 5.76 **Porbeagle Shark: All Life Stages Combined..**

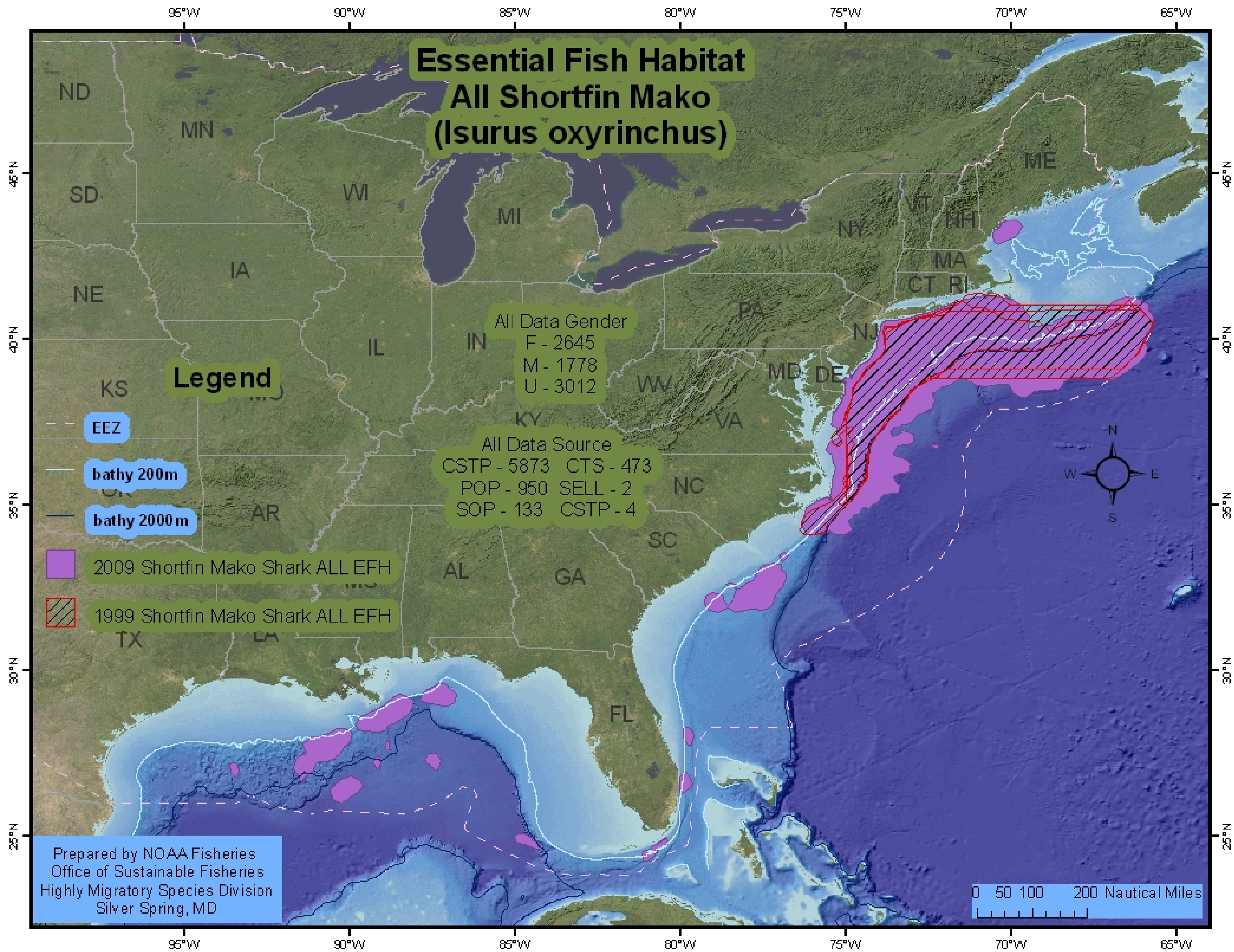

Figure 5.77 Shortfin Mako Shark: All Life Stages Combined.

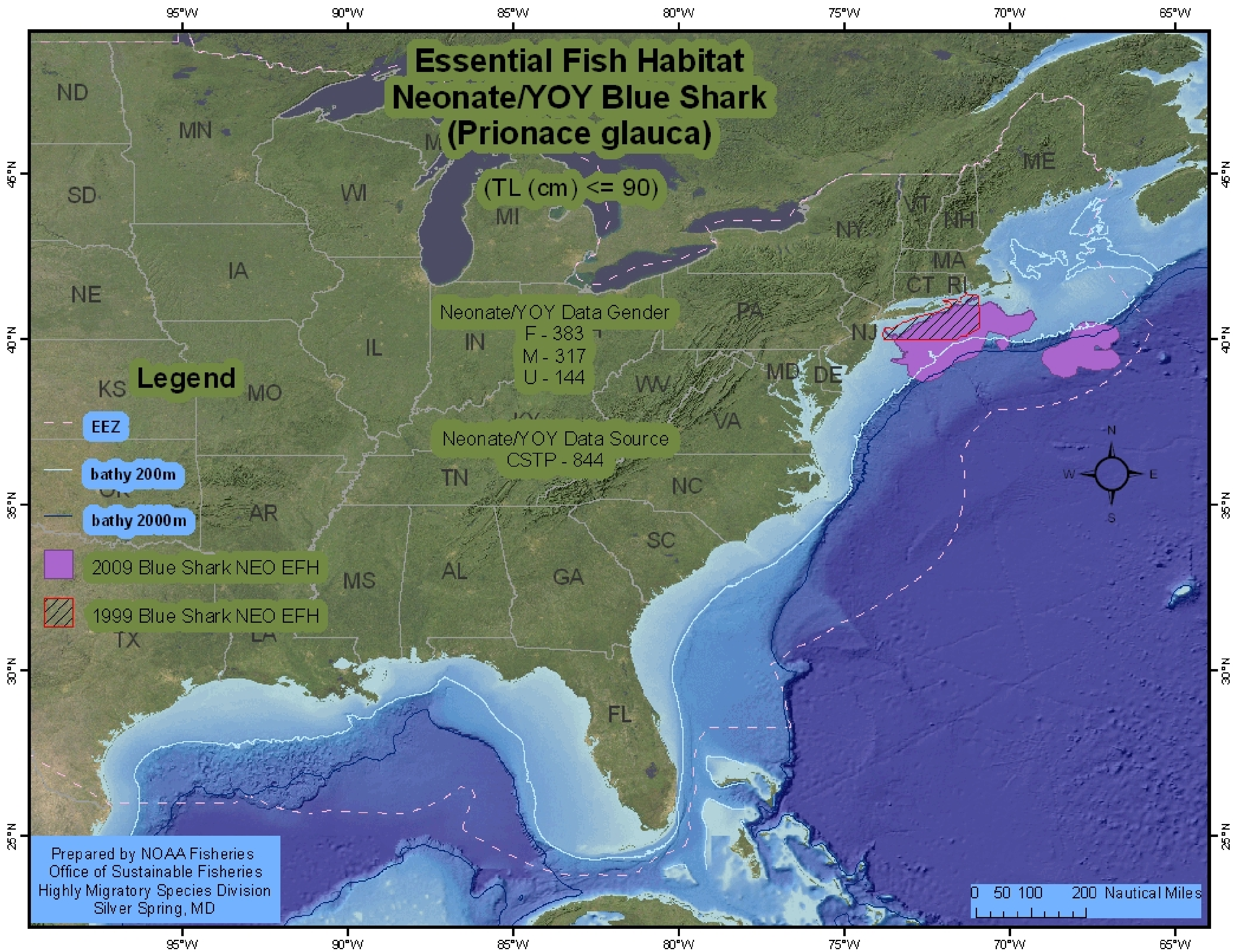

Figure 5.78 Blue Shark: Neonate.

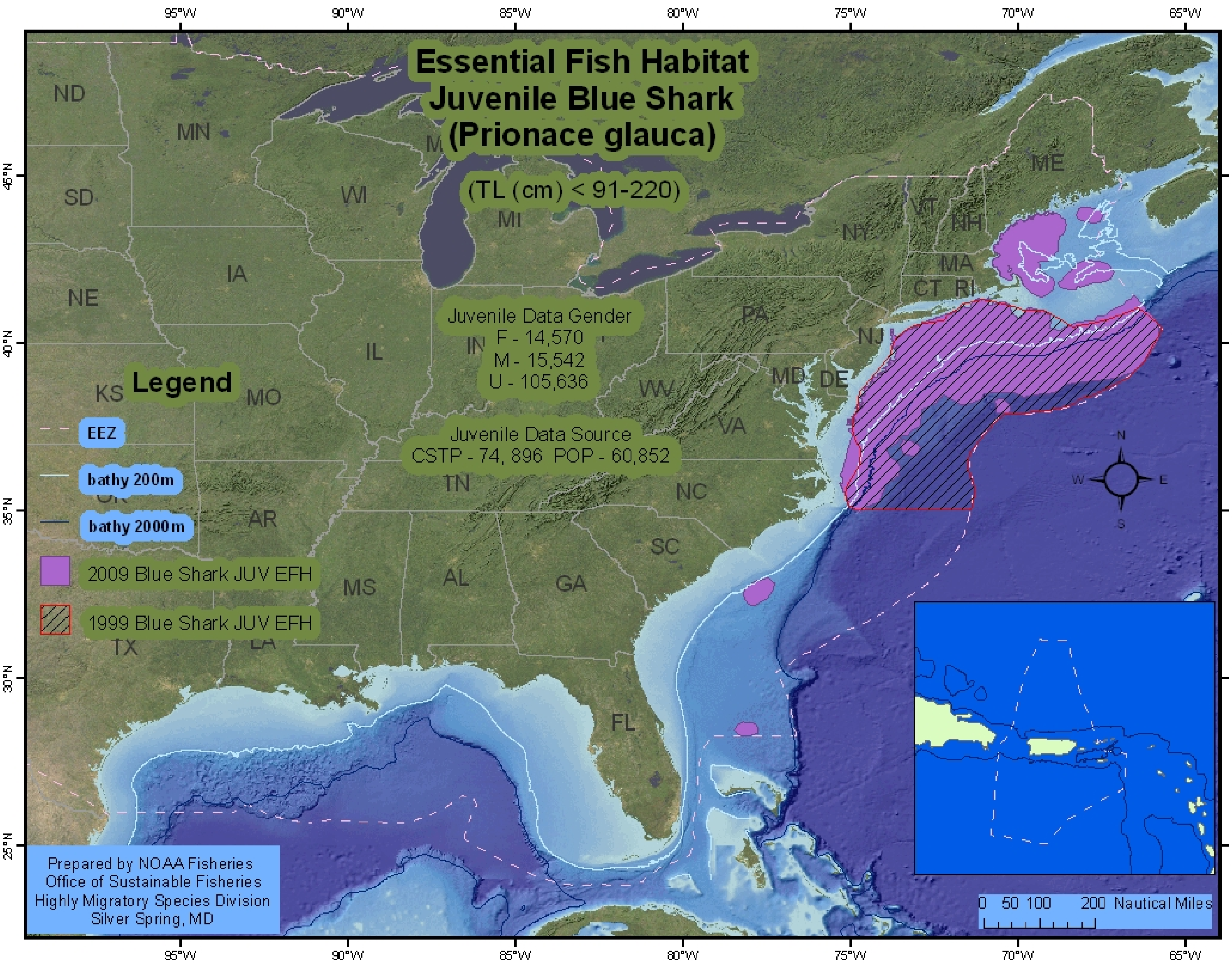

Figure 5.79 Blue Shark: Juvenile.

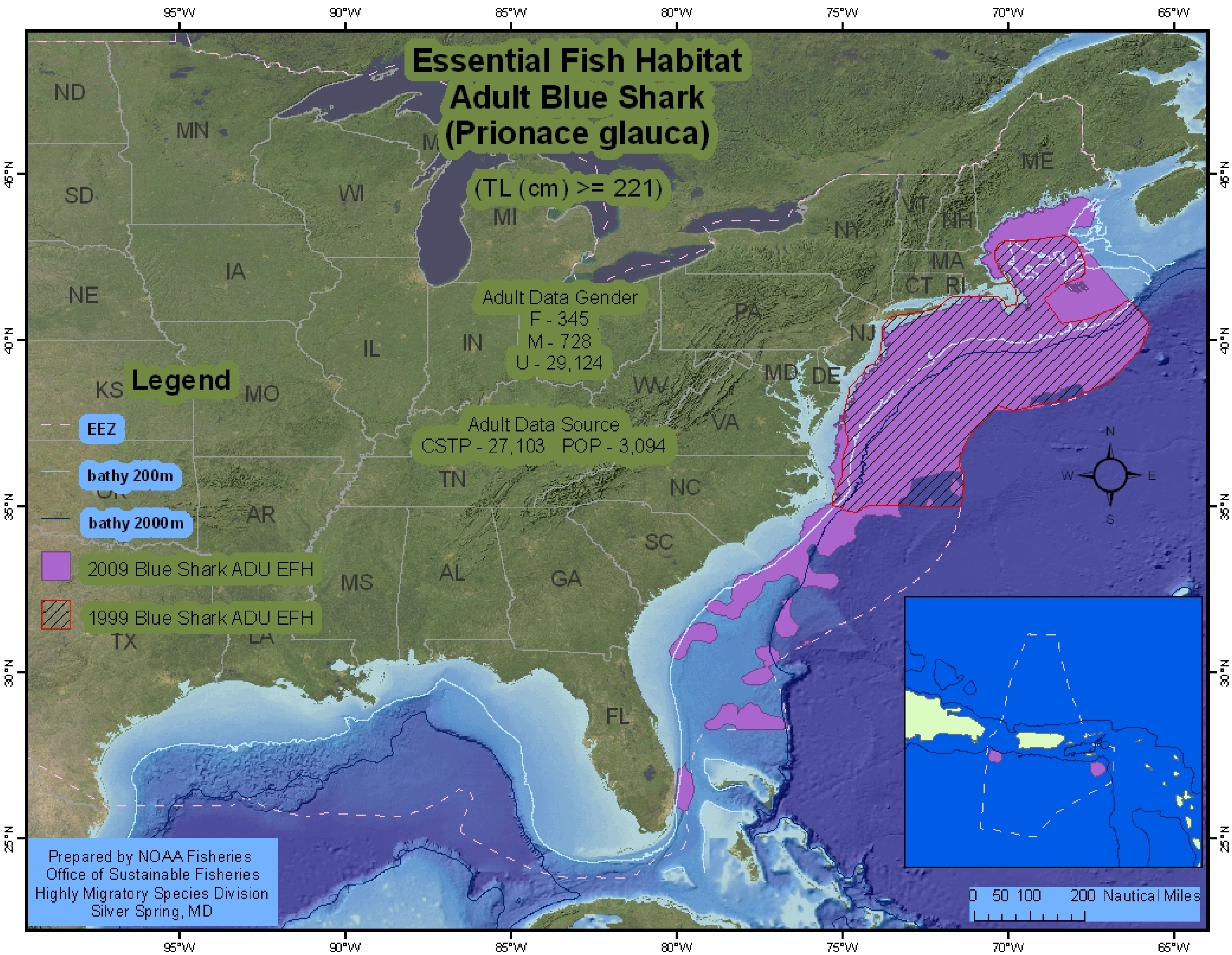

Figure 5.80 Blue Shark: Adult.

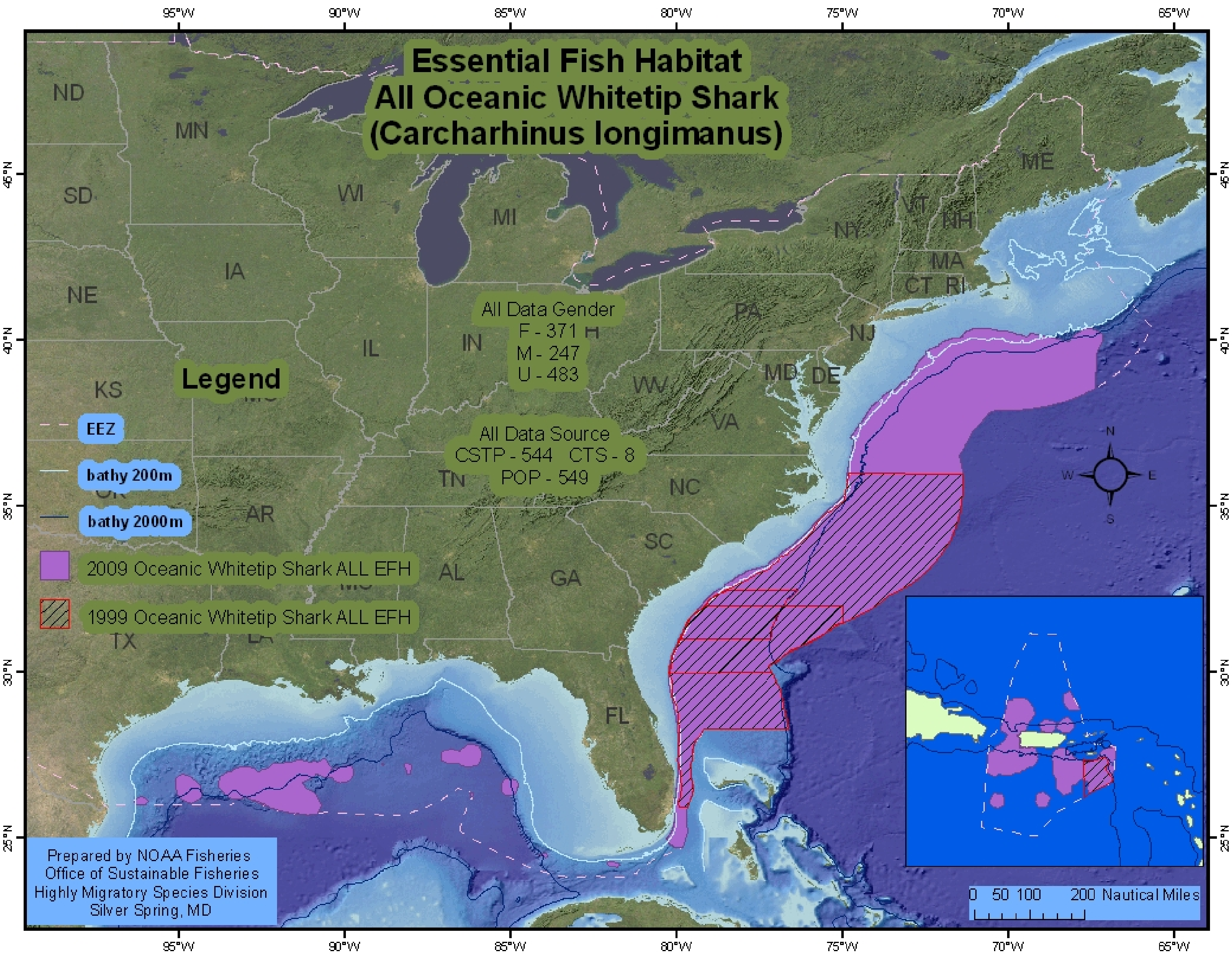

Figure 5.81 Oceanic Whitetip Shark: All Life Stages Combined.

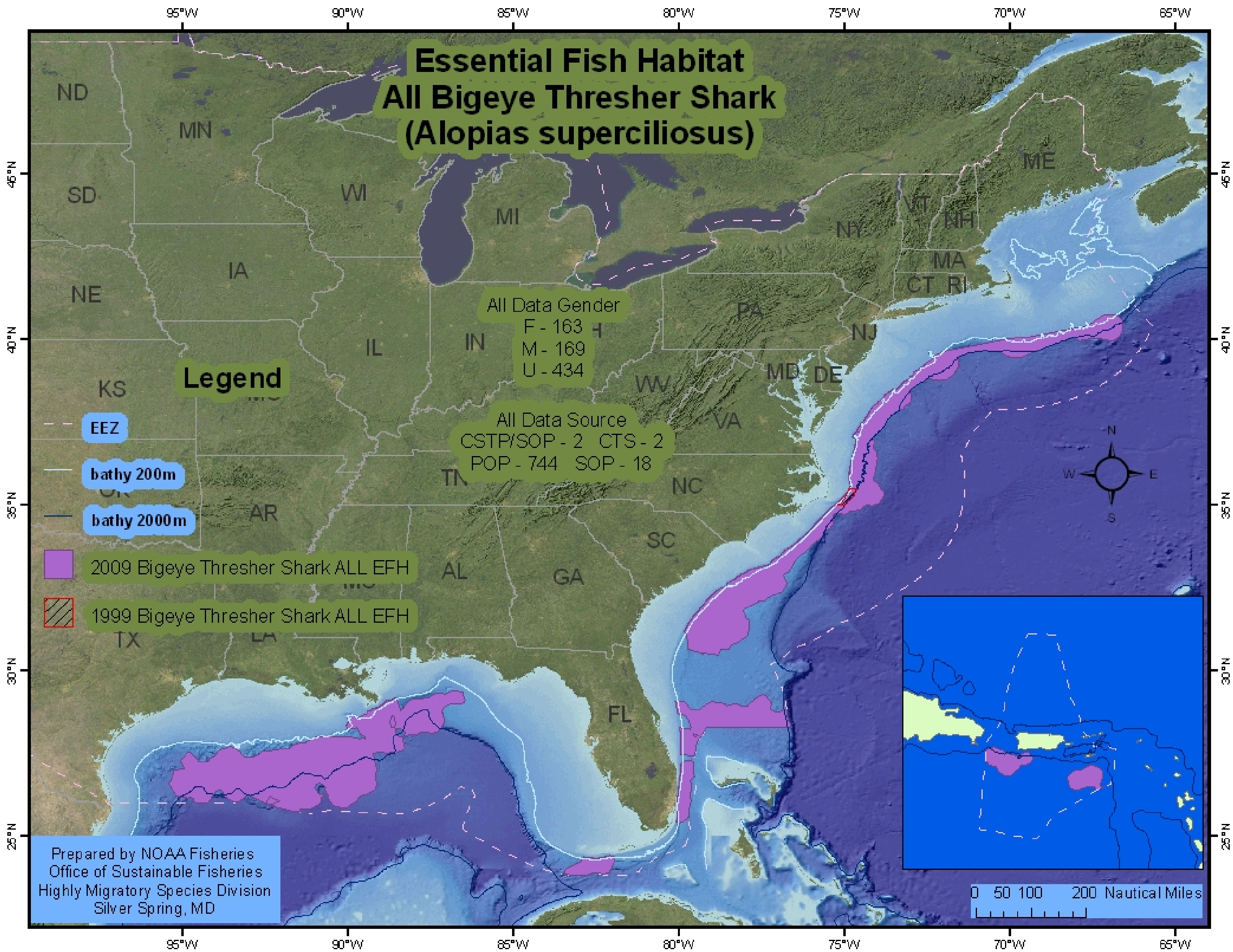

Figure 5.82 Bigeye Thresher Shark: All Life Stages Combined.

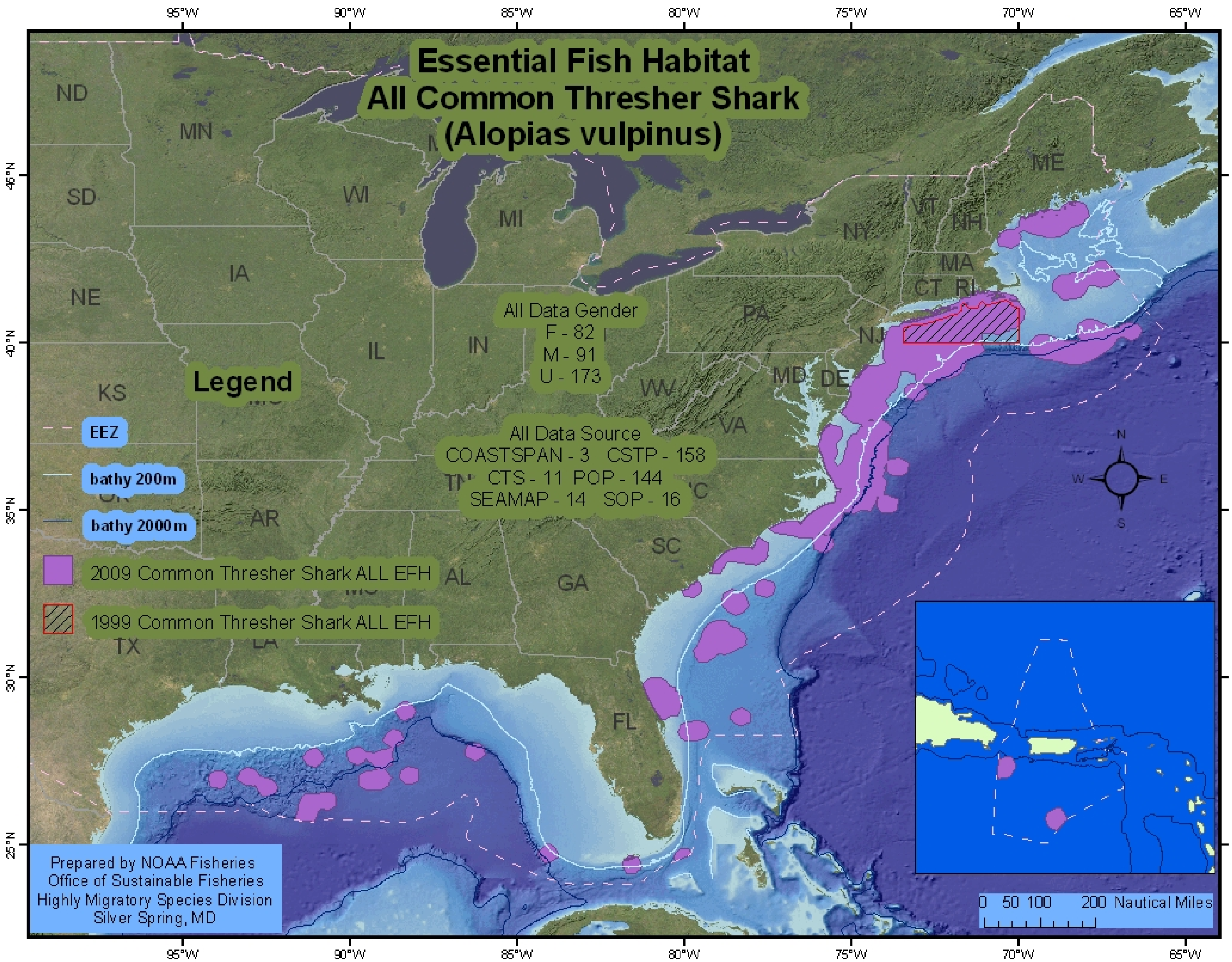

Figure 5.83 Common Thresher Shark: All Life Stages Combined.

CHAPTER 5 REFERENCES

Aasen, O. 1963. Length and growth of the porbeagle [*Lamna nasus* (Bonnaterre)] in the North West Atlantic. Rep. Norw. Fish. Invest. 13(6): 20-37.

Abel, D.C., R.F. Young, J.A. Garwood, M.J. Travaline, and B.K. Yednock. 2007. Survey of shark fauna in two South Carolina estuaries and the impact of salinity structure. American Fisheries Society Symposium 50:109-124.

Abercrombie, D.L., S.C. Clarke, and M.S. Shivji. 2005. Global-scale genetic identification of hammerhead sharks: Application to assessment of the international fin trade and law enforcement. Conservation Genetics; 1-14.

Adams, D.H., and R. Paperno. 2007. Preliminary Assessment of a nearshore nursery ground for the scalloped hammerhead off the Atlantic Coast of Florida. American Fisheries Society Symposium 50:165-174.

Allen, B.R. and S.P. Wintner. 2002. Age and growth of the spinner shark *Carcharhinus brevipinna* (Muller and Henle, 1839) off the Kwazulu-Natal Coast, South Africa. South African Journal of Marine Science 24: 1-8.

Anderson, R.C., and J.D. Stevens. 1996. Review of information on diurnal vertical migration in the bignose shark (*Carcharhinus altimus*). Marine and Freshwater Research 47(4):605-608.

Arocha, F. 1997. The reproductive dynamics of swordfish *Xiphias gladius* L. and management implications in the northwestern Atlantic. PhD Dissertation, University of Miami, Coral Gables, Florida.

Arocha, F., D.W. Lee, L.A. Marcano, and J.S. Marcano. 2001. Updated information on the spawning of yellowfin tuna (*Thunnus albacares*). Col. Vol. Sci. Pap. ICCAT 52(1): 167-176.

Arocha, F., A. Barrios, and D.W. Lee. 2006. Spatial-temporal distribution, sex ratio at size and gonad index of white marlin (*Tetrapturus albidus*) and longbill spearfish (*Tetrapturus pfluegeri*) in the Western Central Atlantic during the period of 2002-2005. ICCAT SCRS/2006/061: 1-11.

Aubrey, C.W. and F.F. Snelson, Jr. 2007. Early life history of the spinner shark in a Florida nursery. American Fisheries Society Symposium 50:175-189.

Backus, R.H., S. Springer, and E.L. Arnold. 1956. A contribution to the natural history of the whitetip shark, *Pterolamiops longimanus*. Deep-Sea Res. 3: 178-188.

Baglin, R.E. 1977. Maturity, fecundity and sex composition of white marlin (*Tetrapturus albidus*). Col.Vol.Sci.Pap. ICCAT 6: 408-416.

Baglin, R. E., Jr. 1982. Reproductive biology of western bluefin tuna (*Thunnus thynnus*). Fisheries Bulletin 80(1):121-134.

Baremore, I.E. and J.K. Carlson. 2004. Preliminary reproductive parmeters of the Atlantic Angel Shark with a potential example of reproductive senescence. Paper presented at the American Elasmobranch Society 2004 Annual Meeting, Norman, Oklahoma.

Barker, M.J., S.H. Gruber, S.P. Newman and V. Schluessel. 2005. Spatial and ontogenetic variation in growth of nursery-bound juvenile lemon sharks, *Negaprion brevirostris*: a comparison of two age-assigning techniques. Environ. Biol. Fishes 72: 343-355.

Bass, A.J., J.D. D' Aubrey, and N. Kistnasamy. 1973. Sharks of the east coast of southern Africa. I. The genus *Carcharhinus* (Carcharhinidae). Invest. Rep. Oceanog. Res. Inst., Durban, S. Afr. 33: 1-168.

Baum, J.K. 2004. "Hexanchus griseus" (On-line). Animal Diversity Web. Available at http://animaldiversity.ummz.umich.edu/site/accounts/information/Hexanchus_griseus.html. (accessed on 21 Aug 2008).

Baum, J.K. and R.A. Myers. 2004. Shifting baselines and the decline of pelagic sharks in the Gulf of Mexico. Ecology Letters 7:135-145.

Baum, J.K., R.A. Myers, D.G. Kehler, B. Worm, S.J. Harley, and P.A. Doherty. 2003. Collapse and conservation of shark populations in the Northwest Atlantic. Science 299:389-392.

Bayley, R. E. and E. D. Prince. 1993. A review of tag release and recapture files for Istiophoridae from the Southeast Fisheries Center's cooperative game fish tagging program, 1954 to present. Meet of the ICCAT standing committee on research and statistics, Madrid (Spain), Nov. 1992. Collect Vol. Sci. Pap. ICCAT SCRS/92/60.

Beardsley, G. L., Jr., N. R. Merrett and W. J. Richards. 1975. Synopsis of the biology of the sailfish *Istiophorus platypterus* (Shaw and Nodder, 1791). Pages 95-120 *in:* Shomura, R. S. and F. Williams. eds. Proceedings of the International Billfish Symposium Kailua-Kona, Hawaii, 9-12 August 1972. Part 3. Species Synopses. NOAA Tech. Rep. NMFS SSRF-675. 159 p.

Bedford, D.W. 1985. Pelagic shark/swordfish drift gill net fishery. Calif. Dept. Fish. Game, Management Information Document. 74pp.

Beerkircher, L.R., E. Cortbs, and M. Shivji. 2002. Characteristics of shark bycatch observed on pelagic longlines off the southeastern United States, 1992-2000. Marine Fisheries Review 64:40-49.

Belcher, C. and T. Shierling. 2002. Preliminary findings for Georgia's shark nursery study, a part of the Cooperative Atlantic States Shark Pupping and Nursery (COASTSPAN) survey. In: McCandless *et al*. 2002. Shark nursery grounds of the Gulf of Mexico and the East Coast waters of the United States: an overview. 286 pp.

Berkeley, S. A. and E. D. Houde. 1981. Swordfish, *Xiphias gladius*, dynamics in the Straits of Florida. Collect. Vol. Sci. Pap. Vol. 15(2): 372 –380.

Berkeley, S.A., and W.L. Campos. 1988. Relative abundance and fishery potential of pelagic sharks along Florida's east coast. Mar. Fish. Rev. 50(1): 9-16.

Bernal, D. and C.A. Sepulveda. 2005. Evidence for temperature elevation in the aerobic swimming musculature of the common thresher shark, *Alopias vulpinus*. Copeia. 2005(1):146-151.

Bethea, D.M., J.A. Buckel and J.K. Carlson. 2004. Foraging ecology of the early life stages of four sympatric shark species. Marine Ecology Progress Series 268: 245-264.

Bethea, D.M., J.K. Carlson, J.A. Buckel, and M. Satterwhite. 2006. Ontogenetic and Site-Related Trends in the Diet of the Atlantic Sharpnose Shark Rhizoprionodon Terraenovae from the Northeast Gulf Of Mexico. Bulletin of Marine Science. 78(2):287-307.

Bigelow, H.B., and W.C. Schroeder. 1948. Fishes of the western North Atlantic. Pt.1. Lancelets, cyclostomes and sharks. New Haven: Mem. Sears Fdn. Mar. Res. 576pp.

Bigelow, H. B., and W. C. Schroeder. 1958. A large white shark, Carcharodon carcharias, taken in Massachusetts Bay. Copeia 1958(1):54–55.

Bishop, S.D.H.; M.P. Francis; C. Duffy and J.C. Montgomery. 2006. Age, growth, maturity, longevity and natural mortality of the shortfin mako shark (*Isurus oxyrinchus*) in New Zealand waters. Marine and Freshwater Research. 57:143-154.

Blackburn, J.K., J.A. Neer, and B.A. Thompson. 2007. Delineation of Bull Shark Nursery Areas in the Inland and Coastal Waters of Louisiana. American Fisheries Society Symposium 50:331–343.

Block, B.A., S.L.H. Teo, A. Walli, A. Boustany, M.J.W. Stokesbury, C.J. Farwell, K.C. Weng, H. Dewar, T.D. Williams. 2005. Electronic tagging and population structure of Atlantic bluefin tuna. Nature. Vol. 434. 1121-1127.

Block, E.A., J.E. Keen, B. Castillo, H. Dewar, E.V. Freund, D.J. Marcinek, R.W. Brill, and C. Farwell. 1997. Environmental preferences of yellowfin tuna (*Thunnus albacares*) at the northern extent of its range. Marine Biology 130: 119-132.

Bonfil, R.1977. Status of shark resources in the southern Gulf of Mexico and Caribbean: Implications and management. Fisheries Resources 29:101-117.

Bonfil, R., R. Mena, and D. de Anda. 1993. Biological parameters of commercially exploited silky sharks, *Carcharhinus falciformis*, from the Campeche Bank, Mexico. *In* S. Branstetter (ed.): Conservation Biology of Sharks. NOAA Technical Report NMFS 115. U.S. Dept. Comm., Miami: 14pp.

Bonfil, R., M. Meyer, M.C. Scholl, R. Johnson, S. O'Brien, H. Oosthuizen, S. Swanson, D. Kotze, and M. Paterson. 2005. Transoceanic Migration, Spatial Dynamics, and Population Linkages of White Sharks. Science 310 (5745):100-103.

Boustany, A.M., S.F. Davis, P. Pyle, S.D. Anderson, B.J. Le Boeuf, and B.A. Block. 2002. Nature 415(6867):35-36.

Branstetter, S. 1981. Biological notes on the sharks of the north central Gulf of Mexico. Contrib. Mar. Sci. 24:13-34.

Branstetter, S. 1987a. Age and growth estimates for blacktip, *Carcharhinus limbatus*, and spinner, C*archarhinus brevipinna*, sharks from the Northwestern Gulf of Mexico. Copeia 1987(4): 964-974.

Branstetter, S. 1987b. Age, growth and reproductive biology of the silky shark, *Carcharhinus falciformis*, and the scalloped hammerhead, *Sphyrna lewini*, from the northwestern Gulf of Mexico. Environmental Biology of Fishes 19: 161–173.

Branstetter, S. 1990. Early life-history implications of selected carcharinoid and lamnoid sharks of the northwest Atlantic. NOAA Technical Reports NMFS 90: 17–28.

Branstetter, S., and J.D. McEachran. 1986. Age and growth of four carcharhinid sharks common to the Gulf of Mexico: A summary paper. In T. Uyeno, R. Arai, T. Taniuchi, and K. Matsuura (eds.): Indo-Pacific Fish Biology: Proceedings of the Second International Conference on Indo-Pacific Fishes. Ichth. Soc. Jpn. 11pp.

Branstetter, S., and R. Stiles. 1987. Age and growth estimates of the bull shark, *Carcharhinus leucas*, from the northern Gulf of Mexico. Environ. Biol. Fishes 20(3): 169-181.

Branstetter, S., J.A. Musick, and J.A. Colvocoresses. 1987. A comparison of the age and growth of the tiger shark, *Galeocerdo cuvieri*, from off Virginia and from the northwestern Gulf of Mexico. Fish. Bull. 85: 269-279.

Branstetter, S., and J.A. Musick. 1994. Age and growth estimates for the sand tiger in the northwestern Atlantic Ocean. Trans. Am. Fish. Soc. 123: 242-254.

Brill, R.W., K.A. Bigelow, M.K. Musyl, K.A. Fritsches, and E.J. Warrant. 2005. Bigeye Tuna (Thunnus obesus) Behavior and Physiology and Their Relevance to Stock Assessments and Fishery Biology. Col. Vol. Sci. Pap. ICCAT 57(2):142-161.

Brown, C.A., and S.H. Gruber. 1988. Age assessment of the lemon shark*, Negaprion brevirostris*, using tetracycline validated vertebral centra. Copeia 1988(3): 747-753.

Buencuerpo, V.; S. Rios; and J. Moron. 1998. Pelagic sharks associated with the swordfish, *Xipyhias gladius*, fishery in the eastern North Atlantic Ocean and the strait of Gibraltar. Fish. Bull. 96:667-685.

Bumguardner, B.W. and J.D. Anderson. 2007. Atlantic billfish research program: age and growth, reproduction and genetics of billfish in Gulf of Mexico waters off Texas. Final Report to the Gulf States Marine Fisheries Commission. GSMFC Subcontract No. Billfish-2005-7. Texas Parks & Wildlife Department, Palacios, TX.

Bunkley-Williams, L., and E.H. Williams, Jr. 2004. New locality, depth, and size records and species character modifications of some Caribbean deep-reef/shallow slope fishes and a new host and locality record for the chimaera cestodarian. Caribbean Journal of Science*,* Vol. 40, No. 1, 88-119, 2004.

Burgess, G.H.. 2005. Commercial Shark Fishery Observer Program.- Monitoring the Directed Bottom Longline Shark Fishery in the Atlantic ocean and Gulf of Mexico off the Mid- and Southeastern United States, 2005 Fishing Season 1. Florida Museum of Natural History. University of Florida. Gainesville, FL.

Burgess, G.H., L.R. Beerkircher, G.M. Cailliet, J.K. Carlson, E. Cortés, K.J. Goldman, R. D. Grubbs, J.A. Musick, M.K. Musyl, and C.A. Simpfendorfer. 2005a. Is the collapse of shark populations in the northwest Atlantic Ocean and Gulf of Mexico real? Fisheries 30(10):19–26.

Burgess, G.H., L.R. Beerkircher, G.M. Cailliet, J.K. Carlson, E. Cortés, K.J. Goldman, R. D. Grubbs, J.A. Musick, M.K. Musyl, and C.A. Simpfendorfer. 2005b. Reply to "Robust estimates of decline for pelagic shark populations in the Northwest Atlantic and Gulf of Mexico." www.fisheries.org. 30(10) 30-31.

Burks, C.M., W.B. Driggers III and K.D.Mullin. 2006. Abundance and distribution of whale sharks (*Rhincodon typus*) in the northern Gulf of Mexico. Fish. Bull. 104:570-584.

Cailliet, G.M., and D.W. Bedford. 1983. The biology of three pelagic sharks from California waters, and their emerging fisheries: A review. Cal. Mar. Res. Comm., COFI Rep. 24: 57-69.

Cailliet, G.M., L.K. Martin, J.T. Harvey, D. Kusher, and B.A. Welden. 1983. Preliminary studies on the age and growth of blue, *Prionace glauca*, common thresher, *Alopias vulpinus*, and shortfin mako, *Isurus oxyrhinchus*, sharks from California waters. NOAA Technical Report NMFS 8. U.S. Dept. Comm., Washington DC: 179-188.

Cailliet, G.M., L.J. Natanson, B.A. Welden, and D.A. Ebert. 1985. Preliminary studies on the age and growth of the white shark, *Carcharodon carcharias*, using vertebral bands. Mem. South. Calif. Acad. Sci. 9: 49-60.

Cailliet, G.M. and H. M. Mollet. 1997. Preliminary demographic analysis of the shortfin mako, *Isurus oxyrinchus*. Abstract. ASIH 77th Annual Meeting, June 26-July 2, 1997. University of Washington, Seattle.

Campana, S.E. and W.N. Joyce. 2004. Temperature and depth associations of porbeagle shark (*Lamna nasus*) in the northwest Atlantic. Fisheries Oceanography 13: 52-64.

Campana, S.E., L.J. Natanson and S. Myklevoll. 2002. Bomb dating and age determination of large pelagic sharks. Can. J. Fish. Aquat. Sci. 59: 450-455.

Campana, S.E., L. Marks, and W. Joyce. 2005. The biology and fishery of shortfin mako sharks (*Isurus oxyrinchus*) in Atlantic Canadian waters. Fish. Res. 73:341-352.

Campana, S.E.; L. Marks; W.Joyce; and N.E. Kohler. 2006. Effects of recreational and commercial fishing on blue sharks (*Prionace glauca*) in Atlantic Canada, with inferences on the North Atlantic population. Can. J. Fish. Aquat. Sci. 63:670-682.

Capape, C., F. Hemida, A.A. Seck, Y. Diatta, O. Guelorget and J. Zaouali. 2003. Distribution and reproductive biology of the spinner shark, *Carcharhinus brevipinna* (Muller and Henle, 1841) (Chondrichthyes: Carcharhinidae). Israel Journal of Zoology 49: 269-286.

Carey, F.G. and E. Clark. 1995. Depth telemetry from the sixgill shark, *Hexanchus griseus*, at Bermuda. Environmental Biology of Fishes 42(1) 7-14.

Carlson, J.K. and G.R. Parsons. 1997. Age and growth of the bonnethead shark, *Sphyrna tiburo*, from northwest Florida, with comments on clinal variation. Environ. Biol. Fishes 50: 331-341

Carlson, J.K., and J.H. Brusher. 1999. An index of abundance for coastal species of juvenile sharks from the northeast Gulf of Mexico. Mar. Fish. Rev. 61:37-45.

Carlson, J.K., E. Cortés and A.G. Johnson. 1999. Age and growth of the blacknose shark, *Carcharhinus acronotus*, in the eastern Gulf of Mexico. Copeia 1999(3): 684-691.

Carlson, J.K. 2002. Shark nurseries in the northeastern Gulf of Mexico. In: McCandless, C.T. and H.L. Pratt, Jr. (eds.) Gulf of Mexico and- Atlantic States shark nursery overview. US Department of Commerce, NOAAINational Marine Fisheries ServiceIHighly Migratory Species Management Division, FISFI NMFS Office of Sustainable Fisheries, 1315 East-West Highway, Silver Spring MD.

Carlson, J.K., and I.E. Baremore. 2003. Changes in biological parameters of Atlantic sharpnose shark *Rhizoprionodon terraenovae* in the Gulf of Mexico: evidence for density-dependent growth and maturity? Marine and Freshwater Research 54:227-234.

Carlson, J.K., E. Cortés and D. Bethea. 2003. Life history and population dynamics of the finetooth shark, Carcharhinus isodon, in the northeast Gulf of Mexico. Fish. Bull. 101:281-292.

Carlson, J.K., and I.E. Baremore. 2005. Growth dynamics of the spinner shark, *Carcharhinus brevipinna*, off the United States Southeast and Gulf of Mexico coasts: a comparison of methods. Fish. Bull.. 103: 280-291.

Carlson, J.K., M.R. Heupel, D.M. Bethea, and L.D. Hollensead. 2008. Coastal habitat use and residency of juvenile Atlantic sharpnose sharks (*Rhizoprionodon terraenovae*). Estuaries and Coasts. 10p.

Carlson, J.K., and E. Cortés, J. A. Neer, C. T. McCandless, and L. R. Beerkircher. 2008. The Status of the United States Population of Night Shark, *Carcharhinus signatus*. Marine Fisheries Review 70(1):1-13.

Casey, J.G., and L.J. Natanson. 1992. Revised estimates of age and growth of the sandbar shark (*Carcharhinus plumbeus*) from the western North Atlantic. Can. J. Fish. Aquat. Sci. 49(7): 1474-1477.

Casey, J.G., and N.E. Kohler. 1992. Tagging studies on the shortfin mako shark (*Isurus oxyrhinchus*) in the western North Atlantic. Aust. J. Mar. Freshwater Res. 43: 45-60.

Casey, J.G., and H.L. Pratt, Jr. 1985. Distribution of the white shark, *Carcharodon carcharias*, in the western North Atlantic. Memoirs of the Southern California Academy of Sciences 9:2-14.

Cassoff, R.M.; S.E. Campana; and S. Myklevoll. 2007. Changes in baseline growth and maturation parameters of Northwest Atlantic porbeagle, *Lamna nasus*, following heavy exploitation. Can. J. Fish. Aquat. Sci. 64:19-29.

Castillo, G.J.L. 1992. Diagnostico de la pesqueria de tiburon en Mexico. Secretaria de Pesca, Mexico. 72pp.

Castro, J.I. 1983. The sharks of North American waters. Tex. A&M Univ. Press, College Station: 180pp.

Castro, J.I. 1993a. The biology of the finetooth shark, *Carcharhinus isodon*. Environ. Biol. Fishes 36: 219-232.

Castro, J.I. 1993b. The shark nursery of Bulls Bay, South Carolina, with a review of the shark nurseries of the southeastern coast of the United States. Environ. Biol. Fishes 38(1): 37-48.

Castro, J.I. 1996. The biology of the blacktip shark, *Carcharhinus limbatus*, off the southeastern United States. Bull. Mar. Sci. 59(3): 508-522.

Castro, J.I. In Press. The Sharks of North America. Oxford Univ. Press

Castro, J.I., and J.P. Wourms. 1993. Reproduction, placentation, and embryonic development of the Atlantic sharpnose shark, *Rhizoprionodon terraenovae*. J. Morph. 218: 257-280.

Cavalcanti, M.J. 2007. A phylogenetic supertree of the hammerhead sharks (Carcharhiniformes: Sphyrnidae). Zoological Studies 46(1):6-11.

Cervigón, F., R. Cipriani, W. Fischer *et al*. 1993. *Field guide to the commercial marine and brackish-water resources of the northern coast of South America. FAO species identification sheets for fishery purposes.* Rome, Italy: Food and Agriculture Organization of the United Nations. XL plates.

Chang, W.B., M.Y. Leu and L.S. Fang. 1997. Embryos of the whale shark, *Rhincodon typus*: early growth and size distribution. Copeia 1997(2): 444-446.

Chapman, D.D., and S. H. Gruber. 2002. A further observation of the prey-handling behavior of the great hammerhead shark, *Sphynra mokarran*: predation upon the spotted eagle ray, *Aetobatus narinari*. Bulletin of Marine Science 70(3): 947-952.

Chapman, D.D., E.K. Pikitch, E.A. Babcock, and M.S. Shivji. 2005. Marine Reserve Design and Evaluation Using Automated Acoustic Telemetry: A Case Study Involving Coral Reef-associated Sharks in the Mesoamerican Caribbean. Marine Technology Society Journal 39:42-55.

Chapman, D.D., M.S. Shivji, E. Louis, J. Sommer, H. Fletcher, and P.A. Prodohl. 2007. Virgin birth is a hammerhead shark. Biology Letters 3:425-427.

Chase, B. 2002. Differences in the diet of Atlantic bluefin tuna (*Thunnus thynnus*) at five seasonal feeding grounds on the New England continental shelf. Fisheries Bulletin 100:168–180

Chen, C., T. Leu, and S. Joung. 1988. Notes on reproduction in the scalloped hammerhead, *Sphyrna lewini*, in northeastern Taiwan waters. Fishery Bulletin 86:389–393.

Chen, C.T., K.M. Liu and Y.C. Chang. 1997. Reproductive biology of the bigeye thresher shark, *Alopias superciliosus* (Lowe, 1839) (Chondrichthyes: Alopiidae), in the northwestern Pacific. Ichthyological Research 44: 227-235.

Childs, J. 2000. Habitat Use of Shelf-Edge Topographic Highs in the Northwestern Gulf of Mexico by Sharks and Rays (Subclass Elasmobranchii. Proceedings: Gulf of Mexico Fish and Fisheries: Bringing Together New and Recent Research. 674 pp.

Chow, S., S. Clarke, M. Nakadate and M. Okazaki. 2007 Boundary between the north and south Atlantic populations of the swordfish (*Xiphias gladius*) inferred by a single nucleotide polymorphism at calmodulin gene intron. Mar. Biol. 152:87-93.

Clark, E. 1963. The maintenance of sharks in captivity, with a report of their instrumental conditioning. *In* P.Gilbert (ed.): Sharks and survival. D.C. Heath and Co., Boston: 115-149.

Clark, E., and K. von Schmidt. 1965. Sharks of the central gulf coast of Florida. Bull. Mar. Sci. 15: 13-83.

Clarke, T. A. 1971. The ecology of the scalloped hammerhead, *Sphyrna lewini*, in Hawaii. Pacific Science 25:133–144.

Claro, R. 1994. Caracterı´sticas generales de la ictiofauna. In *Ecologı´a de los peces marinos de Cuba*, ed. R. Claro, 55-71. Chetumal, Mexico: Instituto de Oceanologı´a Academia de Ciencias de Cuba, Cuba, and Centro de Investigaciones de Quintana Roo (CIQRO).

Cliff, G., and S.F.J. Dudley. 1991. Sharks caught in the protective gill nets off Natal, South Africa: The bull shark, *Carcharhinus leucas* Valenciennes. S. Afr. J. Mar. Sci. 10, 253-270.

Cliff, G., and S.F.J. Dudley. 1992. Sharks caught in the protective gill nets off Natal, South Africa. 6. The copper shark *Carcharhinus brachyurus* (Günther). S. Afr. J. Mar. Sci. 12: 663-674.

Collette, B.B and C.E. Nauen. 1983. FAO species catalogue Vol. 2. Scombrids of the world. An annotated and illustrated catalogue of tunas, mackerels, bonitos and related species known to date. FAO Fish. Synop., (125) Vol. 2: 137 p.

Collette, B.B., J.R. McDowell, and J.E. Graves. 2006. Phylogeny of recent billfishes (Xiphioidei). Bulletin of Marine Science 79: 455-468.

Colman, J.G. 1997. A review of the biology and ecology of the whale shark. Journal of Fish Biology 51: 1219-1234.

Compagno, L.J.V. 1984. FAO Species Catalog Vol.4, Part 1 and 2: Sharks of the world: An annotated and illustrated catalogue of shark species known to date. FAO Fish. Synop. 125. FAO, Rome, Italy.

Compagno, L. J. V., and V. H. Niem. 1998. Hexanchidae. Cowsharks, sixgill, and sevengill sharks. In *FAO identification guide for fishery purposes. The Living Marine Resources of the Western Central Pacific*, ed. K. E. Carpenter and V. H. Niem, 1208-1210. Rome, Italy: Food and Agriculture Organization, United Nations.

Compagno, L. J. V., D. A. Ebert, and M. J. Smale. 1989. *Guide to the sharks and rays of southern Africa*. London, England: New Holland (Publ.) Ltd.

Conrath, C.L., and J.A. Musick. 2007. Investigations into depth and temperature habitat utilization and overwintering grounds of juvenile sandbar sharks, Carcharinus plumbeus: the importance of near shore North Carolina waters. Environmental Biology of Fishes. In Press.

Consoli, P., T. Romero, P.Battaglia, L. Castriota, V. Esposito and F. Andaloro. 2008. Feeding habits of the albacore tuna *Thunnus alaunga* (Perciformes, Scombridae) from central Mediterranean Sea. Mar. Biol. 155: 113-120.

Cortés, E. 1995. Demographic analysis of the Atlantic sharpnose shark, *Rhizoprionodon-terraenovae*, in the Gulf of Mexico. Fish. Bull. 93: 57-66.

Cortés E. 2002. Catches and catch rates of Pelagic sharks from the northwestern Atlantic, Gulf of Mexico, and Caribbean. Col. Vol. Sci. Pap. ICCAT, 54 (4): 1164-1181.

Cortés, E., C.A. Manire and R.E. Hueter. 1996. Diet, feeding habits, and diel feeding chronology of the bonnethead shark, *Sphyrna tiburo*, in southwest Florida. Bulletin of Marine Science 58: 353-367.

Cortés, E. and G.R. Parsons. 1996. Comparative demography of two populations of the bonnethead shark (*Sphyrna tiburo*). Can. J. Fish. Aquat. Sci. 53: 709-718.

Cotton, P.A., D.W. Sims, S. Fanshawe, and M. Chadwick. 2005. The effects of climate variability on zooplankton and basking shark (*Cetorhinus maximus*) relative abundance off southwest Britain. Fisheries Oceanography 14(2):151–155.

Cramer, J. 1996. Large pelagic logbook indices for sharks. 1996 Shark Stock Assessment Workshop. NOAA/NMFS/SEFSC, Miami: 7pp.

Cramer, J. and Scott, G.P. 1998. Summarization of Catch and Effort in the Pelagic Longline Fishery and Analysis of the Effect of Two Degree Square Closures on Swordfish and Discards Landings. Author affiliation: Southeast Fisheries Science Center, Miami FL. Sustainable Fisheries Division Contribution MIA-97/98-17.

Davies, J. H. and S. A. Bortone. 1976. Partial food list of 3 species of Istiophoridae Pisces from the northeastern Gulf of Mexico. Fla. Sci. 39(4)249-253. ICCAT –SCRS Vol. 45(3) : 67-85.

deSylva D.P., and W.P. Davis. 1963. White marlin, *Tetrapterus albidus*, in the Middle Atlantic Bight, with observations on the hydrography of the fishing grounds. Copeia 1963(1): 81-99.

de Sylva, D.P. and P.R. Breder. 1997. Reproduction, gonad histology, and spawning cycles of north Atlantic billfishes (Istiophoridae). Bull. Mar. Sci. 60(3): 668-697.

Dennis, G. D., III. 2003. Annotated checklist of shallow-water marine fishes from the Puerto Rico Plateau including Puerto Rico, Culebra, Vieques, St. Thomas, St. John, Tortola, Virgin Gorda, and Anegada. Florida Integrated Science Center, U.S. Geological Survey, Gainesville, Florida. Introduction, [cars.er.usgs.gov/ Marine_Puerto_Rico_Plateau/ Plateau_Into/plateau_into.html]; History of ichthyology in Puerto Rico [. . . Plateau_History/ plateau_history.html]; Annotated list of species from the Puerto Rican Plateau, 224 pp. [cars. er.usgs.gov//PRAnnotated.pdf]; References, 26 pp. [. . . ///PRreference.pdf], revised 20 February 2003, accessed 15 March 2003.

Dewar, H., M. Domeier, and N. Nasby-Lucas. 2004. Insights into young of the year white shark, *Carcharodon carcharias*, behavior in the Southern California Bight. Environmental Biology of Fishes 70: 133–143.

Diamond, J.A. 1985. Filter-feeding on a grand scale. Nature 316:679-680.

Diaz, G.A. and J.E. Serafy. 2005. Longline-caught blue shark (*Prionace glauca*): factors affecting the numbers available for live release. Fish. Bull. 103:720-724.

Diaz, G.A., and S.C. Turner. 2007. Size frequency distribution and age estimation of BFT in the Gulf of Mexico during the spawning season. Collective Volume of Scientific Papers. ICCAT 60(4):1160-1170.

Dodrill, J.W. 1977. A hook and line survey of the sharks found within five hundred meters of shore along Melbourne Beach, Brevard County, Florida. M.S. Thesis. Florida Inst. Techn., Melbourne, FL. 304pp.

Dragovich, A. 1969. Review of studies of tuna food in the Atlantic Ocean. U. S. Fish wildl. Serv. Spec. Sci. Rep.-Fish. 593:21 p.

Dragovich, A. 1970a. The food of skipjack and yellowfin tunas in the Atlantic Ocean. Fish. Bull. U. S. 68(3):445-460.

Dragovich, A. 1970b. The food of bluefin tuna (*Thunnus thynnus*) in the western North Atlantic Ocean. Trans. Am. Fish. Soc. 99(4):726-731.

Dragovich, A. and T. Potthoff. 1972. Comparative study of food of skipjack and yellowfin tunas off the west coast of West Africa. Fish. Bull. U. S. 70(4): 1087-1110.

Driggers,W.B., D. Oakley, G. Ulrich, J.K. Carlson, B.J. Cullum, and J.M. Dean. 2004. Reproductive biology of the blacknose shark (*Carcharhinus acrontus*) in the coastal waters of South Carolina. Journal of Fish Biology 64:1540-1551.

Drigger, W.B., G.W. Ingram, Jr., M.A. Grace, J.K. Carlson, G.F. Ulrich, J.A. Sulikowski, and J.M. Quattro. 2007. Life history and population genetics of blacknose sharks, *Carcharhinus acronotus*, in the South Atlantic Bight and the northern Gulf of Mexico. SEDAR 13-DW-17, 29 pp.

Driggers, W.B. III, G.W. Ingram, Jr., M.A. Grace, C.T. Gledhill, T.A. Henwood, C.N. Horton and C.M. Jones. 2008. Pupping areas and mortality rates of young tiger sharks *Galeocerdo cuvier* in the western North Atlantic Ocean. Aquatic Biology 2:161-170.

Dudley, S.F.J., and G. Cliff. 1993. Sharks caught in the protective gills nets off Natal, South Africa. 7. The blacktip shark *Carcharhinus limbatus* (Valenciennes). S. Afr. J. Mar. Sci. 13: 237-254.

Dulvy, N.K. and J.D. Reynolds, 1997. Evolutionary transitions among egg-laying, live-bearing and maternal inputs in sharks and rays. Proc. R. Soc. Lond., Ser. B: Biol. Sci. 264:1309-1315.

Duncan, K.M., and K.N. Holland. 2006. Habitat use, growth rates and dispersal patterns of juvenile scalloped hammerhead sharks (*Sphyrna lewini*) in a nursery habitat. Marine Ecology Progress Series 312: 211-221.

Duncan, K.M., A. P. Martin, B. W. Bowen, and H. G. De Couet. 2006. Global phylogeography of the scalloped hammerhead shark (*Sphyrna lewini*). Molecular Ecology 15(8):2239-2251.

Earle S. 1940. The white marlin fishery of Ocean City, Maryland. United States Bureau of Fisheries, Department of the Interior, Special Report.

Ebert, D.A. 1986. Observations on the elasmobranch assemblage of San Francisco Bay. Calif. Dep. Fish. Game, Fish. Bull. 72(4): 244-249.

Ebert, E.A. 1992. Cowsharks. *In* California's living marine resources and their utilization, (W. S. Leet, C. M. Dewees, and C. W. Haugen, eds.), p. 54–55. Sea Grant Extension Publication UCSGEP-92-12.

Estrada, J.A., M. Lutcavage, and S. Thorrold. 2005. Diet and trophic position inferred from stable carbon and nitrogen isotopes of Atlantic bluefin tuna. Marine Biology 147(1):37-45.

Estrada, J.A., A.N. Rice, L.J. Natanson, and G.B. Skomal. 2006. The use of isotopic analysis of vertebrae in reconstructing ontogenetic feeding ecology in white sharks. Ecology 87:829-834.

Far Seas Fisheries Research Laboratory, Shimizu. March 1978. Distribution atlas of larval tunas, billfishes and related species. Results of larval surveys by R/V Shunyo Maru and Shoyu Maru (1956 –1975). Far Seas Fish. Res. Lab. S Ser. 9. 99p.

FishBase. 2008 *Negaprion brevirostris* Lemon shark. Available at http://www.fishbase.com/Summary/speciesSummary.php?ID=897&genusname=Negaprion&speciesname=brevirostris. (accessed on 01 July 2008).

Fitch, J.E. and W.L. Craig. 1964. First records for the bigeye thresher (*Alopias super ciliosus*) and slender tuna (*Allothunnus fallai*) from California, with notes on eastern Pacific scombrid otoliths. Calif. Fish Game 50:195-206.

Fourmanoir, P. 1961. Requins de la cote ouest de Madagascar. Memoires de L'Institut Scientifique de Madagascar. Tome IV. 81pp.

Fowler, H.W. 1906. Some cold blooded vertebrates of the Florida Keys. Proc. Acad. Nat. Sci. Phila. 58: 77-113.

Francis, M, 1996. Observations of a pregnant white shark with a review of reproductive biology. *In*: Great white sharks: The biology of *Carcharodon carcharias*. *Eds*: A.P. Klimley and D.G. Ainley. Academic Press. 517 pp.

Francis, M.P. and J.D. Stevens. 2000. Reproduction, embryonic development, and growth of the porbeagle shark, *Lamna nasus*, in the Southwest Pacific Ocean. Fish. Bull. 98: 41-63.

Francis, M.P. and C. Duffy. 2005. Length at maturity in three pelagic sharks (*Lamna nasus*, *Isurus oxyrinchus*, and *Prionace glauca*) from New Zealand. Fish. Bull. 103: 489-500.

Francis, M.P.; L.J. Natanson; and S.E. Campana. 2008. The biology and ecology of the porbeagle shark, *Lamna nasus*. p. 105-113. *In*: Sharks of the Open Ocean, Biology, Fisheries, and Conservation (eds. M.D. Camhi, E.K. Pikitch, and E.A. Babcock). Blackwell Publishing, Oxford UK.

Francis, M.P.; S.E. Campana; and C.M. Jones. 2007. Age under-estimation in New Zealand porbeagle sharks (*Lamna nasus*): is there an upper limit to ages that can be determined from shark vertebrae? Marine and Freshwater Research 58:10-23.

Frentzel-Beyme, B.Z. and F.W. Koster. 2002. On the biology of the sharpnose sevengill shark, *Heptranchias perlo*, from the Great Meteor Seamount (central eastern Atlantic). 4th Meeting of the European Elasmobranch Association. Proceedings. pp. 77-96.

Fromentin, J.M. and A. Fonteneau. 2001. Fishing effects and life history traits: a case study comparing tropical versus temperate tunas. Fisheries Research 53:133-150.

Fromentin, J.M., and J.E. Powers. 2005. Atlantic bluefin tuna: population dynamics, ecology, fisheries and management. Fish and Fisheries 6:281–306.

Garla, R.C., D.D. Chapman, M.S. Shivji, B.M. Wetherbee, and A.F. Amorim. 2006. Habitat of juvenile Caribbean reef sharks, Carcharhinus perezi, at two oceanic insular marine protected areas in the southwestern Atlantic Ocean: Fernando de Noronha Archipelago and Atol das Rocas, Brazil. Fisheries Research 81:236-241.

Garrick, J.A.F. 1982. Sharks of the genus *Carcharhinus.* NOAA Technical Report NMFS Circ. 445. U.S. Dept. Comm., Washington DC: 194pp.

Gauld, J.A. 1989. Records of porbeagles landed in Scotland, with observations on the biology, distribution and exploitation of the species. Scottish Fisheries Research Report 45. Dept. Ag., Edinburgh, Scotland: 1-15.

Gelsleichter, J., J.A. Musick and S. Nichols. 1999. Food habits of the smooth dogfish, Mustelus canis, dusky shark, *Carcharhinus obscurus*, Atlantic sharpnose shark, *Rhizoprionodon terraenovae*, and the sand tiger, *Carcharias taurus*, from the northwest Atlantic Ocean. Environ. Biol. Fishes 54: 205-217.

Gilmore, R. G. 1983. Reproduction and embryonic development of the sand tiger shark, *Odontaspis taurus* (Rafinesque). U.S. Wildl. Serv. Fish. Bull.: 192):201-225.

Gilmore, R.G. 1993. Reproductive biology of Lamnoid sharks. Environ. Biol. Fishes 38:95-114.

Goldstein, J.S. Heppell, A. Cooper, S. Brault, and M. Lutcavage. 2007. Reproductive status and body condition of Atlantic bluefin tuna in the Gulf of Maine, 2000–2002. Marine Biology 151:2063–2075

Goodyear, C.P. 2003. Mean hook depth-an unsuitable metric for computing effective effort for standardizing billfish longline CPUE. Int. Comm. Conserv. Atl. Tunas, Madrid. Collect. Vol. Sci. Pap. 55(2):669–687.

Govender, A., N. Kistnasamy, and R.P. Van Der Elst. 1991. Growth of spotted ragged-tooth sharks, *Carcharias taurus* (Rafinesque) in captivity. S. Afr. J. Mar. Sci. 11: 15-19.

Govoni, J.J., E.H. Laban, and J.A. Hare. 2003. The early life history of swordfish (Xiphias gladius) in the western North Atlantic. Fish. Bull. 101(4) 778-789.

Grall, C., D.P. de Sylva and E.D. Houde. 1983. Distribution, relative abundance, and seasonality of swordfish larvae. Trans. Am. Fish. Soc. 112:235-246.

Graves, J.E. and J.R. McDowell. 2001. A genetic perspective on the stock structures of blue marlin and white marlin in the Atlantic Ocean. ICCAT Col. Vol. Sci. Pap. 53:180-187.

Graves, J.E. and J.R. McDowell. 2003. Stock structure of the world's istiophorid billfishes: a genetic perspective. Marine and Freshwater Research. 54:287-298.

Grubbs, R.D. and J.A. Musick. 2002. Shark nurseries of Virginia: spatial and temporal delineation, migratory patters, and habitat selection; a case study. In: McCandless *et al*. 2002. Shark nursery grounds of the Gulf of Mexico and the East Coast waters of the United States: an overview. 286 pp.

Grubbs, R.D., and J.A. Musick. 2007. Spatial delineation of summer nursery areas for juvenile sandbar sharks in Chesapeake Bay, Virginia. Pages 63-86 *in* C.T. McCandless, N.E. Kohler, and H.L. Pratt, Jr. editors. Shark nursery grounds of the Gulf of Mexico and the east coast waters of the United States. American Fisheries Society Symposium 50, Bethesda, Maryland.

Gubanov, Y.P., and V.N. Grigor'yev. 1975. Observations on the distribution and biology of the blue shark *Prionace glauca* (Carcharhinidae) of the Indian Ocean. J. Ichth. 15(1): 37-43.

Gudger, E.W.1912. Summary of work done on the fishes of Tortugas. Carnegie Inst. Washington. Year book No. 11:148-149.

Guitart Manday, D. 1975. Las pesquerias pelagico- oceanicas de corto radio de accion en la region noroccidental de Cuba. Academia de Ciencias de Cuba, Instituto de Oceanologia. Serie Oceanologia 31. 26pp.

Gurshin, C.W.D. 2002. Shark nursery grounds in Sapelo Island National Estuarine Reserve, Georgia and coastal Alabama. 2002. In: McCandless *et al*. 2002. Shark nursery grounds of the Gulf of Mexico and the East Coast waters of the United States: an overview. 286 pp.

Gurshin, C.W.D. 2007. Shark Nursery Grounds in Sapelo Island National Estuarine Research Reserve, Georgia. American Fisheries Society, Symposium 50: 141-152.

Hart, J. L. 1973. Pacific fishes of Canada. Bulletin of Fisheries Research Board, Canada 180, 740 p.

Harvey-Clark, C. 1995. Protection of sixgill sharks. In N.L. Shackell, and J.H.M. Willison (eds): Marine protected areas and sustainable fisheries. Sci. Manag. Protected Areas Ass., Nova Scotia: 286-289.

Harvey-Clark, C.J., W.T. Stobo, E. Helle, and M. Mattson. 1999. Putative mating behaviour in basking sharks off the Nova Scotia coast. Copeia 1999:780–782.

Hazin, F.H.V., F.M. Lucena, T. Souza, C.E. Boeckman, M.K. Broadhurst and R.C. Menni. 2000. Maturation of the night shark, *Carcharhinus signatus*, in the southwestern equatorial Atlantic Ocean. Bulletin of Marine Science 66: 173-185.

Hazin, F., A. Fischer and M. Broadhurst. 2001. Aspects of reproductive biology of the scalloped hammerhead shark, *Sphyrna lewini*, off northeastern Brazil. Environ. Biol. Fishes 61: 151-159.

Hazin, F.H.V., P.G. Oliveira and M.K. Broadhurst. 2002. Reproduction of the blacknose shark (*Carcharhinus acronotus*) in coastal waters off northeastern Brazil. Fish. Bull. 100: 143-148.

Hazin, F.H.V., P.G.V. Oliveira, and B.C.L. Macena. 2007. Aspects of the reproductive biology of the silky shark, *Carcharinus falciformis* (Nardo, 1827), in the vicinity of Archipelago of Saint Peter and Saint Paul, in the equatorial Atlantic Ocean. Col. Vol. Sci. Pap. ICCAT 60(2):648-651.

Heist, E.J., J.A. Musick and J.E. Graves. 1996. Genetic population structure of the shortfin mako (*Isurus oxyrinchus*) inferred from restriction fragment length polymorphism analysis of mitochondrial DNA. Can. J. Fish. Aquat. Sci. 53: 583-588.

Heithaus, M.R., L.M. Dill, G.J. Marshall and B. Buhleier. 2002. Habitat use and foraging behavior of tiger sharks (*Galeocerdo cuvier*) in a seagrass ecosystem. Mar. Biol. 140:237-248.

Hendon, J.R. and E.R. Hoffmayer. 2007. Mississippi coastal sport fish studies 2004-2006. Final Report. U.S. Fish and Wildlife Service, Wallop-Breaux Sport Fish Restoration Program, 75 pp.

Heupel, M.R. 2007. Exiting Terra Ceia Bay: examination of cues stimulating migration from a summer nursery area. American Fisheries Society, Symposium 50: 265-280.

Heupel, M.R. and R.E. Hueter. 2002. Importance of prey density in relation to the movement patterns of juvenile blacktip sharks (*Carcharhinus limbatus*) within a coastal nursery area. Marine and Freshwater Research 53: 543-550.

Heupel, M.R. and C.A. Simpfendorfer. 2002. Estimation of mortality of juvenile blacktip sharks, *Carcharhinus limbatus*, within a nursery area using telemetry data. Can. J. Fish. Aquat. Sci. 59: 624-632.

Heupel, M.R., C.A. Simpfendorfer and R.E. Hueter. 2004. Estimation of shark home ranges using passive monitoring techniques. Environ. Biol. Fishes 71: 135-142.

Heupel, M.R. and C.A. Simpfendorfer. 2005a. Quantitative analysis of aggregation behavior in juvenile blacktip sharks. Marine Biology 147: 1239-1249.

Heupel, M.R. and C.A. Simpfendorfer. 2005b. Using acoustic monitoring to evaluate MPAs for shark nursery areas: the importance of long-term data. Marine Technology Society Journal 39: 10-18.

Hoelzel, A.R., M.S. Shivji, J. Magnussen, and M.P. Francis. 2006. Low worldwide genetic diversity in the basking shark (*Cetorhinus maximus*). Biology Letters 2: 639–642.

Hoolihan, J.P., J. Luo, D.E. Richardson, D. Snodgrass, E.S. Orbesen and E.D. Prince. *in prep*. Vertical behavior of Atlantic billfishes inferred from pop-up satellite archival tags.

Horodysky, A.Z. and J.E. Graves. 2005. Application of pop-up satellite archival tag technology to estimate post-release survival of white marlin (*Tetrapturus albidus*) caught on circle and straight-shank ("J") hooks in the western north Atlantic recreational fishery. Fish. Bull. 103:84-96.

Horodysky A.Z., D.W. Kerstetter, R.J. Latour, and J.E. Graves. 2007. Habitat utilization and vertical movements of white marlin (*Tetrapturus albidus*) released from commercial and recreational fishing gears in the western North Atlantic Ocean: inferences from short duration pop-up archival satellite tags. Fisheries Oceanography 16: 240-256.

Hoffmayer, E.R. and G.R. Parsons. 2003. Food habits of three shark species from the Mississippi Sound in the northern Gulf of Mexico. Southeastern Naturalist 2: 271-280.

Hoffmayer, E.R., J.S. Franks, and J.P. Shelley. 2005. Recent observations of the whale shark (Rhincodon typus) in the north central Gulf of Mexico. Gulf and Caribbean Research Vol 17, 117-120.

Hoffmayer. E.R., J.S. Franks, W.B. Driggers III, K.J. Oswald and J.M. Quattro. 2007. Observations of a feeding aggregation of whale sharks, *Rhincodon typus*, in the north central Gulf of Mexico. Gulf and Caribbean Research 19(2) 69-73.

Holts, D.B., A. Julian, O. Sosa-Nishizaki, and N.W. Bartoo. 1996. Pelagic shark fisheries along the west coast of the United States and Baja California, Mexico. American Fisheries Society 1995 Proceedings. 37pp.

Hueter, R.E. and J.P. Tyminski. 2002. Center for Shark Research (CSR) U.S. shark nursery research overview 1991-2001. *In*: McCandless *et al*. 2002. Shark nursery grounds of the Gulf of Mexico and the East Coast waters of the United States: an overview. 286 pp.Hoff, T.B. 1990. Conservation and management of the western North Atlantic shark resource based on the life history strategy limitations of sandbar sharks. Ph.D. dissertation, Univ. of Delaware. 282pp.

Hueter, R., and J. Tyminski. 2007. Species-specific distribution and habitat characteristics of shark nurseries in Gulf of Mexico waters off peninsular Florida and Texas. American Fisheries Society Symposium 50:193-223.

Hueter, R.E., M.R. Heupel, E.J. Heist, and D.B. Keeney. 2005. Evidence of philopatry in sharks and implications for the management of shark fisheries. Journal of Northwest Atlantic Fishery Science 35:239–247.

ICCAT. 1994. Report of the working group to evaluate Atlantic yellowfin tuna. Collect. Vol. Pap. ICCAT 1994 Vol. 42(2) : 1-25.

ICCAT. 1995. 1995 SCRS detailed report on skipjack.

ICCAT. 1997. Report for biennial period 1996-97, 1(2).

ICCAT. 2001. Report of the fourth ICCAT billfish workshop. ICCAT Col. Vol. Sci. Pap. 53:1-130.

ICCAT. 2008a. Bigeye Tuna Executive Summary. *In* Report for Biennial Period, 2006-07, SCRS, Part II, Vol.2. pp.70-78.

ICCAT. 2008b. Skipjack Tuna Executive Summary. *In* Report for Biennial Period, 2006-07, SCRS, Part II, Vol.2. pp.79-87.

ICCAT. 2008c. Yellowfin Tuna Executive Summary. *In* Report for Biennial Period, 2006-07, SCRS, Part II, Vol.2. pp.62-69.

ICES. 1995. Report of the study group on elasmobranch fishes. ICES Headquarters, Copenhagen, Denmark. ICES CM 1995/g:3. 92pp.

Idyll, C. P. and D. de Sylva. 1963. Synopsis of biological data on albacore *Thunnus alalunga* (Gmelin) 1788 (Western Atlantic). Pages 749-754 in: H. Rosa Jr. ed. Proceedings of the World Scientific Meeting on the Biology of Tunas and Related Species. FAO Fisheries Reports No. 6 (2).

IUCN. 2002. 2002 IUCN Red List of Threatened Species. Gland, Switzerland and Cambridge, UK: IUCN.

Jensen, C., Schwartz, F.J., Hopkins, G., 1995. Occurrence of an adult male reef shark, *Carcharhinus perezi* (Carcharhinidae) off North Carolina. J. Elisha Mitchell Sci. Soc. 111, 121–125.

Jensen, C.F., L.J. Natanson, H.L. Pratt, N.E. Kohler and S.E. Campana. 2002. The reproductive biology of the porbeagle shark (*Lamna nasus*) in the western North Atlantic Ocean. Fish. Bull. 100: 727-738.

Jensen, C.F., T.A. Thorpe, M.L. Moser, J.J. Francesconi, G.A. Hopkins, and D. Bersoff. 2002. Shark nursery areas in North Carolina state waters. In: McCandless *et al*. 2002. Shark nursery grounds of the Gulf of Mexico and the East Coast waters of the United States: an overview. 286 pp.

Jensen, N.H. 1976. Reproduction of the bull shark *Carcharhinus leucas*, in the Lake Nicaragua-Rio San Juan system. In: T. B. Thorson (ed.). Investigations of the ichthyofauna of Nicaraguan lakes. University of Nebraska-Lincoln, Lincoln. p. 539-559.

Joung, S.J., C-T Chen, E. Clark, S. Uchida, and W.Y.P. Huang. 1996. The whale shark, *Rhincodon typus*, is a livebearer: 300 embryos found in a one "Megamamma" supreme. Environ. Biol. Fishes 46: 219-223.

Joung, S.J., Y.Y. Liao, K.M. Liu, C.T. Chen and L.C. Leu. 2005. Age, growth, and reproduction of the spinner shark, *Carcharhinus brevipinna*, in the northeastern waters of Taiwan. Zoological Studies 44: 102-110.

Joyce, W.N., S.E. Campana, L.J. Natanson, N.E. Kohler, H.L. Pratt and C.F. Jensen. 2002. Analysis of stomach contents of the porbeagle shark (*Lamna nasus* Bonnaterre) in the northwest Atlantic. ICES Journal of Marine Science 59: 1263-1269.

Junior, T.V., C.M. Vooren, and R.P. Lessa. 2004. Feeding habits of four species of Istiophoridae (Pisces: Perciformes) from northeastern Brazil. Environmental Biology of Fishes 70: 293-304.

Kato, S., S. Springer, and M.H. Wagner. 1967. Field guide to eastern Pacific and Hawaiian sharks. U.S. Dept. Interior, Fish. Wildl. Ser., Bureau of Comm. Fish., Circular 271, Washington DC: 47pp.

Kenney, R.D., R.E. Owen and H.E. Winn. 1985. Shark distributions off the northeast United States from marine mammal surveys. Copeia 1985(1): 220-223.

Keeney, D.B., M. Heupel, R.E. Hueter and E.J. Heist. 2003. Genetic heterogeneity among blacktip shark, *Carcharhinus limbatus*, continental nurseries along the US Atlantic and Gulf of Mexico. Marine Biology 143: 1039-1046.

Keeney, D.B., M.R. Heupel, R.E. Hueter and E.J. Heist. 2005. Microsatellite and mitochondrial DNA analyses of the genetic structure of blacktip shark (*Carcharhinus limbatus*) nurseries in the northwestern Atlantic, Gulf of Mexico, and Caribbean Sea. Molecular Ecology 14: 1911-1923.

Kerstetter, D.W., J.J. Polovina, and J.E. Graves. 2004. Evidence of shark predation and scavenging on fishes equipped with pop-up satellite archival tags. Fish. Bull. 102:750-756.

Kerstetter, D.W., and J.E. Graves. 2006. Survival of white marlin (*Tetrapturus albidus*) released from commercial pelagic longline gear in the western North Atlantic. Fishery Bulletin 104: 434-444.

Klimley, A. P. 1985. The areal distribution and autoecology of the white shark, *Carcharodon carcharias,* off the west coast of North America. Memoirs of the Southern California Academy of Sciences 9:15–40.

Klimley, A.P. 1987. The determinants of sexual segregation in the scalloped hammerhead shark, *Sphyrna lewini*. Environmental Biology of Fishes 18: 27–40.

Knickle, C. 2008. Silky Shark Biological Profile. Florida Museum of Natural History. Available at http://www.flmnh.ufl.edu/fish/Gallery/Descript/silkyshark/silkyshark.html. (accessed 17 July 2008).

Kohler, N.E., and P.A. Turner. 2001. Shark tagging: a review of conventional methods and studies. Environmental Biology of Fishes 60:191–223.

Kohler, N.E., J.G. Casey, and P.A. Turner. 1998. NMFS cooperative shark tagging program, 1962–93: an atlas of shark tag and recapture data. Marine Fisheries Review 60:1–87.

Lessa, R. and F.M. Santana. 1998. Age determination and growth of the smalltail shark, *Carcharhinus porosus*, from northern Brazil. Marine and Freshwater Research 49: 705-711.

Lessa, R.P. and Z. Almeida. 1998. Feeding habits of the bonnethead shark, *Sphyrna tiburo*, from northern Brazil. Cybium 22: 383-394.

Lessa, R., R.C. Menni and F. Lucena. 1998. Biological observations on *Sphyrna lewini* and *S. tudes* (Chondrichthyes, Sphyrnidae) from northern Brazil. Life and Environment 48: 203-213.

Lessa, R., R. Paglerani, and F.M. Santana. 1999a. Biology and morphometry of the oceanic whitetip shark, *Carcharhinus longimanus* (Carcharhinidae), off northeastern Brazil. Cybium 23: 353-368.

Lessa, R., F. Santana, R. Menni, and Z. Almeida. 1999b. Population structure and reproductive biology of the smalltail shark (*Carcharhinus porosus*) off Maranhao (Brazil). Marine and Freshwater Research 50: 383-388.

Lessa, R., F.M. Santana, and R. Paglerani. 1999c. Age, growth and stock structure of the oceanic whitetip shark, *Carcharhinus longimanus*, from the southwestern equatorial Atlantic. Fisheries Research 42: 21-30.

Lessa, R.; F.M. Santana; and F.H. Hazin. 2004. Age and growth of the blue shark *Prionace glauca* (Linnaeus, 1758) off northeastern Brazil. Fisheries Research 66:19-30.

Lingham-Soliar, T. 2005a. Caudal Fin in the White Shark, *Carcharodon carcharias* (Lamnidae): A Dynamic Propeller for Fast, Efficient Swimming. Journal of Morphology 264:233–252.

Lingham-Soliar, T. 2005b. Caudal fin allometry in the white shark Carcharodon carcharias:implications for locomotory performance and ecology. Naturwissenschaften 92: 231–236.

Lingham-Soliar, T. 2005c. Dorsal Fin in the White Shark, *Carcharodon carcharias*: A Dynamic Stabilizer for Fast Swimming. Journal of Morphology 264:233–252.

Liu, K.M., P.J. Chiang, and C.T. Chen. 1998. Age and growth estimates of the bigeye thresher shark, *Alopias superciliosus*, in northeastern Taiwan waters. Fish. Bull. 96: 482-491.

Loefer, J.K. and G.R. Sedberry. 2003. Life history of the Atlantic sharpnose shark (*Rhizoprionodon terraenovae*) (Richardson, 1836) off the southeastern United States. Fish. Bull. 101: 75-88.

Lombardi-Carlson, L.A., E. Cortés, G.R. Parsons and C.A. Manire. 2003. Latitudinal variation in life-history traits of bonnethead sharks, *Sphyrna tiburo*, (Carcharhiniformes: Sphyrnidae) from the eastern Gulf of Mexico. Marine and Freshwater Research 54: 875-883.

Lombardi-Carlson, L. 2007. Life history traits of bonnethead sharks, *Sphyrna tiburo*, from the eastern Gulf of Mexico. Panama City Laboratory Contribution 06-22. SEDAR 13-DW-24-V3.

Lucifora, L.O., R.C. Menni, and A.H. Escalante. 2002. Reproductive ecology and abundance of the sand tiger shark, *Carcharias taurus*, from the southwestern Atlantic. ICES Journal of Marine Science 59: 553-561.

Luckhurst, B.E., E.D. Prince, J.K. Llopiz, D. Snodgrass, and E.B. Brothers. 2006. Evidence of blue marlin (*Makaira nigricans*) spawning in Bermuda waters and elevated mercury levels in large specimens. Bulletin off Marine Science 79(3):691-704.

Lutcavage, M.E., R.W. Brill, G.B. Skomal, B.C. Chase, and P.W. Howey. 1999. Results of pop-up satellite tagging of spawning size class fish in the Gulf of Maine: do North Atlantic bluefin tuna spawn in the mid-Atlantic? Can. J. Fish. Aquat. Sci. 56:173–177.

Luthy, S.A., J.E. Serafy, R.K. Cowen, K.L. Denit, and S. Sponaugle. 2005. Age and growth of larval Atlantic sailfish, Istiophorus platypterus. Marine and Freshwater Research 56(7):1027-1035.

MacNeil, M.A., G.B. Skomal, and A.T. Fisk. 2005. Stable isotopes from multiple tissues reveal diet switching in sharks. Marine Ecology Progress Series 302: 199-206.

Maia, A.; N. Queiroz; J.P. Correia; H. Cabral. 2007a. Food habits of the shortfin mako, Isurus oxyrinchus, off the southwest coast of Potugal. Environ. Biol. Fish. 77:157-167.

Maia, A.; N. Queiroz; H.N. Cabral; A.M. Santos; and J.P. Correia. 2007b. Reproductive biology and population dynamics of the shortfin mako, *Isurus oxyrinchus* Rafinesque, 1810, off the southwest Portuguese coast, eastern North Atlantic. Journal of Applied Ichthyology 23:246-251.

Mancini, P.L. and A.F. Amorim. 2006. Embryos of common thresher shark *Alopias vulpinus* in southern Brazil, South Atlantic Ocean. Journal of Fish Biology 69:318-321.

Marquez-Farias, J.F., J.L. Castillo-Geniz, and M.C.R. de la Cruz. 1998. Demography of the bonnethead shark, *Sphyrna tiburo* (Linnaeus, 1758), in the southeastern Gulf of Mexico. Ciencias Marinas 24: 13-34.

Martinez, J.L. 1947. The Cuban shark industry. US. Fish Widl. Serv. Fishery Leaflet 250. 18pp.

Martins, C., P. Pinheiro, P. Travassos, F. Hazin. 2007. Preliminary results on reproductive biology of blue marlin, *Makaira nigricans* (Lacepede, 1803), in the tropical western Atlantic Ocean. Col. Vol. Sci. Pap. ICCAT 60(5):1636-1642.

Mather, F.J., lll, H.L. Clark, and J.M. Mason, Jr. 1975. Synopsis of the biology of the white marlin *Tetrapturus albidus* Poey (1861). Pages 55-94 *in:* Shomura, R. S. and F. Williams. eds. Proceedings of the International Billfish Symposium Kailua-Kona, Hawaii, 9-12 August 1972. Part 3. Species Synopses. NOAA Tech. Rep. NMFS SSRF-675. 159 p.

Mather, F.J., J.M. Mason, and A.C. Jones. 1995. Historical document: life history and fisheries of Atlantic bluefin tuna. NOAA Technical Memorandum NMFS-SEFSC – 370: 165 p.

Matthews L.H. 1950. Reproduction in the basking shark *Cetorhinus maximus* (Gunner). Philosophical transactions of the Royal Society of London. B 234:247–316

Matsumoto, T. and N. Miyabe. 2001. Preliminary report on the maturity and spawning of bigeye tuna (*Thunnus obesus*) in the central Atlantic ocean. Col. Vol. Sci. Pap. ICCAT 54(1):246-260.

Matthews, F.D., D.M. Damkaer, L.W. Knapp, and B.B. Collette. 1977. Food of wesatern North Atlantic tunas (*Thunnus*) and lancetfishes (Alepisaurus). NOAA Tech. Rep. NMFS-SSRF-706:19 p.

McCandless, C.T., H.L. Pratt, Jr., N.E. Kohler, R.R. Merson, and C.W. Recksiek. 2007. Distribution, localized abundance, movements, and migrations of juvenile sandbar sharks tagged in Delaware Bay. Pages 45-62 *In* C.T. McCandless, N.E. Kohler, and H.L. Pratt, Jr. editors. Shark nursery grounds of the Gulf of Mexico and the east coast waters of the United States. American Fisheries Society Symposium 50, Bethesda, Maryland.

McCosker, J. E. 1985. White shark attack behavior: observations of and speculations about predator and prey strategies. Memoirs of the Southern California Academy of Sciences 9: 123–135.

McFarlane, G.A., J.R. King, and M.W. Saunders. 2002. Preliminary study on the use of neural arches in the age determination of bluntnose sixgill sharks (*Hexanchus griseus*). Fish. Bull. 100: 861-864.

McGowan, M.F. and W.J. Richards. 1989. Bluefin tuna, Thunnus thynnus, larvae in the Gulf Stream off the southeastern United States: satellite and shipboard observations of their environment. Fish. Bull. 87: 615-631.

Merson, R. & H.L. Pratt, Jr. 2001. Distribution, movements and growth of young sandbar sharks, *Carcharhinus plumbeus*, in the nursery grounds of Delaware Bay. Env. Biol. Fish. 61: 13–24.

Merson, R.R., and H.L. Pratt Jr. 2007. Sandbar shark nurseries in New Jersey and New York: Evidence of northern pupping grounds along the United States east coast. Pages 35-43 *In* C.T. McCandless, N.E. Kohler, and H.L. Pratt, Jr. editors. Shark nursery grounds of the Gulf of Mexico and the east coast waters of the United States. American Fisheries Society Symposium 50, Bethesda, Maryland.

Michel, M. and P. Steiner. 2002. Sharks of the Ten Thousand Islands Estuary in Florida. In: McCandless *et al*. 2002. Shark nursery grounds of the Gulf of Mexico and the East Coast waters of the United States: an overview. 286 pp.

Miles, P. 1971. The mystery of the great white shark. Oceans, 4(5):51–59.

Mollet, H.F., and G. M. Cailliet. 2002. Comparative population demography of elasmobranchs using life history tables, Leslie matrices and stage-based matrix models. Marine and Freshwater Research 53, 503–516.

Mollet, H.F., G. Cliff, H.L. Pratt, and J.D. Stevens. 2000. Reproductive biology of the female shortfin mako, *Isurus oxyrinchus* Rafinesque, 1810, with comments on the embryonic development of lamnoids. Fish. Bull. 98: 299-318.

Moreno, J.A., and J. Morón. 1992. Reproductive biology of the bigeye thresher shark, *Alopias superciliosus* (Lowe 1839). Aust. J. Mar. Freshwater Res. 43: 77-86.

Morgan, A. .2008. Lemon Shark Biological Profile. Florida Museum of Natural History. Available at http://www.flmnh.ufl.edu/fish/Gallery/Descript/LemonShark/LemonShark.html. (accessed on 01 July 2008).

Morgan, S. G., C. S. Manooch III, D. L. Mason and J. W. Goy. 1985. Pelagic fish predation on *Cerataspis*, a rare larval genus of oceanic penaeoid. Bull. Mar. Sci. 36(2): 249-259.

Musick, J.A. and J.A. Colvocoresses. 1986. Seasonal recruitment of subtropical sharks in Cheasapeake Bight, USA. IOC/FAO Workshop on recruitment in tropical demersal communities. Ciudad del Carmen, Mexico. Intergovernmental Oceanographic Commision Workshop Report No. 44-Supplement. pp301-311.

Musick, J.A., S. Branstetter, and J.A. Colvocoresses. 1993. Trends in shark abundance from 1974 to 1991 for the Chesapeake Bight region of the U.S. Mid-Atlantic Coast. In S. Branstetter (ed.): Conservation biology of elasmobranchs. NOAA Technical Report NMFS 115: 1-18.

Musyl, M.K., R.W. Brill, C.H. Boggs, D.S. Curran, T.K. Kazama, and M.P. Seki. 2003. Vertical movements of bigeye tuna (*Thunnus obesus*) associated with islands, buoys, and seamounts near the main Hawaiian Islands from archival tagging data. Fisheries Oceanography, Vol. 12(3): 152-169.

Nakamura, H. 1935. On the two species of the thresher shark from Formosan waters. Mem. Fac. Sci. Agric. Taihoku Imp. Univ. 14: 1-6.

Nakamura, I. 1985. FAO Species Catalogue Vol. 5. Billfishes of the world. An annotated and illustrated catalogue of marlins, sailfishes, spearfishes and swordfishes known to date. FAO Fish. Synop., (125) Vol. 5. 65 p.

Nakano, H. 1994. Age, reproduction and migration of blue shark in the North Pacific Ocean. Bull. Nat. Inst. Far Seas Fish. 31: 141-144.

Nakano, H.; H. Matsunaga; H. Okamoto; and M. Okazaki. 2003. Acoustic tracking of bigeye thresher shark, *Alopias superciliosus*, in the eastern Pacific Ocean. Marine Ecology Progress Series 265:255-261.

Natanson, L.J. 1990. Relationship of vertebral band deposition to age and growth in the dusky shark, *Carcharhinus obscurus*, and the little skate, *Raja erinacea.* Ph.D.dissertation. University of Rhode Island:153 pp.

Natanson, L.J. 2002. Preliminary investigations into the age and growth of the shortfin mako, *Isurus oxyrinchus*, white shark, *Carcharodon carcharias*, and thresher shark, *Alopias vulpinus*, in the western North Atlantic Ocean. Collective Volume of Scientific Papers ICCAT 54:1280-1293.

Natanson, L.J., J.G. Casey, and N.E. Kohler. 1995. Age and growth estimates for the dusky shark, *Carcharhinus obscurus*, in the western North Atlantic Ocean. Fish. Bull. 93: 116-126.

Natanson, L.J., J.G. Casey, N.E. Kohler, and T. Colket. 1998. Growth of the tiger shark, *Galeocerdo cuvier*, in the western North Atlantic based on tag returns and length frequencies; and a note on the effects of tagging. Fish. Bull. 97: 944-953.

Natanson, L.J., J.J. Mello, and S.E. Campana. 2002. Validated age and growth of the porbeagle shark (*Lamna nasus*) in the western North Atlantic Ocean. Fish. Bull. 100: 266-278.

Neer, J.A., B.A. Thompson, R.E. Condrey, J.A. De Silva, G.W. Peterson, K.P. Barry, J.K. Blackburn, and D.W. Parnell. 2002. Shark nursery areas of Louisiana's nearshore coastal waters: a preliminary review. *In*: McCandless *et al*. 2002. Shark nursery grounds of the Gulf of Mexico and the East Coast waters of the United States: an overview. 286 pp.

Neer, J.A., B.A. Thompson, and J.K. Carlson. 2005. Age and growth of the bull shark, *Carcharhinus leucas,* in the northern Gulf of Mexico: incorporating variability in size at birth. Journal of Fish Biology 67: 370-383.

Neer, J.A., J.K. Blackburn, and B.A. Thompson. 2007. Shark Nursery Areas of Central Louisiana's Nearshore Coastal Waters. American Fisheries Society Symposium 50:317–330.

Neilson, J.D., and S.E. Campana. 2007. Pilot study of bluefin tuna age validation. Collective Volume of Scientific Papers. ICCAT 60(3):1001-1007.

Oguri, M. 1964. Rectal glands of marine and fresh-water sharks: comparative histology. Science 144(3622):1151–1152.

Orbesen, E.S., J.P. Hoolihan, J.E. Serafy, D. Snodgrass, E.M. Peel, and E.D. Prince. In Press. Transboundary movement of Atlantic Istiophorid billfishes among international and U.S. domestic management areas inferred from mark-recapture studies. Marine Fisheries Review.

Ortiz, M., E.D. Prince, J.E. Serafy, D.B. Holts, K.B. Davy, J.G. Pepperell, M.B. Lowry, and J.C. Holdsworth. 2003. Global overview of the major constituent-based billfish tagging programs and their results since 1954. Marine and Freshwater Research 54:489-507.

Owen, R.E. 1984. Distribution and ecology of the basking shark *Cetorhinus maximus* (Gunnerus 1765). MS thesis, University of Rhode Island, Kingston, RI.

Palko, B.J., G.L. Beardsley, and W.J. Richards. 1981. Synopsis of the biology of the Swordfish, *Xiphias gladius* Linnaeus. FAO Fisheries Synopsis No. 127. NOAA Tech. Rep. NMFS Circular 441. 21p.

Pardini, A.T., C.S. Jones, L.R. Noble, B. Kreiser, H. Malcolm, B.D. Bruce, J.D. Sevens, G. Cliff, M.C. Scholl, M. Francis, C.A.J. Duffy, and A.P. Martin. 2001. Sex-biased dispersal of great white sharks. Nature 412(6843):139-140.

Parker, H.W. and M. Boeseman. 1954. The basking shark, *Cetorhinus maximus*, in winter. Proceedings of the Zoological Society of London 124:185-194.

Parker, H.W., and F.C. Stott. 1965. Age, size and vertebral calcification in the basking shark, *Cetorhinus maximus* (Gunnerus). Zool. Meded. 40(34): 305-319.

Parsons, G.R. 1993. Age determination and growth of the bonnethead shark *Sphyrna tiburo*: a comparison of two populations. Mar. Biol. 117: 23-31.

Parsons, G.R. 2002. Identification of shark nursery grounds along the Mississippi and Alabama Gulf coasts. *In*: McCandless *et al*. 2002. Shark nursery grounds of the Gulf of Mexico and the East Coast waters of the United States: an overview. 286 pp.

Parsons, G.R., and E.R. Hoffmayer. 2007. Identification and Characterization of shark nursery grounds along the Mississippi and Alabama Gulf Coasts. American Fisheries Society Symposium 50:301–316.

Piercy, A.N., J. Carlson, J.A. Sulikowski, and G.H. Burgess. 2007. Age and growth of the scalloped hammerhead shark, *Sphyrna lewini*, in the north-west Atlantic Ocean and Gulf of Mexico. Marine and Freshwater Research 58(1):34-40.

Pikitch, E.K., D.D. Chapman, E.A. Babcock, and M.S. Shivji. 2005. Habitat use and demographic population structure of elasmobranchs at a Caribbean atoll (Glover's Reef, Belize). Marine Ecology Progress Series 302:187-197.

Polo-Silva, C.; A. Baigorri-Santacruz; F. Galvan-Magana; M. Grijalba-Bendeck; and A. Sanjuan-Munoz. 2007. Habitos alimentarios del tiburon zorro, *Alopias superciliosus* (Lowe, 1839), en el Pacifico ecuatoriano.

Pratt, H.L. 1979. Reproduction in the blue shark, *Prionace glauca*. U.S. Fish Wildl. Serv. Fish. Bull. 77: 445-470.

Pratt, H.L. and J.G. Casey. 1983. Age and growth of the shortfin mako, *Isurus oxyrinchus*. *In* E.D. Prince and L.M. Pulos (eds), Proceedings of the international workshop on age determination of oceanic pelagic fishes: Tunas, billfishes, and sharks. NOAA Tech. Rep. NMFS 8: 175-177.

Pratt Jr., H.L. and J.G. Casey. 1983. Age and Growth of the shortfin mako, *Isurus oxyrinchus*, using four methods. Can. J. Fish. Aquat. Sci. 40: 1944-1957.

Pratt, H.L., Jr., and J.C. Carrier. 2001. A review of elasmobranch reproductive behavior with a case study on the nurse shark, *Ginglymostoma cirratum*. Environmental Biology of Fishes 60:157-188.

Press, M. 2008. Narrowtooth Shark Biological Profile. Floridia Museum of Natural History. Available at http://www.flmnh.ufl.edu/fish/Gallery/Descript/narrowtoothshark/narrowtoothshark.html. (accessed on 17 July 2008).

Preti, A.; S.E. Smith; and D.A. Ramon. 2004. Diet differences in the thresher shark (*Alopias vulpinus*) during transition from a warm-water regime to a cool-water regime off California-Oregon, 1998-2000.

Prince, E.D., D.W. Lee, C.A. Wilson, and J.M. Dean. 1986. Longevity and age validation of a tag-recaptured Atlantic sailfish, *Istiophorus platypterus*, using dorsal spines and otoliths.Fish. Bull. U.S. 84(3):493-502.

Prince, E.D., D.W. Lee, and J.R. Zweifel. 1991. Estimating age and growth of young Atlantic blue marlin *Makaira nigricans* from otolith microstructure. Fish. Bull., U.S. 89:441-459.

Prince, E.D., R.K. Cowen, E.S. Orbesen, S.A. Luthy, J.K. Llopiz, D.E. Richardson, and J.E. Serafy. 2005. Movements and spawning of white marlin (*Tetrapturus albidus*) and blue marlin (*Makaira nigricans*) off Punta Cana, Dominican Republic. Fishery Bulletin 103(4):659-669.

Prince, E.D. and C.P. Goodyear. 2006. Hypoxia-based habitat compression of tropical pelagic fishes. Fisheries Oceanography 15(6):451-464.

Quattro, J.M., D.S. Stoner, W.B. Driggers, C.A. Anderson, K.A. Priede, E.C. Hoppmann, N.H. Campbell, K.M. Duncan, J.M. Grady. 2006. Genetic evidence of cryptic speciation within hammerhead sharks (Genus *Sphyrna*). Marine Biology 148(5)1143-1155.

Queiroz, N.; F.P. Lima; A. Maia; P.A. Ribeiro; J.P. Correia; and A.M. Santos. 2005. Movement of blue shark, *Prionace glauca*, in the north-east Atlantic based on mark-recapture data. J. Jar. Biol. Ass. U.K. 85:1107-1112.

Ramjohn, D. D. 1999. *Checklist of coastal and marine fishes of Trinidad and Tobago*. Marine Fishery Analysis Unit, Fisheries Division, Ministry of Agriculture, Land and Marine Resources, Trinidad and Tobago. Fisheries Information Series 8:151 pp.

Restrepo V.R., E. Roderíguez-Marín, J.L. Cort, and C. Rodríguez-Cabello. 2007. Are the growth curves currently used for Atlantic bluefin tuna statistically different? Collective Volume of Scientific Papers. ICCAT 60(3):1014-1026.

Richards, W.J. 1969. Distribution and relative apparent abundance of larval tunas collected in the tropical Atlantic during Equalant I and II. Proc. Symp. Ocean. Fish. Res. Trop. Atl. – Review papers and contributions. pp. 289 – 315.

Richards, W.J. 1976. Spawning of bluefin tuna in the Atlantic Ocean and adjacent seas. Collective Volume of Scientific Papers. ICCAT 5(2):267-278.

Richards, W.J. 1990. Results of a review of the U.S. bluefin tuna larval assessment with a brief response. Collective Volume of Scientific Papers. ICCAT 32(2):240-247.

Richards, W.J. 1991. Early life history of the Atlantic bluefin tuna from the western north Atlantic. IATTC Spec. Rep. 7. 357 p.

Richards, W.J. and D.C. Simmons. 1971. Distribution of tuna larvae (Pisces, Scombridae) in the northwestern Gulf of Guinea and off Sierra Leone. Fish. Bull. U.S. 69(3):555-568.

Rivas, L.R. 1975. Synopsis of biological data on blue marlin, *Makaira nigricans* Lacepede, 1802. Pages 1-16 *In:* Shomura, R. S. and F. Williams. eds. Proceedings of the International Billfish Symposium Kailua-Kona, Hawaii, 9-12 August 1972. Part 3. Species Synopses. NOAA Tech. Rep. NMFS SSRF-675. 159 p.

Robins, C.R. 1975. Synopsis of biological data on the longbill spearfish *Tetrapturus pflugeri* Robins and de Sylva. Pages 28-38 *in:* Shomura, R. S. and F. Williams. eds. Proceedings of the International Billfish Symposium Kailua-Kona, Hawaii, 9-12 August 1972. Part 3. Species Synopses. NOAA Tech. Rep. NMFS SSRF-675. 159 p.

Rooker, J.R., and D.H. Secor. 2004. Stock structure and mixing of Atlantic bluefin tuna: evidence from stable δ^{13}C and δ^{18}O isotopes in otoliths. Collective Volume of Scientific Papers. ICCAT 56:1115–1120.

Rooker, J.R., J.R. Alvarado-Bremer, B.A. Block, H. Dewar, G. de Metrio, A. Corriero, R.T. Kraus, E.D. Prince, E. Rodr'guez-Mar'in, and D.H. Secor. 2007. Life History and Stock Structure of Atlantic Bluefin Tuna (Thunnus thynnus). Reviews in Fisheries Science. 15:265-310

Rooker, J.R. personal communication with R. Blankinship via e-mail, August 16, 2007.

Russell, S.J. 1993. Shark bycatch in the Northern Gulf of Mexico tuna longline fishery, 1988-91, with observations on the nearshore directed shark fishery. *In* S. Branstetter (ed.): Conservation Biology of Elasmobranchs. NOAA Technical Report NMFS 115: 19-29.

Sadowsky, V. 1971. Notes on the bull shark *Carcharhinus leucas* in the lagoon region of Cananeia, Brazil. Boletim do Instituto Oceangrafico San Paulo 20:71-78.

Saidi, B., M.N. Bradai, A. Bouain, O. Guelorget, and C. Capape. 2005. Capture of a pregnant female white shark, Carcharodon carcharias (Lamnidae) in the Gulf of Gabes (southern Tunisia, central Mediterranean) with comments on oophagy in sharks. Cybium 29(3):303-307.

Santana, F.M. and R. Lessa. 2004. Age determination and growth of the night shark (*Carcharhinus signatus*) off the northeastern Brazilian coast. Fish. Bull. 102: 156-167.

Santiago, J. and H. Arrizabalaga. 2005. An integrated growth study for North Atlantic albocore (*Thunnus alalunga* Bonn. 1788). ICES Journal of Marine Science: Journal du Conseil 62(4):740-749.

Schwartz, F.J. 1984. Occurrence, abundance and biology of the blacknose shark*, Carcharhinus acronotus* in North Carolina. Northeast Gulf Sci. 7 (1): 29-47.

SCRS, 1997. Report of the ICCAT SCRS bluefin tuna stock assessment session. Collective Volume of Scientific Papers. ICCAT 46(1):1-186.

SCRS. 2004. Report of the 2004 Meeting of the Standing Committee on Research & Statistics. International Commission for the Conservation of Atlantic Tunas. PLE-025/2004, Madrid, 4-8 October 2004.

SCRS. 2006. Report of the 2006 ICCAT billfish stock assessment. ICCAT SCI-012/2006, Madrid, Spain.

Serafy, J.E., R.K. Cowen, C.B. Paris, T.R. Capo, and S.A. Luthy. 2003. Evidence of blue marlin, *Makaira nigricans*, spawning in the vicinity of Exuma Sound, Bahamas.

Serafy, J.E., T.R. Capo, and C.R. Kelble. 2006. Live capture of larval billfishes: design and field testing of the continuous access neuston observation net (CANON). Bulletin of Marine Science. 79(3):853-858.

Serena, F. 2005. Field identification guide to the sharks and rays of the Mediterranean and Black Sea. FAO Species Identification Guide for Fishery Purposes. Rome, FAO. 97p. 11 colour plates + egg cases.

Shann, E.W. 1911. VIII- A description of the advanced embryonic stage of *Lamna cornubica*. *In:* The 28th Annual Report of the Fishery Board for Scotland: 73-79.

Schrey, AW., and E. J. Heist. 2003. Microsatellite analysis of population structure in the shortfin mako (*Isurus oxyrinchus*). Can. J. Fish. Aquat. Sci. 60:670-675.

Shivji, M.S., J.E. Magnussen, L.R. Beerkircher, G. Hinteregger, D.W. Lee, J.E. Serafy, and E.D. Prince. 2006. Validity, identification and distribution of the roundscale spearfish, *Tetrapturus georgii* (Teleostei: Istiophoridae); morphological and molecular evidence. Bulletin of Marine Science 79: 483-491.

Simpfendorfer, C. 1992. Biology of tiger sharks (*Galeocerdo cuvier*) caught by the Queensland shark meshing program off Townsville, Australia. Aust. J. Mar. Freshwater Res. 43: 33-43.

Simpfendorfer, C. A., and N.E. Milward. 1993. Utilization of a tropical bay as a nursery area by sharks of the families Carcharhinidae and Sphyrnidae. Environmental Biology of Fishes 37: 337–45.

Sims, D.W. 1999. Threshold foraging behaviour of basking sharks on zooplankton: life on an energetic knife-edge? Proceedings of the Royal Society of London, Series B-Biological Sciences 266: 1437-1443.

Sims, D.W. and D.A. Merrett. 1997. Determination of zooplankton characteristics in the presence of surface feeding basking sharks *Cetorhinus maximus*. Marine Ecology Progress Series 158: 297-302.

Sims, D.W. and V.A. Quayle. 1998. Selective foraging behaviour of basking sharks on zooplankton in a small-scale front. Nature 393: 460-464.

Sims, D.W. and P.C. Reid. 2002. Congruent trends in longterm zooplankton decline in the north-east Atlantic and basking shark (*Cetorhinus maximus*) fishery catches off west Ireland. Fisheries Oceanography 11:59–63.

Sims, D.W., E.J. Southall, V.A. Quayle, and A.M. Fox. 2000. Annual social behaviour of basking sharks associated with coastal front areas. Proceedings of the Royal Society of London, Series B 267:1897–1904.

Sims, D.W., E.J. Southall, A.J. Richardson, P.C. Reid, and J.D. Metcalfe. 2003. Seasonal movements and behaviour of basking sharks from archival tagging: no evidence of winter hibernation. Marine Ecology Progress Series 248:187–196.

Skomal, G. 2007. Shark Nursery Areas in the Coastal Waters of Massachusetts. American Fisheries Society, Symposium 50: 17-34.

Skomal, G.B. and L.J. Natanson. 2003. Age and growth of the blue shark (*Prionace glauca*) in the North Atlantic Ocean. Fish. Bull. 101: 627-639.

Skomal, G., G. Wood, and N. Caloyianis. 2004. Archival tagging of a basking shark, *Cetorhinus maximus*, in the western North Atlantic. Journal of the Marine Biological Association of the United Kingdom 84: 795-799.

Sminkey, T.R. and J.A. Musick. 1995. Age and growth of the sandbar shark, *Carcharhinus plumbeus*, before and after population depletion. Copeia 1995(4): 871-83.

Snelson, F.F., Jr., T.J. Mulligan, and S.E. Williams. 1984. Food habits, occurrence, and population structure of the bull shark, *Carcharhinus leucas*, in Florida coastal lagoons. Bull. Mar. Sci. 34(1): 71-80.

Southeast Data Assessment and Review. (SEDAR) 13. 2007. Stock assessment report for small coastal shark complex, Atlantic sharpnose, blacknose, bonnethead, and finetooth sharks. November 23, 2007. http://www.sefsc.noaa.gov/sedar/Sedar_Workshops.jsp?WorkshopNum=13

Southall, E.J., D.W. Sims, J.D. Metcalfe, J.I. Doyle, S. Fanshawe, C. Lacey, J. Shrimpton, J.-L. Solandt, and C.D. Speedie. 2005. Spatial distribution patterns of basking sharks on the European shelf: preliminary comparison of satellite-tag geolocation, survey and public sightings data. Journal of the Marine Biological Association of the United Kingdom 85:1083-1088.

Sponaugle, S., K.L. Denit, S.A. Luthy, J.E. Serafy, and R.K. Cowen. 2005. Growth variation in larval *Makaira nigricans*. Journal of Fish Biology 66(3):822-835.

Springer, S. 1948. Oviphagous embryos of the sand shark, *Carcharias taurus.* Copeia 1948(3): 153-157.

Springer, S. 1950a. An outline for a Trinidad shark fishery. Proceedings of the Gulf and Caribbean Fisheries Institute. Second Annual Session. Univ. of Miami. Coral Gables: 17-26.

Springer, S. 1950b. Natural history notes on the lemon shark, *Negaprion brevirostris*. Tex. J. Sci. 3: 349-359.

Springer, S. 1950c. A revision of North American sharks allied to the genus *Carcharhinus*. Am. Mus. Novit. 1451: 13pp.

Springer, S. 1960. Natural history of the sandbar shark *Eulamia milberti*. U.S. Fish. Wildl. Serv. Fish. Bull. 61 (178): 1-38.

Springer, S. 1967. Social organizations of shark populations. *In* P. Gilbert (ed.): Sharks, skates, and rays. John Hopkins Press, Baltimore: 149-174.

Springer, S. 1979. Report on shark fishing in the western central Atlantic. WECAF report No. 3. UNDP. FAO. Panama: 39 pp.

Springer, S. and R.A. Waller. 1969. *Hexanchus vitulus*, a new sixgill shark from the Bahamas. Bull. Mar. Sci. 19: 159-174.

Springer, V. G. 1964. A revision of the carcharhinid shark genera *Scoliodon*, *Loxodon*, and *Rhizoprionodon*. Proc. U. S. Nat. Mus. 115 (no. 3493): 559-632.

Squire, J.L., Jr. 1967. Observations of basking sharks and great white sharks in Monterey Bay, 1948–50. Copeia 1967(1):247–250.

Stevens, J.D. and J.M. Lyle. 1989. Biology of three hammerhead sharks *(Eusphyra blochii, Sphyrna mokarran, and S. lewini*) from northern Australia. Aust. J. Mar. Freshwater Res. 40: 129-46.

Stevens, J.D. and K.J. Mcloughlin. 1991. Distribution, size, and sex composition, reproductive biology and diet of sharks from northern Australia. Austr. J. Mar. Freshwater Res., 42: 151-99.

Stillwell, C.E. and J.G. Casey. 1976. Observations on the bigeye thresher shark, *Alopias superciliosus*, in the western North Atlantic. Fish. Bull. 74:221-225.

Stillwell, C.E. and N. Kohler. 1985. Food and feeding ecology of the swordfish *Xiphias gladius* in the western north Atlantic Ocean with estimates of daily ration. Mar. Ecol. Prog. Ser. 22:239-247.

Steiner, P.A., and M. Michel. 2007. Effects of Tidal Current on the Movement Patterns of Juvenile Bull Sharks and Blacktip Sharks. American Fisheries Society Symposium 50:251-264.

Steiner, P.A., M. Michel, and P.M. O'Donnell. 2007. Notes on the Occurrence and Distribution of Elasmobranchs in the Ten Thousand Islands Estuary, Florida. American Fisheries Society Symposium 50:237-250.

Strasburg, D.W. 1958. Distribution, abundance, and habits of pelagic sharks in the central Pacific Ocean. U.S. Fish. Wildl. Serv. Fish. Bull. 138 (58): 335-361.

Strong, W.R., S.H. Gruber, and F.F. Snelson. 1990. Hammerhead shark predation on stingrays: an observation of prey handling by *Sphyrna mokarrann*. Copeia 1990(3): 836-840.

Strong, W.R., Jr., R.C. Murphy, B.D. Bruce, and D.R. Nelson. 1992. Movements and associated observations of bait-attracted white sharks, *Carcharodon carcharias*: a preliminary report. Aust. J. Mar. Freshwater Res. 43: 13-20.

Suda, A. 1953. Ecological study on the blue shark (*Prionace glauca* Linne). South Seas Area Fisheries Research Laboratory, Report 26, Supplement 1: 15pp.

Sulikowski, J.A., W.B. Driggers III, T. S. Ford, R. K. Boonstra, and J. K. Carlson. 2007. Reproductive cycle of the blacknose shark *Carcharhinus acronotus* in the Gulf of Mexico. Journal of Fish Biology 70:1-13.

Sundstrom, L.F., S.H. Gruber, S.M. Clermont, J.P.S. Correia, J.R.C. de Marignac, J.F. Morrissey, C.R. Lowrance, L. Thomassen, and M.T. Oliveira. 2001. Review of elasmobranch behavioral studies using ultrasonic telemetry with special reference to the lemon shark, *Negaprion brevirostris*, around Bimini Islands, Bahamas. Environ. Biol. Fishes 60: 225-250.

Tanaka, S. and K. Mizue. 1977. Studies on sharks-XI: Reproduction in female *Heptranchias perlo*. Bull. Fac. Fish. Nagasaki Univ. 42: 1-9.

Templeman, W. 1963. Distribution of sharks in the Canadian Atlantic. Bulletin of the Fisheries Research Board of Canada 140.

Teo, S.L.H., A. Boustany, H. Dewar, M.J.W. Stokesbury, K.C. Weng, S. Beemer, A.C. Seitz, C.J. Farwell, E.D. Prince, and B.A. Block. 2007a. Annual migrations, diving behavior, and thermal biology of Atlantic bluefin tuna, *Thunnus thynnus*, on their Gulf of Mexico breeding grounds. Marine Biology 151:1–18.

Teo, S.L.H., A. Boustany, and B.A. Block. 2007b. Oceanographic preferences of Atlantic bluefin tuna, *Thunnus thynnus*, on their Gulf of Mexico breeding grounds. Marine Biology. Marine Biology 152:1105–1119.

Thorpe, T. 1997. First occurrence and new length record for the bigeye thresher shark in the northeast Atlantic. J. Fish Biol. 50:222-224.

Thorson, T. B., C.M. Cowan, and D.E. Watson. 1973. Body fluid solutes of juveniles and adults of the euryhaline bull shark, *Carcharhinus leucas*, from freshwater and saline environments. Physiological Zoology 46(1):29-42.

Thorson, T.B. 1976. The status of the Lake Nicaragua shark: An updated appraisal. *In* T.B. Thorson (ed.): Investigations of the ichthyofauna of Nicaraguan lakes. School of Life Sciences, University of Nebraska-Lincoln, Lincoln: 561-574.

Tiews, K. 1963. Synopsis of biological data on the bluefin tuna *Thunnus thynnus* (Linnaeus) 1758 (Atlantic and Mediterranean). Pages 422- 481 *In*: H. Rosa Jr. ed. Proceedings of the World Scientific Meeting on the Biology of Tunas and Related Species. FAO Fisheries Reports No. 6 (2)

Toll, R.B. and S.C. Hess. 1981. Cephalopods in the diet of the swordfish, *Xiphias gladius*, from the Florida Straits. Fish. Bull. 79(4): 765–774.

Tuma, R. E. 1976. An investigation of the feeding habitats of the bull shark, *Carcharhinus leucas*, in the lake Nicaragua-Rio San Juan system. Pages 533-538 *In*: T. B. Thorson, editor. Investigations of the Ichthyofauna of Nicaragua lakes. School of Life Science, University of Nebraska, Lincoln.

Turner, S.C., V.R. Restrepo, and A.M. Edlund. 1991. A review of the growth rate of Atlantic bluefin tuna, *Thunnus thynnus*. Col. Vol. Sci. Pap. ICCAT 35 (2): 271-293.

Uchida, S., M. Toda, K. Teshima, and K. Yano. 1996. Pregnant white sharks and full-term embryos from Japan. *In*: 'Great white sharks: the biology of *Carcharodon carcharias.* Klimley, P., and Ainley, D.G. (Eds.) Acad. Press, New York: 139-155.

Ulrich, G.F. and C.P. Riley. 2002. Shark nursery areas in South Carolina estuarine and coastal waters. *In*: McCandless *et al*. 2002. Shark nursery grounds of the Gulf of Mexico and the East Coast waters of the United States: an overview. 286 pp.

Ulrich, G.F., C.M. Jones, W.B. Driggers, J.M. Drymon, D.O. Oakley, and C. Riley. 2007. Habitat utilization, relative abundance, and seasonality of sharks in the estuarine and nearshore waters of South Carolina. American Fisheries Society Symposium 50:125-139.

UNEP-WCMC. 2003. Checklist of Fish and Invertebrates Listed in the CITES Appendices and in EC Regulation 338/97, 6th ed. JNCC Report No. 341. Peterborough, UK: JNCC.

Vinnichenko, V.I. 1996. New data on the distribution of some species of tuna (Scombridae) in the North Atlantic. J. of Ichth. 36(8): 679-681.

Vodyanitsky, V.A., and I.I. Kazanova, 1954. Key to the pelagic fishes and larvae of the Black Sea. Tr. Vges. Nauchno-Issled. Inst. Morsk. Rybn. Khoz. Okeanogr. 28:240-345 (In Russian).

Walter, J.P. and D.A. Ebert. 1991. Preliminary estimates of age of the bronze whaler, *Carcharhinus brachyurus,* (Chondrichthyes: Carcharhinidae) from southern Africa, with a review of some life history parameters. S. Afr. J. Mar. Sci. 10: 37-44.

Weng, K.C. and B.A. Block. 2004. Diel vertical migration of the bigeye thresher shark (*Alopias superciliosus*), a species possessing orbital retia mirabilia. Fish. Bull. 102: 221-229.

Wetherbee, B.M., G.L. Crow, and C.G. Lowe. 1996. Biology of the Galapagos shark, *Carcharhinus galapagensis*, in Hawaii. Environ. Biol. Fishes 45: 299-310.

White Marlin Biological Review Team. 2007. Atlantic white marlin status review. Report to National Marine Fisheries Service, Southeast Regional Office, December 10, 2007. 88 pp.

White, W.T. 2007. Biological observations on lamnoid sharks (Lamniformes) caught by fisheries in eastern Indonesia. Journal of the Marine Biological Association of the United Kingdom 87(3):781-788.

Whitney, N.M., H.L. Pratt, and J.C. Carrier. 2004. Group courtship, mating behaviour and siphon sac function in the whitetip reef shark, *Triaenodon obesus*. Animal Behaviour 68: 1435-1442.

Whitney, N.M. and G.L. Crow. 2007. Reproductive biology of the tiger shark (*Galeocerdo cuvier*) in Hawaii. Mar. Biol. 151:63-70.

Wiley, T.A. and C. Simpendorfer. 2007. The Ecology of Elasmobranchs Occurring in the Everglades National Park, Florida: Implications for Conservation and Management. Bulletin of Marine Science 80(1): 171-189.

Wilson, S.G. 2004. Basking sharks (*Cetorhinus maximus*) schooling in the southern Gulf of Maine. Fisheries Oceanography 13: 283-286.

Wilson, C. A., J. M. Dean, E. D. Prince, and D. W. Lee. 1991. An examination of sexual dimorphism in Atlantic and Pacific blue marlin using body weight, sagittae weight, and age estimates. J. Exp. Mar. Biol. Ecol. 151: 209–225.

Wintner, S.P. 2000. Preliminary study of vertebral growth rings in the whale shark, *Rhincodon typus*, from the east coast of South Africa. Environ. Biol. Fishes 59: 441-451.

Wintner, S.P. and S.F.J. Dudley. 2000. Age and growth estimates for the tiger shark, *Galeocerdo cuvier*, from the east coast of South Africa. Marine and Freshwater Research 51: 43-53.

References for Shark Sizes in Tables A.1 and A.2

Bonfil, R., R. Mena and D. de Anda. 1993. Biological parameters of commercially exploited silky sharks, *Carcharhinus falciformis*, from the Campeche Bank, Mexico. *In*: S. Branstetter (ed.): Conservation biology of sharks. NOAA Technical Report NMFS 115. U.S. Dept. Comm., Miami. pp. 72-86

Branstetter, S. 1987. Age and growth estimates for blacktip, *Carcharhinus limbatus,* and spinner, *C. brevipinna*, sharks from the northwestern Gulf of Mexico. Copeia 1997(4): 964-975.

Branstetter, S. 1987. Age, growth and reproductive biology of the silky shark, *Carcharhinus falciformis*, and the scalloped hammerhead, *Sphyrna lewini*, from the northwestern Gulf of Mexico. Environ. Biol. Fishes 19(3): 161-173.

Branstetter, S. and R. Stiles. 1987. Age and growth estimates of the bull shark, *Carcharhinus leucas*, from the northern Gulf of Mexico. Env. Biol. Fish. 20(3): 169-181.

Carlson, J.K. 2002. Shark nurseries in the northeastern Gulf of Mexico. *In*: McCandless, C. T. and H. L. Pratt, Jr. (eds.) Gulf of Mexico and- Atlantic States shark nursery overview. US

Department of Commerce, NOAAINational Marine Fisheries Service Highly Migratory Species Management Division, FISFI NMFS Office of Sustainable Fisheries, 13 15 East-West Highway, Silver Spring, MD.

Carlson, J.K. J.R. Sulikowski, and L.E. Baremore. In review. Do differences in life history exist for blacktip sharks, Carcharhinus limbatus, from the United States South Atlantic Bight and Eastern Gulf of Mexico? Environ. Biol. Fishes .

Castro, J.A. and J. Mejuto. 1995. Reproductive parameters of blue shark *Prionace glauca* and other sharks in the Gulf of Guinea. Marine and Freshwater Research 46(6): 967-933.

Castro, J.I. 1983. The sharks of North American waters. Texas A. & M. University Press, College Station.180pp.

Castro, J.I. 1993a. The biology of the finetooth shark, *Carcharhinus isodon*. Environ. Biol. Fishes 36: 219-232.

Castro, J.I. 1993b. The shark nursery of Bulls Bay, South Carolina, with a review of the shark nurseries of the southeastern coast of the United States. Environ. Biol. Fishes 38: 37-48.

Castro, J.I. 1996. Biology of the blacktip shark, *Carcharhinus limbatus*, off the southeastern United States. Bulletin of Marine Science 59(3): 508-522.

Castro, J.I. 2000. The biology of the nurse shark, *Ginglymostoma cirratum*, off the Florida east coast and the Bahama Islands. Environ. Biol. Fishes 58: 1-22.

Castro, J.I., C. M. Woodley, and R. L. Brudek. 1999. A preliminary evaluation of the status of shark species. FAO Fisheries Technical Paper 380. 72pp.

Clarke, E. and K. von Schmidt. 1965. Sharks of the central Gulf coast of Florida. Bulletin of Marine Science 15(1): 13-83.

Clarke, T.A. 1971. The ecology of the scalloped hammerhead shark, *Sphyrna lewini*, in Hawaii. Pacific Science 25: 133-144.

Compagno, L.J.V. 1984. FAO Species Catalog Vol. 4 Part 1: Sharks of the world: an annotated and illustrated catalogue of shark species known to date. FAO Fisheries Synopsis 125. FAO, Rome, Italy. 249pp.

Duffy, C. and M.P. Francis. 2001. Evidence of summer parturition in shortfin mako (*Isurus oxyrinchus*) sharks from New Zealand waters. New Zealand Journal of Marine and Freshwater Research 35(2): 319-324.

Ebert, D.A. 1986. Biological aspects of the sixgill shark, *Hexanchus griseus*. Copeia 1986(1):131-135.

Fourmanoir, P. 1961. Requins de la cote ouest de Madagascar. Memoires de L'Institut Scientifique de Madagascar. Tome IV. 81pp.

Gilmore, R.G. 1983. Observations on the embryos of the longfin mako, *Isurus paucus*, and the bigeye thresher, *Alopias superciliosus*. Copeia 1983(2): 375-382.

Gilmore, R.G. 1993. Reproductive biology of lamnoid sharks. Env. Biol. Fish. 38: 95-114.

Gilmore, R.G., J.W. Dodrill, and P.A.Linley. 1983. Reproduction and embryonic development of the sand tiger shark, *Odontaspis taurus* (Rafinesque) Fish. Bull. 81(2): 201-225.

Guitart-Manday, D. 1966. Nuevo nombre para una especie de tiburon del genero *Isurus* (Elasmobranchii: Isuridae) de aguas Cubanas. Poeyana 15: 1-9.

Hazin, F.H.V., P.G. Oliveira, and M.K. Broadhurst. 2002. Reproduction of the blacknose shark (*Carcharhinus acronotus*) in coastal waters off northeaster Brazil. Fish. Bull. 100: 143-148.

Hoese, H.D. 1962. Sharks and rays of Virginia's seaside bays. Chesapeake Science 3(3): 166-172.

Jensen, C.F., L.J. Natanson, H.L. Pratt, Jr., N.E. Kohler, and S.E. Campana. 2002. The reproductive biology of the porbeagle shark (*Lamna nasus*) in the western North Atlantic Ocean. Fish. Bull. 100: 727-738.

Loefer, J.K. and G.R. Sedberry. 2003. Life history of the Atlantic sharpnose shark (*Rhizoprionodon terraenovae*) (Richardson, 1836) off the southeastern United States. Fish. Bull. 101(1): 75-88.

Merson, R.R. 1998. Nursery grounds and maturation of the sandbar shark in the western North Atlantic. Ph.D. Dissertation, University of Rhode Island, Kingston, RI. 150pp.

Mollet, H.F., G. Cliff, H.L. Pratt, Jr., J.D. Stevens. 2000. Reproductive biology of the female shortfin mako, *Isurus oxyrinchus* Rafinesque, 1810, with comments on the embryonic development of lamnoids. Fish. Bull. 98(2): 299-318.

Moreno, J.A. and J. Moron. 1992. Reproductive biology of the bigeye thresher shark, *Alopias superciliosus* (Lowe, 1839). Aust. J. Mar. Freshwater Res. 43: 77-86.

Moreno, J.A., J.I. Parajua, and J. Moron. 1989. Biologia reproductiva y fenologia de *Alopias vulpinus* (Bonnaterre, 1788) (Squaliformes: Alopiidae) en el Atlantico nor-oriental y Mediterraneo occidental. Scientia Marina (Barcelona) 53(1): 37-46.

Parsons, G.R. 1983. The reproductive biology of the Atlantic sharpnose shark, *Rhizoprionodon terraenovae* (Richardson). Fish. Bull. 81(1): 61-73.

Parsons, G.R. 1993. Geographic variation in reproduction between two populations of the bonnethead shark, *Sphyrna tiburo*. Env. Biol. Fish. 38: 25-35.

Pratt, Jr., H.L. 1979. Reproduction in the blue shark, *Prionace glauca*. Fish. Bull. 77(2): 445-470.

Raschi, W., J.A. Musick, and L.J.V. Compagno. 1982. *Hypoprion bigelowi*, a synonym of *Carcharhinus signatus* (Pisces: Carcharhinidae), with a description of ontogenetic heterodonty in this species and notes on its natural history. Copeia 1982(1): 102-109.

Rooker, J.R., D.H. Secor, G.DeMetrio, A.J. Kaufman, A.B. Rios, and V. Ticina. 2008. Evidence of trans-Atlantic movement and natal homing of bluefin tuna from stable isotopes in otoliths. Marine Ecology Progress Series 368:231-239.

Seki, T., T. Taniuchi, H. Nakano, and M. Shimizu. 1998. Age, growth and reproduction of the oceanic whitetip shark from the Pacific Ocean. Fisheries Science 64(1): 14-20.

Springer, S. 1960. Natural history of the sandbar shark, *Eulamia milberti*. Fish. Bull. 61(178): 1-38.

Springer, S. and R.A. Waller. 1969. *Hexanchus vitulus*, a new sixgill shark from the Bahamas. Bulletin of Marine Science 19(1): 159-174.

Stevens, J.D. and J.M. Lyle. 1989. Biology of three hammerhead sharks (*Eusphyra blochii*, *Sphyrna mokarran* and *S. lewini*) from northern Australia Australian Journal of Marine and Freshwater Research 40: 129-146.

Uchida, S., M. Toda, K. Teshima, and K. Yano. 1996. Pregnant white sharks and full-term embryos from Japan. *In*: A.P. Klimley and D.G. Ainley (eds.) Great white sharks: The biology of Carcharodon carcharias. Academic Press, New York: 139-155.

Wetherbee, B.M., G.L. Crow, and C.G. Lowe. 1996. Biology of the Galapagos shark, *Carcharhinus galapagensis*, in Hawaii. Env. Biol. Fish. 45: 299-310.

Williams, F. 1977. Notes on the biology and ecology of the blue shark (*Prionace glauca*) in the eastern Pacific Ocean and a review of data from the World Ocean (unpublished manuscript).