LOGGERHEAD, GREEN, KEMP'S RIDLEY, LEATHERBACK, AND HAWKSBILL SEA TURTLE

CONSERVATION PLAN for NORTH CAROLINA

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DRAFT





NC WILDLIFE RESOURCES COMMISSION

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EXECUTIVE SUMMARY

Five species of sea turtles occur in coastal North Carolina, the Loggerhead Sea Turtle (*Caretta caretta*), Green Sea Turtle (*Chelonia mydas*), Kemp's Ridley Sea Turtle (*Lepidochelys kempii*), Leatherback Sea Turtle (*Dermochelys coriacea*), and Hawksbill Sea Turtle (*Eretmochelys imbricata*). Loggerhead and Green Sea Turtles are listed as Threatened at state and federal levels, while the Kemp's Ridley, Leatherback, and Hawksbill Sea Turtles are listed as Endangered at state and federal levels. Adult female sea turtles lay eggs on open sandy beaches along coastal barrier islands of North Carolina primarily between May and August, with hatchling emergences from nests occurring mainly between July and early November. Juvenile Loggerhead, Green, and Kemp's Ridley Sea Turtles commonly forage in coastal estuarine waters, while large juveniles and adults of all five species regularly traverse through North Carolina's coastal waters. Steep population declines relative to historical levels, high rates of anthropogenic mortality, and habitat degradation were primary reasons for original federal listing of these species. Ongoing threats to sea turtles in North Carolina include loss and degradation of habitat due to incompatible coastal development, exposure to visible artificial lighting at night, beach driving during the nesting and hatchling emergence seasons in certain parts of the state, incidental bycatch in recreational and commercial fishing gear, collisions with boats and other marine traffic, and lack of state authority to enforce federal rules for the protection of sea turtles when in state waters. Climate change poses another significant threat to sea turtles in North Carolina. Climate change threats include alteration and loss of habitat due to sea level rise and temperature changes, reduced abundance of prey species (seagrass, mollusks, and shellfish), altered seasonality of reproduction, and reduced hatching success from weather extremes. The goal of the conservation plan is for recovery of all sea turtle populations in North Carolina so they serve the ecological roles they had before population declines started over a century ago.

Leatherback Sea Turtle hatchlings

BIOLOGICAL INFORMATION

Description and Taxonomic Classification

The Loggerhead Sea Turtle can grow to greater than 100 centimeters carapace length and weigh more than 100 kilograms. They are characterized by a large head with blunt strong jaws, which aid crushing shellfish and mollusks, its main prey. Adults and subadults have a yellowish to reddish-brown carapace and head, and yellow flippers and plastron. The normal scute pattern on the carapace is five pairs of costal (lateral) scutes and five vertebral scutes. Adult males are characterized by an elongated tail that extends well beyond the end of the carapace; large, recurved claws on the front flippers; and a concave plastron. There is little difference in carapace length between adult males and adult females (Figgener et al. 2022). Juvenile Loggerhead Sea Turtles are not sexually dimorphic.

Linneaus described the species as *Testudo caretta* in 1758, based on a specimen from Bermuda or the Bahamas (Dodd 1988). Subsequently nearly three dozen binomial names were assigned to the species until 1873, when Leonhard Stejneger was the first to use *Caretta caretta* (Dodd 1988). Genetic evidence does not support the existence of subspecies of Loggerheads (Bowen 2003).

The Green Sea Turtle can reach greater than 110 centimeters carapace length and weigh more than 175 kilograms. The Green Turtle has a small head with a serrated edge on its lower jaw. Juvenile and adult Green Turtles primarily eat seagrass or algae. The carapace is heart-shaped with four pairs of costal (lateral) scutes and five vertebral scutes. The name "Green Turtle" derives from the color of the internal fat that lines the body cavity. The carapace color ranges from light to dark brown, with or without mottled patterns. The plastron is white to yellow, although in some regions it may also be gray. Adult males are characterized by an elongated tail that extends well beyond the end of the carapace; large, recurved claws on the front flippers; and a concave plastron. Adult female carapaces are several centimeters longer on average than those of adult males (Godley et al. 2002). Juvenile Green Turtles are not sexually dimorphic.

Linneaus described the species as *Testudo mydas* in 1758, based on a turtle from Ascension Island in the central Atlantic Ocean. The binomial name in use today, *Chelonia mydas*, was assigned by Schweigger in 1812 (Rhodin et al. 2010). While some have described a specific or subspecies status to the "black turtle" in the eastern Pacific, this taxonomic distinction is not supported by genetic evidence (Bowen et al. 1992). No subspecies of Green Sea Turtles are currently accepted.

The Kemp's Ridley Sea Turtle can reach 65 centimeters carapace length and weigh up to 50 kilograms. The head is large with a semi-curved upper beak that helps it eat mollusks and shellfish. The carapace has five or more pairs of costal (lateral) scutes and five vertebral scutes, and ranges in color from dark grey to light olive grey. The plastron color ranges from yellow to cream. On the right and left bridges that join the carapace to the plastron there are four scutes, each with a visible pore that is associated with the Rathke's gland. Adult males are characterized by an elongated tail that extends well beyond the end of the carapace; large, recurved claws on the front flippers; and a concave plastron. There is little difference in carapace length between adult males and adult females (Figgener et al. 2022). Juvenile Kemp's Ridley Sea Turtles are not sexually dimorphic.

This turtle was originally named *Thalassochelys kempii* (or *Colpochelys kempii*) by Garman in 1880, in honor of Richard M. Kemp, a fisherman in Florida who submitted the type specimen to Garman. The etymology of the name "ridley" is unknown (Dundee 2001). In 1942, *Lepidochelys kempii* was the binomial name recognized by Carr (1942), as a congeneric of *Lepidochelys olivacea*, the Olive Ridley Sea Turtle. The species distinction between Olive and Kemp's Ridley Sea Turtles is fully supported by genetic evidence (Bowen et al. 1991). No subspecies of Kemp's Ridley Sea Turtles are currently accepted.

The Leatherback Sea Turtle is the largest living species of turtle. Its carapace length can exceed 170 centimeters and individuals may weigh more than 600 kilograms (James et al. 2007). While the carapace and plastron of hatchlings have visible scales, the adult carapace has 6 or 7 prominent keels and is covered by dark leathery skin without scales that is sometimes mottled with white spots. The adult jaw features two prominent cusps used for grasping jellyfish and other soft bodied prey. The top of the head features a distinctive pink patch, and the front flippers are long and clawless. Adult males are characterized by an elongated tail that extends well beyond the end of the carapace. There is little difference in carapace length between adult males and adult females (Figgener et al. 2022). There is limited published information about juvenile Leatherback Sea Turtles (Stewart and Johnson 2006).

In 1761, the Leatherback was named *Testudo coriacea* by Vandelli based on a type specimen found in Italy. It was reclassified as *Dermochelys coriacea* nearly 100 years later and this is the accepted binomial name currently. It is the only member of its Family Dermochelyidae (Rhodin et al. 2010). No subspecies of Leatherback Sea Turtles are currently accepted.

The Hawksbill Sea Turtle is a medium sized sea turtle and can reach a carapace length greater than 90 centimeters and weigh more than 90 kilograms. It has an elongated head and a distinctive beaked mouth that is the basis of its common name. The carapace has thick overlapping scutes that have a classic "tortoiseshell"

coloration and have been used historically for jewelry, eyeglass frames, and other luxury items. The carapace has four pairs of costal (lateral) scutes and five vertebral scutes, and the posterior edges appear serrated. Adult males are characterized by an elongated tail that extends well beyond the end of the carapace; large, recurved claws on the front flippers; and a concave plastron. There is little difference in carapace length between adult males and adult females (Figgener et al. 2022). Juvenile Hawksbill Sea Turtles are not sexually dimorphic.

The Hawksbill was given the name *Testudo imbricata* in 1766, and in 1843, it was given its current binomial, *Eretmochelys imbricata*, by Fitzinger (Rhodin et al. 2010). No subspecies of Hawksbill Sea Turtles are currently accepted.

Life History and Habitat

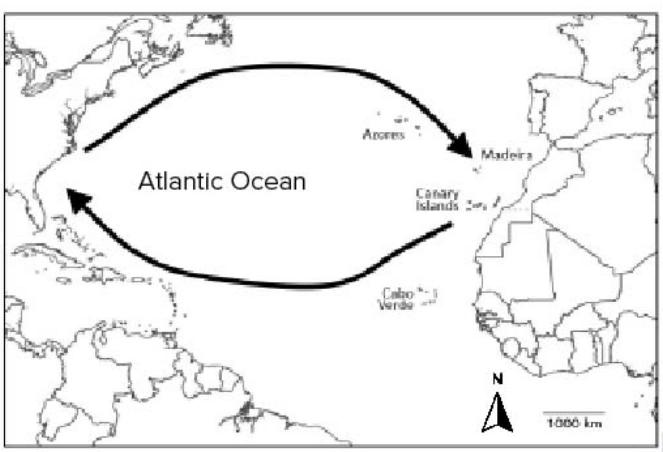
All sea turtles share similar life histories, with some species-specific differences. Adult female sea turtles prepare for reproduction in their foraging areas months or years before they begin their migration to mating areas, which can be hundreds or thousands of kilometers from their foraging areas. Little is known about the migratory patterns of Green, Leatherback, Kemp's Ridley, and Hawksbill Sea Turtles that nest in North Carolina, although it is assumed they are similar to the Loggerhead Sea Turtles. When not breeding, adult Loggerhead Sea Turtles along the Southeast Coast of the U.S. generally remain in neritic waters along the continental shelf, taking advantage of northerly foraging sites, from the Mid-Atlantic Bight up to Atlantic Canada, when ocean temperatures are warmer in late spring, summer, and early autumn months; they will move farther south or farther east beyond the Gulf Stream during cold water months between late autumn and early spring (Arendt et al. 2012; Griffin et al. 2013). When in breeding condition, males and females will congregate in nearshore coastal areas of North Carolina to mate before the nesting season. Anecdotal observations of mating pairs of loggerheads are reported each year in April and early May, primarily around Cape Lookout bight, although it is likely that mating occurs elsewhere along the North Carolina coast. During their seasonal and reproductive migrations, sea turtles occupy state waters (estuarine waters and up to 4.8 km [3 miles] from the coastline of North Carolina), federal waters (between 4.8 to 322 km [3 to 200 miles] from the coastline), and international waters (beyond 322 km [200 miles] from the coastline). While in North Carolina state waters and federal waters, sea turtles fall under the jurisdiction of the National Oceanic Atmospheric Administration - National Marine Fisheries Service (NOAA-NMFS), and legal protections can be enforced by NOAA-NMFS law enforcement and the

US Coast Guard. The state of North Carolina has codified some specific rules for the protection of sea turtles that can be enforced by North Carolina Division of Marine Fisheries (NCDMF) law enforcement. These include time-area closures for commercial fisheries, and the required use of Turtle Excluder Devices in otter and skimmer trawlers. When in international waters, sea turtles may be afforded certain protections associated with international agreements such as the Convention on Migratory Species or the Inter-American Convention for the Protection and Conservation of Sea Turtles, or Regional Fisheries Management Organizations such as the International Commission for the Conservation of Atlantic Tunas (Tiwari 2002).

Males and females mate with multiple partners, and multiple paternity in sea turtle clutches has been documented in all sea turtle species (Lee et al. 2017). For all sea turtles, successful egg laying and hatchling production occurs on beaches that have the following minimum requirements: the sandy habitat must be accessible from the ocean; the nesting zone must be sufficiently high above the water table to escape daily or overly frequent inundation from high tides; the sand supports the construction of nest cavities; and the sand is within the range of temperatures conducive to embryonic development (Mortimer 1990). Reproductively active females tend to lay several clutches of eggs during the nesting season, almost exclusively at night.

For each female, their successively laid clutches are separated by 10-15 days during which the females remain in waters of the nearby coastal shelf. Most sea turtles exhibit nest site fidelity, tending to return to the same coastal location to lay eggs over the season and over years, although some individuals may move several hundred kilometers between successive nesting locations. Research using maternally inherited DNA has demonstrated that females tend to return to nest in the general region where they were produced as hatchlings, creating discrete population segments of adult females (Meylan et al. 1992). However, adult males can and do mate across regions, providing sufficient male-mediated gene flow to inhibit subspecies differentiation (Karl et al. 1992).

Most sea turtle eggs laid in North Carolina are from Loggerhead Sea Turtles. Typical clutch size is 110 eggs, with an average clutch frequency per reproductive female of 4.3 nests per nesting season (Shamblin et al. 2017). Loggerhead Sea Turtle nesting generally occurs between May and the end of August. Some Green Sea Turtle eggs are laid each year in North Carolina from June through September, with occasional nesting in October or later. The average clutch size for Green Sea Turtles is 120 eggs. Typically, at least one Kemp's Ridley Sea Turtle nest is found each year in North Carolina, generally from May through July, with an average clutch size of 110 eggs. Leatherback Sea Turtles infrequently nest on North Carolina's beaches, generally in May and June, with an average clutch size of 83 eggs. Only two clutches laid by Hawksbill Sea Turtles have been documented in North Carolina (Finn et al. 2016).



Stylized map of the developmental migration of Loggerhead Sea Turtles produced on nesting beaches in the Southeast USA. Created using Maptool (SEATURTLE.ORG, Inc. http://www.seaturtle.org/maptool/ (17 December 2023).

All sea turtles exhibit temperature dependent sexual differentiation (TSD), with warmer egg incubation temperatures producing more females, and cooler egg incubation temperatures producing more males (Wibbels 2003). The incubation period for sea turtle eggs ranges from 50 to 70 days, depending on temperature. Sea turtle hatchlings normally emerge from their nest cavities at night, scramble down the beach to the swash zone, and swim directly offshore toward deep water. Loggerhead Sea Turtle hatchlings eventually migrate to the Northeast Atlantic Ocean where they spend several years growing to roughly 50-centimeters carapace length, after which they return to the Northwest Atlantic Coast (Bolten et al. 1998). Loggerhead Sea Turtles reach maturity at approximately 30-35 years (Avens & Snover 2017). Large juvenile and adult Loggerhead Sea Turtles move along the east coast of the United States, exploiting suitable foraging habitat in northern areas during periods of warmer water temperatures between April and December. They move to warmer waters during cooler winter months, either farther south or to the east near the Gulf Stream (McClellan and Read 2007; Griffin et al. 2013).

For hatchling Green, Leatherback, Kemp's Ridley, and Hawksbill Sea Turtles produced on North Carolina's beaches, relatively little is known about their behavior and life cycle. Because juvenile Green and Kemp's Ridley Sea Turtles are smaller than juvenile Loggerhead Sea Turtles in Northwest Atlantic coastal waters, it is assumed that they do not have a protracted developmental migration similar to Loggerhead Sea Turtles. Little is known about the behavior or migration of immature Leatherback Sea Turtles (Eckert 2002) and relatively few observations exist for immature Leatherback Sea Turtles. Hawksbill Sea Turtles are considered a tropical species, and their primary developmental habitats in the Northwest Atlantic Ocean are largely confined to the Caribbean, the Bahamas, and southern Florida (Meylan and Redlow 2006).

Distribution and Population Status

Loggerhead Sea Turtles are globally distributed, with nesting occurring in tropical, subtropical, and some temperate beaches in the North and South Atlantic Oceans (including the Mediterranean Sea), North and South Indian Oceans, and the Western Pacific. Juvenile and adult Loggerheads can be found throughout marine and estuarine waters worldwide. In the Atlantic Ocean, they are found as far south as Argentina and as far north as Canada and the United Kingdom. Within North Carolina, Loggerhead Sea Turtles normally frequent coastal and estuarine waters between April and December, leaving coastal waters when temperatures drop below 11 °C (Braun-McNeill et al. 2008). Adult females use all ocean-facing sandy beaches in North Carolina to lay their eggs during the nesting season (May through August). Hatchlings can emerge from these eggs from July into October and November if conditions are favorable. Juvenile and subadults frequent deep and shallow estuarine waters of North Carolina as foraging grounds, targeting crustaceans, mollusks and other invertebrates (McClellan et al. 2009).

The global population of Loggerhead Sea Turtles is considered reduced relative to historical levels due to a variety of threats including: direct harvest, habitat degradation or loss, incidental capture in fisheries and by dredging activities, and exposure to other anthropogenic impacts (Witherington 2003). Loggerhead Sea Turtles in the Carolinas were first described by Catesby (1731-1743). Loggerhead Sea Turtles were subject to a directed fishery in estuarine waters in North Carolina through the end of the 19th Century until the stocks were deemed depleted (Epperly 1995). At the federal level, the Loggerhead Sea Turtle was listed as Threatened under the Endangered Species Act throughout its entire range in 1978 (FR Doc. 78-21047). In 2011, nine distinct population segments (DPSs) of Loggerhead Sea Turtles were recognized by the NOAA-NMFS and the U.S. Fish and Wildlife Service (USFWS), including the Northwest Atlantic DPS, which is listed as Threatened and includes

Loggerheads nesting in North Carolina (FR Doc. 2011-23960). Loggerhead Sea Turtles are listed as Threatened in North Carolina (15A NCAC 10I .0104(a)(7)(D)).

Green Sea Turtles are globally distributed, with nesting occurring in tropical, subtropical, and some temperate beaches in the North and South Atlantic Oceans (including the Mediterranean Sea), North and South Indian Oceans, and the Western, Central, and Eastern Pacific Oceans. In the Atlantic Ocean, they occur as far south as Argentina and as far north as Canada and the United Kingdom. Small juvenile Green Sea Turtles (25- to 40-centimeters carapace length) are the most common life stage found in both coastal and estuarine waters of North Carolina between April and December, or when water temperatures remain above 11 °C (Braun-McNeill et al. 2008). These juveniles generally forage in seagrass beds in shallow estuarine areas in North Carolina (McClellan et al. 2009). Green Sea Turtle nests have been documented on every barrier island on the coast of North Carolina from May to September, with emergent hatchlings produced from July to October or early November.

The global population of Green Sea Turtles is considered reduced relative to historical levels, due to various threats including direct harvest, habitat degradation or loss, incidental captures in fisheries and dredging activities, and disease (McClenachan et al. 2006). Green Sea Turtles were subjected to a directed fishery in coastal Florida and in estuarine waters in North Carolina through the end of the 19th Century until the stocks were deemed depleted (Brimley 1920; Epperly 1995). At the federal level, the Green Sea Turtle was listed as Threatened in 1978 under the Endangered Species Act throughout its range, except for turtles nesting in Florida and the Pacific Coast of Mexico (FR Doc. 78-21047). In 2016, eight DPSs of Green Sea Turtles were recognized by NOAA-NMFS and the USFWS. The North Atlantic DPS, which includes Green Turtles nesting in North Carolina, is listed as Threatened (FR Doc. 2016-07587). Green Sea Turtles are listed as Threatened in North Carolina (15A NCAC 10I .0104(a)(7)(C)).

Kemp's Ridley Sea Turtles are largely restricted to the North Atlantic Ocean and the Gulf of Mexico, and are rarely observed in the Caribbean (Fretey 1999). Kemp's Ridley Sea Turtles are regularly observed along the east coast of the U.S. and the Northeast Atlantic Ocean, with infrequent observations in the Mediterranean. The primary nesting area for Kemp's Ridley Sea Turtles includes beaches along the state of Tamaulipas, Mexico, along the western side of the Gulf of Mexico, with some nesting along adjacent areas of the coast, including Padre Island in Texas. Juvenile Kemp's Ridley Sea Turtles are common in coastal and estuarine waters of North Carolina when water temperatures are above 11 °C, often corresponding to April through November (Brimley 1920; Braun-McNeill et al. 2008; Epperly 1995). Juvenile Kemp's Ridley Sea Turtles use deep and shallow estuarine waters of North Carolina as foraging grounds, targeting crustaceans, mollusks and other invertebrates (McClellan et al.2009). Kemp's Ridley Sea Turtle nests occur in North Carolina nearly every year, but in small numbers (<25). They have been found on ocean facing beaches in every county except Hyde. Nesting in North Carolina generally occurs from May to July, with hatchlings emerging from nests in July through September.

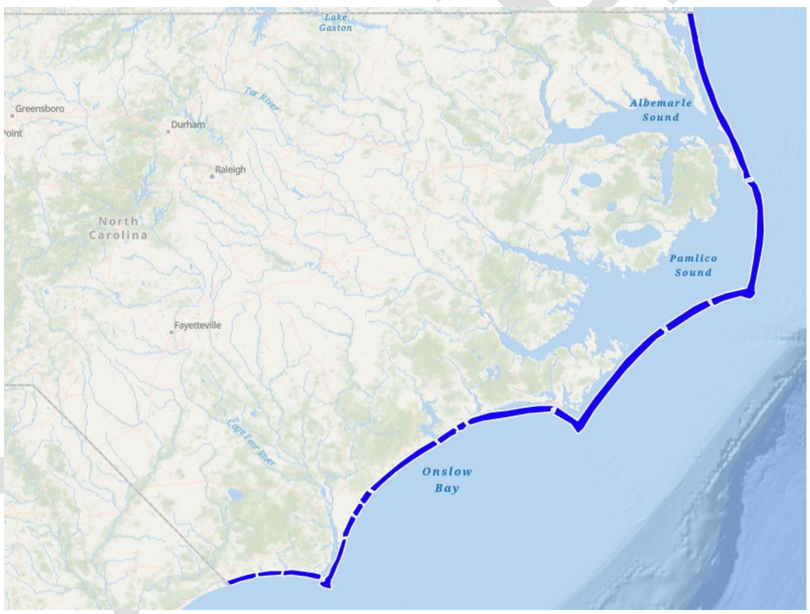
Kemp's Ridley Sea Turtles are considered depleted relative to historical levels, largely due to overharvest of eggs, bycatch in commercial trawl fisheries, habitat degradation, and exposure to oil spills in the Gulf of Mexico (Conant and Shearer 2015). The Kemp's Ridley Sea Turtle was listed as Endangered in 1970 under the Endangered Species Act (FR Doc. 1970-16173); there are no separate DPSs recognized for Kemp's Ridley Sea Turtles. In North Carolina, Kemp's Ridley Sea Turtles are listed as Endangered (15A NCAC 10I .0103(a)(7)(A)).

Leatherback Sea Turtles have physiological adaptations that allow them to remain in cold waters. They have the widest distribution of any reptile species, ranging from latitudes as far north as the United Kingdom and Denmark in the North Atlantic Ocean to New Zealand in the South Pacific Ocean. Nesting sites for Leatherback Sea Turtles occur in the Atlantic, Indian, and Pacific oceans. The earliest documentation of Leatherback Sea Turtles in North Carolina waters is the capture of an adult off Bogue Banks in Carteret County in 1897 (Schwartz 1976). Leatherback Sea Turtles are commonly observed swimming in coastal waters of North Carolina during spring and summer months and are often associated with jellyfish aggregations (Grant et al. 1996; Eckert et al. 2006). Nesting activity by Leatherback Sea Turtles in North Carolina is infrequent, ranging from 0-8 nests per year (Rabon et al. 2003).

The species is considered to have been greatly reduced relative to historical levels, due to incidental capture in fishing gear, directed harvest, ocean pollution, and reduction or loss of suitable nesting habitat. The Leatherback Sea Turtle was listed as Endangered in 1970 under the Endangered Species Act (FR Doc. 1970-16173). In 2020, the NOAA-NMFS and USFWS determined that sufficient information was available to identify seven different Leatherback Sea Turtle populations as DPSs, including the Northwest Atlantic DPS that includes Leatherback Sea Turtles in North Carolina (NMFS & USFWS 2020). Currently Leatherback Sea Turtles remain listed as Endangered throughout their range under the Endangered Species Act. In North Carolina, Leatherback Sea Turtles are listed as Endangered (15A NCAC 10I .0103(a)(7)(C)).

Hawksbill Sea Turtles are distributed globally, although they are commonly associated with coral reef habitat found in tropical and subtropical regions including the Atlantic, Indian, and Pacific oceans. Major nesting locations occur in the Caribbean, the Western Indian Ocean, and the South Pacific Ocean. In U.S. territories in the North Atlantic, major nesting and foraging sites are found in Puerto Rico and the U.S. Virgin Islands. Hawksbill Sea Turtles are infrequent visitors to North Carolina waters, likely due to the lack of coral reef habitat, and only two Hawksbill Sea Turtle nests have been confirmed in North Carolina (Finn et al. 2016).

Throughout their range, Hawksbill Sea Turtles are considered depleted, largely due to directed harvest (Jackson 1997). In 1970, The Hawksbill Sea Turtle was listed as Endangered throughout its range under the Endangered Species Act (FR Doc. 1970-16173). In 2013, the NOAA-NMFS and USFWS suggested that available data warranted an assessment of possible determinations of DPSs for Hawksbill Sea Turtles, although this has not been finalized. In North Carolina, Hawksbill Sea Turtles are listed as Endangered (15A NCAC 10I .0103(a)(7)(B)).



Habitats used by the Loggerhead (*Caretta caretta*), Green (*Chelonia mydas*), Kemp's Ridley (*Lepidochelys kempii*), Leatherback (*Dermochelys coriacea*), and Hawksbill (*Eretmochelys imbricata*) Sea Turtles in North Carolina, in estuarine and coastal state waters (top) and on ocean-facing sandy beaches along coastal barrier islands (bottom). Data come from the North Carolina Sea Turtle Stranding and Salvage Network and the North Carolina Sea Turtle Nesting database. Maps were created using the ESRI Mapmaker (https://www.arcgis.com/apps/instant/atlas/index.html).

THREAT ASSESSMENT

Reason for Listing

All species of sea turtles are considered depleted relative to historic or pre-historic levels (Bjorndal and Bolten 2003). When Loggerhead Sea Turtles were listed as Threatened by NOAA-NMFS and USFWS, major factors contributing to the species' status included: habitat degradation due to human encroachment and activities on nesting beaches; directed harvest of eggs, juveniles, and adults; incidental capture in fisheries; and lack of comprehensive protections. Similarly for Green Sea Turtles, when they were listed as Threatened (except for the breeding populations in Florida and Pacific Mexico, which were listed as Endangered) by NOAA-NMFS and USFWS, the major factors contributing to population decline included: loss or modification of habitats including nesting and foraging habitats; overutilization for commercial and other purposes, including directed harvest of eggs and adult turtles; disease and predation; lack of adequate protections; and incidental capture in fisheries. Kemp's Ridley Sea Turtles were listed as Endangered based on the following risk factors: degradation of nesting and foraging habitats in the Gulf of Mexico; overcollection of eggs from nesting beaches; exposure to predators both on beaches and in the water; lack of comprehensive regulatory mechanisms in marine and terrestrial habitats; exposure to incidental bycatch in fishing gear; and vulnerability to oil spills in the Gulf of Mexico. When Leatherback Sea Turtles were listed as Endangered, the primary threat factors included loss and modification of nesting habitats, overutilization of eggs and adults, exposure of eggs and hatchlings to predators, inadequacy of existing protections, and exposure to incidental capture in fishing gear. Hawksbill Sea Turtles were initially listed as Endangered due to loss of nesting and foraging habitats; overutilization of eggs, juveniles, and adults (primarily for their shell); exposure of eggs and hatchlings to predators; inadequate protections for different life stages; and exposure to incidental capture by fisheries.

Degradation, modification, or loss of habitat due to human encroachment is one contributing factor to all sea turtle species' status as either Threatened (Loggerhead, Green) or Endangered (Kemp's Ridley, Leatherback, Hawksbill).

Present and Anticipated Threats

All species of sea turtles are subject to ongoing threats in North Carolina. In North Carolina waters, juvenile and adult sea turtles are exposed to injury and death from anthropogenic threats including incidental capture by fishing gear (both commercial and recreational), collision with ocean vessels, impingement by hopper dredges, and pollution (McClellan et al. 2011). While all sea turtles are protected from harm by state law in North Carolina (NC General Statute § 113-189), when sea turtles are in coastal fishing waters (NC General Statute 113-129(4)), they are not considered wild animals in North Carolina (NC General Statute 113-129(15)). As a result, NCWRC does not have state authority to manage sea turtles while in coastal waters. Additionally, the lack of a Joint Enforcement Agreement between NCDMF and NOAA-NMFS means that state law enforcement agents working in coastal waters cannot enforce federal laws related to the protection of sea turtles in state waters, unless there are state laws passed that mirror federal rules (McClellan et al. 2011). This lack of clear legal authority to enforce rules is an impediment to minimizing threats to sea turtles in North Carolina coastal waters.

Interactions with recreational and commercial fishing gear are common in North Carolina, such as this Kemp's Ridley Sea Turtle incidentally captured by a hook and line angler on Jennette's Pier in Nags Head. The turtle was brought to the pier with a hoop net so the hook could be successfully removed. (NC Aquariums)

In many parts of the North Carolina coastline, sea turtle nesting habitat overlaps with high human presence, both in terms of housing developments adjacent to nesting beaches and presence of visitors using beaches for recreation. Sea turtles lay eggs during the cover of night, and later, most hatchlings emerge from the nests at night; thus, unless carefully managed, the presence of people on the beach at night (both pedestrians and those driving motorized vehicles, where allowed) can negatively impact adult females and hatchlings that are also using the beach. During the day, beach visitors will avoid disturbing incubating eggs because the nest locations are clearly marked for protection as part of the daily monitoring for newly laid sea turtle eggs on North Carolina beaches. However, no monitoring program is perfect, and it is estimated that daily sea turtle nest patrols have a detection rate error as high as 9% (Ceriani et al. 2019). Therefore, it is assumed that each summer there are many unmarked eggs incubating in the sand on various beaches in North Carolina and they are exposed to accidental take by beach visitors and others using the beach.

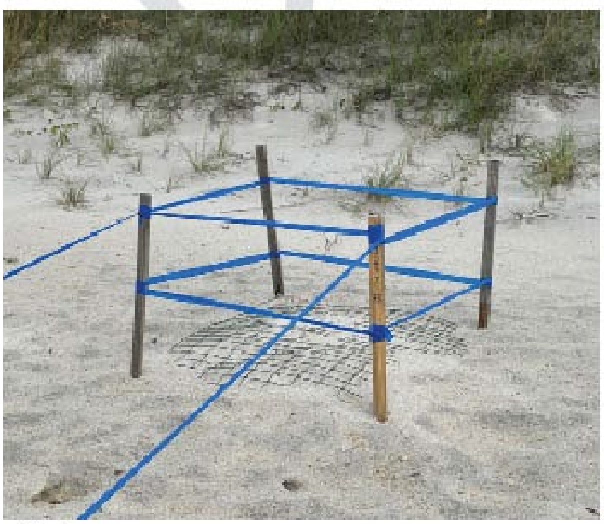
Various aspects of beach development can have negative impacts to nesting sea turtles, incubating eggs, and/or emergent hatchlings. For instance, the presence of homes and businesses adjacent to nesting habitat often results in artificial nighttime lighting reaching the nesting beach, with higher rates of illumination in more densely developed areas (Windle et al. 2018). Artificial light reaching the beach can misorient nesting females (or dissuade them from nesting) and attract emergent hatchlings away from the ocean (Witherington and Martin 1996). Disrupted seafinding of hatchlings can result in depleted energy reserves, increased exposure to terrestrial predators, and increased mortality from vehicle traffic if hatchlings reach roads adjacent to the nesting beach. Beach driving by service vehicles, such as garbage pickup, lifeguards, and beach furniture delivery services, can leave ruts in the sand that can impede the seafinding progress of emergent hatchlings (Hosier et al. 1981), and accidentally crush unmarked incubating eggs. Nesting females can be impeded or impinged by inappropriately placed items used to stabilize the primary dune, such as sand fencing that is placed too closely together, or recycled Christmas trees placed between areas of sand fencing. Beach mats used to facilitate public access to the beach can reduce available nesting habitat to sea turtles by covering over the surface of the sandy beach. Finally, items placed or left by beach visitors on the open beach at night, including furniture, tents, decks, boats, and volleyball nets, can interrupt or impede the nesting process of female sea turtles (Sobel 2002).

Additionally, developed beaches regularly undergo construction activities to counter erosion. These activities include the construction of terminal and/or temporary groins, bulldozing sand from the swash zone to the primary dune (beach scraping), and beach widening projects using material dredged from the ocean or removed from upland areas; often these events are implemented concurrently or in succession. While the outcome of these activities can result in an increase in available nesting habitat for sea turtles, they can also have negative impacts. For example, construction activities occurring during the nesting and/or hatching seasons pose a direct threat to nesting females, incubating eggs, and emergent hatchlings (Wilgus et al. 2002). Relocating eggs to other beach areas safe from construction activities is a commonly employed tool during summer beach construction projects, but this action can have potential negative impacts to the resultant hatchlings (Crain et al. 1995; Mrosovsky 2006). Non-beach compatible material that is used when constructing beaches can have long term negative impacts on nesting sea turtles and their eggs. For example, material with a high rock (or shell) content, or a high silt and/or clay content, can impede both the successful construction of sea turtle nests and the hatching rate of incubating nests (Crain et al. 1995). Beach construction projects that use beach compatible material that is darker in color can result in higher incubation temperatures in sea turtle nests (Shamblott et al. 2021). Dune slope on nesting beaches has been identified as a cue used by sea turtles for nest site selection (Wood and Bjorndal 2000); thus, the slope of dunes created by beach construction projects is an important variable affecting sea turtles. For instance, a turtle may be unable to ascend a steep front-side angle of a constructed dune or may become entrapped by a steep angle on the backside of a constructed dune. The final step of a beach construction project often involves the planting of stabilizing vegetation on constructed dunes, but inappropriate placement of plants on the beach can accelerate root invasion of incubating turtle nests and result in reduced hatching success and/or impingement of hatchlings in the nest cavity (Dodd 1988).

Incubating eggs are threatened by various predators such as unleashed dogs, coyotes, red foxes, raccoons, ghost crabs, fire ants, and mole crickets. Armadillos are a potential future predator as their range is expanding into eastern North Carolina. Historically, nesting beaches with excessive egg predation rates (95% of all clutches being preyed upon) have required direct predator control to reduce egg loss (Engemann et al. 2012). Most sea turtle eggs incubating on beaches in North Carolina are protected from mammalian predation by installing mesh above the eggs that still allows hatchlings to emerge. When predation rates on particular beaches or islands are high, more direct predator control programs have been implemented, and these generally result in at least short-term reduction of predation rates (Urbanek and Sutton 2019).

Several wind energy projects offshore from the North Carolina coast are being considered or planned. The construction and operation of these projects may pose threats to sea turtles, including increased exposure to vessel strikes, impacted sensory systems associated with construction, altered prey availability, and potential alteration of magnetic field reception near electrical transmission cables, including where the cables come ashore (Stearns et al. 2015; Gitschlag et al. 2021).

Red foxes (above), along with other predators such as unleashed dogs, coyotes and raccoons, are a major threat to incubating eggs. Wire mesh (below) placed over nests helps deter these predators.



Jodie Owen

Exposure to pollutants in coastal waters of North Carolina is a threat to sea turtles. Research on juvenile sea turtles in North Carolina reported a correlation between concentrations of organic pollutants, including PCBs and pesticides, and several blood chemistry values, suggesting exposure to organochlorines negatively impacts sea turtle health (Keller et al. 2004). In addition, inorganic compounds, including mercury, have been documented in juvenile loggerheads in North Carolina waters (Day et al. 2010). Marine debris such as plastic bags and sheets pose a threat to sea turtles in North Carolina, in particular leatherbacks, likely due to the visual similarity between floating plastic debris and jellyfish, which leatherbacks forage on (Mrosovsky et al. 2009). Microplastics have been documented in the gastrointestinal tracts of all species of sea turtle that occur in North Carolina, although more research is needed to understand potential health impacts of this exposure (Duncan et al. 2019).

There are several anticipated impacts to sea turtles due to climate change. Sea levels in North Carolina and elsewhere along the U.S. Coast are predicted to rise 25-30 centimeters (10-12 inches) by 2050 (Sweet et al. 2022). This may result in “coastal squeeze” whereby there is a reduction in available open beach habitat for nesting (Fish et al. 2008). This in turn could cause reduced hatching success from issues related to increased nest density such as greater bacterial loads in the sand and higher rates of accidental destruction of incubating eggs by subsequently nesting females (Patricio et al. 2021). Future sea level rise may also lead to increased use of hardened structures (sandbags, rock revetments, seawalls, groins, etc.) to protect developed areas of coastline. The presence of beach protection or stabilization structures can reduce numbers of nests laid and reduce the hatching success of any adjacent nests (Bouchard et al. 1998; Rizkella and Savage 2011). Additionally, climate change is predicted to increase the strength and number of tropical storms occurring in the Northwest Atlantic, which are a driver of reduced hatching success of incubating sea turtle eggs (Fuentes et al. 2019).

Increasing air and sea water temperatures associated with climate change are expected to result in warmer conditions for incubating sea turtle eggs during the nesting season (Patricio et al. 2021). Increased incubation temperatures can lead to more or possibly exclusive production of female hatchlings, due to temperature-dependent sexual differentiation and reduced hatching success (Hawkes et al. 2007). There is also growing evidence that hatchling quality (size, speed, mobility) is affected by increasing incubation temperatures (Fisher et al. 2014). Extreme incubation temperatures and/or reduced hatching success of nests may require management intervention, such as adding water to nests during incubation (Smith et al. 2021).

Increasing ocean temperatures may also affect the phenology of sea turtle reproduction, with turtles arriving earlier and/or remaining later than what is currently understood to be the nesting season (Patricio et al. 2021). Early-season or late-season incubating eggs found on North Carolina beaches may be exposed to impacts that would otherwise be managed during the current nesting season. For juvenile turtles, increasing ocean temperatures may increase the number of weeks in the year that they occur in North Carolina estuarine waters, potentially increasing the risk that they will become cold-stunned (Griffin et al. 2019) or exposed to other threats that previously did not greatly overlap with seasonal sea turtle presence (e.g., fishing gear use, hopper dredge projects).

Direct and indirect impacts of climate change on sea turtle nesting success are anticipated. The increased use of hardened structures, such as sandbags, to protect developed coastline areas from washing away, can block access of reproductive female sea turtles to nesting habitat, and potentially negatively impact adjacent incubating nests. *(Anya Douglas)*

Summary of Threats

- Incidental capture in commercial and recreational fishing gear
- Collision with watercraft
- Impingement in hopper dredges
- Exposure to pollution
- Disease outbreaks, including fibropapillomatosis
- Offshore wind development activities, including altered magnetic fields
- Visible artificial lights at night on ocean-facing beaches
- Human presence on beaches at night, both on foot and driving motorized vehicles
- Blocked access to nesting habitat by furniture, tents, mats, fencing, and other structures remaining on the beach over night
- Excessive predation of eggs and hatchlings by predators
- Destruction of eggs or hatchlings during beach construction activities conducted in the summer and fall
- Placement of incompatible material on the beach during coastal storm reduction projects (nourishment events)
- Motorized vehicle traffic on beaches in summer and fall
- Sea level rise
- Climate change induced reduction of hatching success
- Climate change induced changes to nesting seasonality of sea turtles
- Climate change induced changes to seasonal estuarine water temperature patterns
- Climate change induced increases in the number and severity of tropical cyclones

Historic and Ongoing Conservation Efforts

At the state level, NC General Statute 113-189 protects all sea turtles from harm. In addition, 15A NCAC 03R .0101 describes a sea turtle sanctuary in the waters adjacent to Bear Island, Browns Island, and Onslow Beach in Onslow County: commercial fisheries activity is prohibited within the bounds of the sanctuary between 01 June and 31 August, for the protection of reproductively active female sea turtles. More recently, NCDMF developed a management plan that includes federal authorization for incidental take of sea turtles by gill nets used by commercial fisheries and recreational anglers in estuarine waters of North Carolina (NOAA Incidental Take Permit Number 16230, expired 31 August 2023). Through time-area closures and closely monitoring incidental captures by gill nets, the NCDMF management plan has resulted in a decline in lethal interactions between sea turtles and estuarine gill net gear in North Carolina (Rawls 2022). NCDMF has applied for a subsequent Incidental Take Permit (ITP) for estuarine gill nets in North Carolina, which outlines management actions similar to ITP 16320 and requests authorization for less than 120 estimated lethal and less than 370 non-lethal sea turtle interactions per season, with observers used to calculate bycatch rates. For shrimp trawl gear, a state requirement was enacted in 2009 to require the use of a Turtle Excluder Device (TED) in each trawl net used by otter shrimp trawls in North Carolina waters (15A NCAC 03L .0103(h)), which mirrors the federal law requiring the use of a TED, but which before 2009 was unenforceable by NCDMF Law Enforcement due to the lack of a Joint Enforcement Agreement with NOAA-NMFS.

At the federal level, in 2001, NOAA-NMFS closed the Pamlico Sound to large mesh gill nets between September and December of each year, to reduce bycatch of sea turtles (66 FR 50350; Byrd et al. 2011). In 2002, NOAA-NMFS finalized the closure of all federal waters off North Carolina to large mesh gill nets targeting monkfish, except for waters north of Currituck Beach Light between January and March, to reduce bycatch of sea turtles (67 FR 71895). In 2014, USFWS and NOAA-NMFS assigned critical habitat for Loggerhead Sea Turtles in the Northwest Atlantic (79 FR 39855). In North Carolina, Loggerhead Sea Turtle critical habitat includes nearshore reproductive waters that run parallel to ocean beaches and out 1.6 kilometers (1 mile) from the beaches that are designated nesting beach critical habitat for Loggerheads (Bogue Banks, Topsail Island, Pleasure Island, Bald Head Island, Oak Island, Holden Beach, and Ocean Isle Beach); a constricted migratory corridor and winter habitat that occurs between Cape Lookout Point and the central portion of the Outer Banks (approx. 34.58˚ N and 36˚ N) from the edge of the islands of the Outer Banks to the edge of the continental shelf; and the southern portion of the area of winter concentration of juvenile and adult Loggerheads, which includes water depths from 20 to 100 meters (66 to 328 feet) between Cape Fear and Cape Lookout (approx. 33.29˚ N and 34.58˚ N). NOAA-NMFS published several Biological Opinions for the operation of some recreational fishing piers in North Carolina such as the Bonner Pier in Dare County, the Straights Pier in Carteret County, the Swansboro waterfront pier in Onslow County, and the Carolina Beach State Park fishing dock in New Hanover County. Incidental captures of sea turtles at these piers must be reported to the NCSTSSN.

Volunteers play an immensely important role helping biologists monitor and protect sea turtles during nesting, egg incubation and hatchling emergence. (Melissa McGaw)

In 2012, the National Park Service at Cape Hatteras National Seashore established an off-road vehicle (ORV) management plan for the protection of sea turtles that occur on the beach, including nesting females, incubating eggs, and emergent hatchlings (77 FR 3123). Management actions include restricting nighttime ORV use during the nesting season and controlling ORV access around known incubating sea turtle eggs. The Marine Corps Base Camp Lejeune has an Integrated Natural Resources Management Plan (INRMP; expired 2020 but in effect until updated) that identifies management actions to minimize impacts of the military presence at the base on sea turtles that occur on its beaches. These actions include reducing visible artificial light on the beach and/or use of lights with wavelengths less likely to affect the behavior of sea turtles on the beach; restricting recreational driving on the beach during the nesting season; relocation of eggs away from the amphibious training area; and nighttime monitoring of the nesting beach during nighttime training activities elsewhere. These management activities continue while a new INRMP is being developed.

Among the conservation efforts to protect sea turtles and their nests is prohibiting the planting of invasive beach vitex on coastal beaches because of the negative impacts to sea turtle nests. *(Jodie Owen)*

Summary of protective measures established at the municipal level for the conservation of sea turtles, for towns and unincorporated villages that are directly adjacent to sea turtle nesting beaches along the North Carolina coast. See text for more details.

	SEA TURTLE SANCTUARY	LIGHTING ORDINANCE	BEACH FURNITURE ORDINANCE	BEACH VITEX RESTRICTED	BEACH DRIVING RESTRICTED	COMMENTS
Sunset Beach	Yes	Yes	Yes	No	Yes	
Ocean Isle Beach	Yes	Yes	Yes	Yes	Yes	
Holden Beach	Yes	Yes	Yes	Yes	Yes	
Oak Island	Yes	Yes	Yes	Yes	Yes	
Caswell Beach	Yes	No	Yes	Yes	Yes	
Bald Head Island	Yes	Yes	Yes	Yes	Yes	
Kure Beach	No	No	Yes	Yes	Yes	
Carolina Beach	No	No	Yes	Yes	Yes/No*	*Beach driving allowed in Freeman Park
Wrightsville Beach	Yes	Yes	Yes	Yes	Yes	
Figure Eight Island	No	No	No	No	No	
Topsail Beach	Yes	Yes	Yes	No	Yes	
Surf City	Yes	Yes	Yes	Yes	Yes	
North Topsail Beach	Yes	Yes	Yes	No	Yes	
Emerald Isle	Yes	No	Yes	Yes	Yes	
Indian Beach	No	No	No	Yes	Yes	

	SEA TURTLE SANCTUARY	LIGHTING ORDINANCE	BEACH FURNITURE ORDINANCE	BEACH VITEX RESTRICTED	BEACH DRIVING RESTRICTED	COMMENTS
Pine Knoll Shores	Yes	No	Yes	Yes	Yes	
Atlantic Beach	Yes	No	Yes	Yes	Yes	
Hyde County (unincorporated village)	No	No	No	No	Yes/No*	*Some beach driving during daylight allowed in summer
Dare County (unincorporated villages)	No	No	No	No	Yes/No”	*Some beach driving during daylight allowed in summer
Nags Head	No	Yes	Yes	No	Yes	
Kill Devil Hills	No	No	Yes	No	Yes	
Kitty Hawk	No	Yes	Yes	No	Yes	
Southern Shores	No	Yes	Yes	No	Yes	
Duck	No*	No	No	Yes	Yes	*Town ordinance protecting sea turtles and their eggs
Currituck County	No	No	Yes	Yes	Yes/No*	*Beach driving allowed from Corolla northwards

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The National Park Service at Cape Hatteras National Seashore Off-Road Vehicle Management Plan restricts nighttime driving during the nesting season as well as controls vehicle access around known incubating sea turtle eggs. *(Cape Hatteras National Seashore)*

CONSERVATION GOAL AND OBJECTIVES

Overarching Goal

The conservation goal for sea turtles that occur in North Carolina is to facilitate the recovery of their populations by protecting them from anthropogenic threats and maintaining and/or enhancing the functionality of their habitats (terrestrial and aquatic).

Objectives

1. Monitor the number of nests laid by each species in North Carolina, with the goal that annual totals are not declining over any twenty-year period, and that the trend in nests laid corresponds to the trend in number of nesting females.
2. Monitor the abundance of juvenile sea turtles in North Carolina waters, with the goal that numbers of individuals are increasing at a greater rate than the number of recorded stranded sea turtles of similar size classes.
3. Manage North Carolina coastal beaches for successful nesting by working with partners and stakeholders, to avoid excessive rates (>65%) of nesting crawls that do not result in egg deposition.
4. Manage coastal in-water habitat in North Carolina for successful migration, foraging, development, and reproduction by working with partners and stakeholders, including the establishment of index monitoring sites.
5. Use scientifically based best practices for managing sea turtles, their incubating eggs, and emergent hatchlings in North Carolina, including minimizing nest predation to less than 20% of all eggs laid, while maintaining >65% annual hatching success rates over any ten-year period.
6. Minimize lethal bycatch in commercial and recreational fisheries in North Carolina by working with partners and stakeholders to develop and implement relevant management measures, including maintaining adequate observer programs for fishing gear known to interact with sea turtles.
7. Reduce injuries and mortality caused by vessel strikes in North Carolina by working with partners and stakeholders to develop and implement relevant management measures so that vessel strike mortalities are stable or decreasing over any ten-year period.
8. Respond appropriately to mass stranding events or mass mortality/disease events.
9. Monitor for impacts of climate change and adapt conservation actions appropriately, to reduce negative impacts.
10. Develop and implement local and state legislation for the protection of sea turtles in North Carolina.

CONSERVATION ACTIONS

Action A

Maintain and support current nest monitoring and protection programs to ensure data on nest numbers and hatchling production are sufficient to assess trends in numbers of nests laid and females nesting (see Objectives 1, 3, 5).

Action B

Maintain and support current sea turtle stranding and salvage network activities to detect changes in relative abundance of species, size classes, and threats (see Objective 2).

Action C:

Work with local, state, and federal partners to reduce threats on nesting beaches during sea turtle reproductive periods, including minimizing visible artificial light on the beach, restricting ORV use, restricting beach construction activities to outside of the nesting and hatching seasons, and ensuring beach development actions are compatible with sea turtle reproduction (see Objectives 3, 5, 9, 10).

Action D:

In addition to working with local, county and state legislators to establish rules that benefit sea turtles, work with USFWS and other stakeholders to establish a coastal beach Habitat Conservation Plan to protect nesting females, their incubating eggs, and emergent hatchlings while on beaches in North Carolina (see Objectives 3, 5, 9, 10).

Action E:

Work with local, state, and federal partners to establish a committee to review and assess threats to sea turtles through reduction of in-water anthropogenic threats, including incidental capture by recreational and commercial fishing gear, dredges, vessel strikes, and marine debris (see Objectives 4, 6, 7).

Action F:

Establish protocols for responding appropriately to mass stranding events, including cold stun events, disease outbreaks, and mass mortality associated with an emergent threat (see Objective 8).

Action G:

Based on future changes to sea turtle phenology, distribution, and threats associated with climate change, prepare to adapt current conservation actions and protocols to ensure sea turtles continue to be protected in the future (see Objective 9).

Action H:

Support and conduct research to better understand sea turtle biology, physiology, and behavior in North Carolina to improve or confirm best practices for sea turtle conservation actions (see Objectives 3, 4, 5, 6, 7, 8, 9, 10).

SUMMARY OF ACTIONS NEEDED

Due to their long-distance migratory behavior, sea turtles are challenging to monitor in the marine environment. Therefore, tracking numbers of egg clutches (nests) laid is the most commonly used metric for assessing population trends. Comparing the average numbers of nests laid in North Carolina during an earlier ten-year period (2003-2012) to the later ten-year period (2013-2022), annual number of nests laid by Loggerhead Sea Turtles increased from 748 to 1362; annual Green Sea Turtle nests increased from 13 to 36; annual Kemp's Ridley Sea Turtle nests increased from one to five; annual Leatherback Sea Turtle nests declined from three to one, and annual Hawksbill Sea Turtle nests remained unchanged at zero (only two nests laid in North Carolina have been documented to date). Except for Leatherback and Hawksbill Sea Turtles, which nest in low numbers, all species showed increasing numbers of nests laid per year over the past two decades. Continued monitoring of sea turtle nesting activities will provide annual data against which to assess nesting trends, both for North Carolina (see Objective 1) and for NOAA-NMFS and USFWS, who are responsible for assessing regional trends against the current Federal Recovery Plans. In addition, the monitoring and protection of sea turtle nests in North Carolina establishes a baseline against which to assess potential climate change impacts (see Objective 9), such as alterations in phenology, new threats to incubating eggs and emergent hatchlings, and the potential influx of other species nesting in North Carolina (Patricio et al. 2021).

Similarly, continued operation of the NCSTSSN is important because it provides information on the relative abundance, life stage, behavior, and threats to sea turtles in North Carolina waters. NOAA-NMFS tracked relative abundance of sea turtles by monitoring incidental captures of sea turtles in pound nets in Core and Pamlico Sounds and reported a relative increase in abundance in juvenile Loggerhead, Green, and Kemp's Ridley Sea Turtles between 1995-2009 (Braun-McNeil et al. 2018). Currently, there are no dedicated abundance surveys for sea turtles in North Carolina waters. It would be beneficial to have one or more long-term index surveys of sea turtles in North Carolina waters, against which to compare trends in stranded sea turtles, with the goal of maintaining rates of stranding that is less than rates of growth of the nesting populations (see Objective 2). One or more index survey sites would facilitate more research on different life stages of sea turtles in North Carolina and allow baseline monitoring of metrics such as growth and health.

The suite of threats to nesting females, their incubating eggs, and emergent hatchlings on North Carolina Beaches, including beach driving, beach construction, and nighttime artificial light visible from the beach could be effectively managed through development of a beach Habitat Conservation Plan (HCP) with all coastal stakeholders. A coastal North Carolina HCP, authorized by USFWS, would allow beach development activities, including beach construction, but would be managed so the take of sea turtles is avoided or minimized (see Objectives 3 and 10). The HCP would codify best practices for the conservation of sea turtles (see Objective 5). The HCP also would allow beach construction activities to occur in coastal North Carolina but would delineate when they could be conducted to minimize impacts to sea turtles. An added benefit from development of an HCP is that consideration of other coastal listed species could be included to also minimize impacts to those species, including piping plovers, red knots, and seabeach amaranth.

Despite several efforts to protect sea turtles in the waters of North Carolina (establishment of a sea turtle sanctuary in Onslow County, implementation of an estuarine gill net management plan to reduce incidental capture of sea turtles, and construction of a diversionary structure in Southport to exclude sea turtles from impingement in the intake canal of the Brunswick Steam Electric Plant), there remain many other threats to sea turtles in inshore and offshore waters. The Sea Turtle Advisory Committee of the North Carolina Marine Fisheries Commission (NCMFC) reported that there are several fishing gears of concern for bycatch of sea turtles in estuarine waters. In addition to gill nets and shrimp trawls that are currently managed through rules, gear types that should be considered for rules that could reduce impacts to sea turtles include: pound nets, recreational rod and reel, butterfly net, channel net, long haul seine, swipe net, crab pots, and crab trawls (Sea Turtle Advisory Committee 2006). Many other types of fishing gear that occur in North Carolina ocean waters and that impact sea turtles were not reviewed by the committee. Additional in-water threats include impacts by vessels, impingement by hopper dredges, and risk of entanglement in passive gear associated with research. The Sea Turtle Advisory Committee was disbanded in 2016 by the NCMFC. It would be beneficial to establish a new review committee that expands its purview beyond assessing sea turtle interactions with fishing gear in estuarine waters to encompass all threats to sea turtles in state waters and address the lack of state authority to enforce rules to protect sea turtles in state waters. Potential members of the committee would be made up of stakeholders, including representatives of federal, state, county, and local governments; researchers; biologists; conservationists; NGOs; commercial fishermen and women; and recreational anglers. The goal of this committee would be to review threats and make recommendations that would reduce impacts of the recognized threats, possibly including management actions and changes to state rules (see Objectives 4, 6, 7, 10).

The number of cold-stunned turtles that need rescuing and rehabilitation may increase in the ensuing years, becoming more challenging to manage. *(Matthew Godfrey)*

Nearly every winter in North Carolina, hundreds of juvenile sea turtles in estuarine waters become cold-stunned and are taken to rehabilitation facilities for treatment and eventual release (Niemuth et al. 2020). While these events have been managed relatively effectively to date, it is possible that the number of animals affected may expand and thus become more challenging to respond to. Additionally, other disease events such as exposure to brevetoxin associated with harmful algal blooms or fibropapillomatosis, or mortality associated with oil spills or other types of pollution, could affect sea turtles in North Carolina waters. While it is challenging to anticipate the contours of a major stranding event, it would be beneficial to establish basic protocols for dealing with high numbers of stranded turtles occurring within a short period of time (see Objective 8). These protocols could be expanded to include other coastal marine wildlife, including birds and marine mammals.

In anticipation of impacts to sea turtles in North Carolina due to climate change, including phenological changes, reduced fertility of eggs and/or fitness of hatchlings, emergence of new or altered threats, and expanded ranges of rare or currently absent species (Leatherback Sea Turtles; Hawksbill Sea Turtles; Olive Ridley Sea Turtles), ongoing monitoring of nests and stranded turtles needs to be continued to help identify these types of changes. However, consideration of different approaches to managing these changes is imperative, including identifying thresholds against which management actions should take place (see Objective 9). For example, if extreme incubation temperatures are implicated in greatly reduced hatching success, then adding water to incubating egg clutches may help improve the production of hatchlings by reducing incubation temperatures (Smith et al. 2021).

Although much has been learned about sea turtle biology related to reproduction and migratory behavior of adult females, there remain many gaps in our understanding of their life history, physiology, and behavior, particularly for populations in North Carolina. For example, little is known about the survivorship or average reproductive longevity of adult females, yet these factors are critical for assessing lethal threats at the adult stage. Information on survivorship rates of hatchlings and juveniles is lacking yet is critical for prioritizing management actions for threats affecting these life stages. There is also a lack of information about techniques to reduce the likelihood of interactions between sea turtles in the water and different types of fishing gear, including commercial and recreational. Potentially promising methods are being tested elsewhere, including visual and acoustic deterrents on gear (Wang et al. 2010; Allman et al. 2021). As possible, research findings should be used to inform management actions and regulatory updates (see Objectives 5, 6).

Climate change may result in an increase in nesting for sea turtles that have been historically rare or absent in North Carolina, such as the Kemp's Ridley Sea Turtle (above) that nested on Pine Knoll shores in 2019. The need for conservation and monitoring efforts may increase for these species as potential climate effects are realized. *(Karen Clark)*

A summary of conservation actions needed to address the goals, the partners involved, and the desired outcomes of each action. These actions are listed generally in order of priority, though all actions are considered important and necessary.

#	ACTIONS	SPECIFICS	PARTNERS	DESIRED OUTCOMES	DATES ACTIONS PERFORMED
A	Maintain Nest Monitoring and Protection Network	Continue standardized monitoring and protection of sea turtle nests on North Carolina beaches	USFWS, National Seashores, National Wildlife Refuges, Department of Defense, North Carolina State Parks, North Carolina Division of Coastal Management, North Carolina Audubon, Bald Head Island Conservancy, volunteer organizations	Use standardized data to assess population trends and monitor for changes to hatching success, fertility, and other reproductive metrics (see Objectives 1, 3, 5)	May through November Annually
B	Maintain Sea Turtle Stranding and Salvage Network	Continue to respond to and document sick, injured, dead sea turtles	NOAA-NMFS, USFWS, National Seashores, National Wildlife Refuges, Department of Defense, North Carolina State Parks, North Carolina Division of Coastal Management, North Carolina Division of Marine Fisheries, Audubon North Carolina, Bald Head Island Conservancy, volunteer organizations	Continue standardized data collection, and help transfer sick or injured turtles to appropriate rehabilitation centers (see Objective 2)	Ongoing
C	Coordinate with partners to reduce threats on nesting beaches	Minimize impacts of artificial light, ORVs, and development during the reproductive period	USFWS, National Seashores, National Wildlife Refuges, Department of Defense, North Carolina State Parks, North Carolina Division of Coastal Management, North Carolina Audubon, Bald Head Island Conservancy, coastal towns and counties, volunteer organizations	Encourage conservation measures, use of BMPs, and/or development of local ordinances to minimize impacts of human activity on sea turtles using beach habitat, including through public engagement and outreach (see Objectives 3, 5, 9, 10)	May through November Annually

#	ACTIONS	SPECIFICS	PARTNERS	DESIRED OUTCOMES	DATES ACTIONS PERFORMED
D	Develop a coastal beach Habitat Conservation Plan with USFWS	Minimize impacts of coastal development on sea turtles that use North Carolina beaches	USFWS, National Seashores, National Wildlife Refuges, Department of Defense, North Carolina State Parks, North Carolina Division of Coastal Management, Audubon North Carolina, Bald Head Island Conservancy, volunteer organizations	Establish conservation measures to minimize impacts of coastal development on sea turtles and other listed species that use beach habitat (see Objectives 3, 5, 9, 10)	To be developed
E	Establish Sea Turtle In-water Threats Committee	Review and assess threats to sea turtles in North Carolina waters	NOAA-NMFS, National Seashores, National Wildlife Refuges, Department of Defense, North Carolina State Parks, North Carolina Division of Marine Fisheries, Audubon North Carolina, Bald Head Island Conservancy, volunteer organizations, recreational anglers, boating groups	Develop and implement actions to reduce threats to sea turtles in North Carolina waters, including potential changes to state law and fisheries management rules (see Objectives 4, 6, 7)	To be established
F	Develop protocols for mass stranding events	Research protocols developed for other regions or ocean basins and adapt to North Carolina	USFWS, NOAA-NMFS, North Carolina Aquariums, North Carolina State University College of Veterinary Medicine, North Carolina Division of Marine Fisheries, National Seashores, National Wildlife Refuges, Department of Defense, North Carolina State Parks, North Carolina Division of Coastal Management, Audubon North Carolina, Bald Head Island Conservancy, volunteer organizations	Establish protocols and actions for responding to mass stranding events (see Objective 8)	To be developed
G	Monitor and prepare for threats related to climate change	Analyze data collected during nest monitoring and protection	USFWS, NOAA-NMFS, universities, and other researchers	Keep abreast of changes related to climate change and prepare for management responses (see Objective 9)	To be developed

#	ACTIONS	SPECIFICS	PARTNERS	DESIRED OUTCOMES	DATES ACTIONS PERFORMED
H	Conduct research	Improve our understanding of biology, physiology, and behavior	NCWRC staff, universities, and other researchers	Improve our understanding of juvenile abundance and survivorship, threats and help prioritize management actions (see Objectives 3, 4, 5, 6, 7, 8, 9, 10)	Ongoing

GLOSSARY

Biological Opinion:

An analysis of the impacts of actions of any federal agency on species listed as Endangered or Threatened under the Endangered Species Act. A biological opinion usually includes recommendations to further the recovery of listed species potentially impacted by actions under consideration and can include specific measures to minimize take.

Carapace:

Thick shell which covers the back or dorsal side of the turtle.

Clutch:

The group of eggs laid at one time by a nesting female. Sometimes used synonymously with nest.

Cold stunning:

A state of reduced activity or lethargy that sea turtles enter when exposed to water 10˚ C or less. They become susceptible to stranding, accidental boat strikes, and even death if the exposure is prolonged or water temperatures drop.

Endangered species:

In North Carolina, “Any native or once-native species of wild animal whose continued existence as a viable component of the State’s fauna is determined by the Wildlife Resources Commission to be in jeopardy or any wild animal determined to be an ‘endangered species’ pursuant to the Federal Endangered Species Act.”

Habitat Conservation Plan (HCP):

A planning document approved by USFWS that is associated with an Incidental Take Permit. The Plan includes information on level of take, how impacts are minimized, what conservation measures will be enacted to protect the species covered, and how the actions will be funded.

Incidental Take Permit (ITP):

A permit issued by USFWS or NOAA-NMFS to non-federal entities that authorizes otherwise lawful activities that may result in take of a listed species.

Integrated Natural Resources Management Plan (INRMP):

A comprehensive management plan developed for natural resource conservation and management on US military installations.

Neritic:

The relatively shallow zone of the ocean adjacent to the coast, extending out to edge of the continental shelf (approximately 200 meters depth).

Nest:

The excavated cavity in the sand into which the reproductively active female will deposit her eggs.

North Carolina Sea Turtle Stranding and Salvage Network (NCSTSSN):

A network of volunteers and cooperators from federal, state, local and private organizations that responds to sick, injured, or dead sea turtles, and collects standardized information from each stranded turtle observed in North Carolina.

ORV:

Off-road vehicle, typically with four-wheel drive.

Phenology:

The study of cyclic and seasonal natural phenomena, particularly related to environmental influences on plant and animal populations.

Plastron:

The shell that covers the underside or ventral side of the turtle.

Scute:

A horny or keratinized plate that is part of the shell of a turtle. The number and pattern of scutes on the shell are usually distinguishing characteristics of the species.

Threatened species:

In North Carolina, “Any native or once-native species of wild animal that is likely to become an endangered species within the foreseeable future throughout all or a significant portion of its range or one that is designated as a ‘threatened species’ pursuant to the Endangered Species Act.”

Turtle Excluder Device (TED):

A gear modification for shrimp trawls that allows sea turtles to escape a trawl net before they drown.

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