atlantic loggerheads

Why Isn't the Best Understood Sea Turtle Recovering?

By BLAIR WITHERINGTON, ALAN B. BOLTEN, KATE L. MANSFIELD, LUCIANO SOARES, SIMONA A. CERIANI, and NATHAN F. PUTMAN

The Atlantic Ocean has served as a laboratory for pioneering work to save sea turtles. It is where Professor Archie Carr—and many whom he inspired—first addressed some profound mysteries that had stymied the conservation of such enigmatic marine animals. Loggerhead sea turtles became an exemplar of this work, revealing critical concepts such as the oceanic dispersal, the nature of the "lost years," the migratory connections, and the relative importance of different life stages to population growth. These puzzle pieces have guided strategic sea turtle conservation for decades.

In addition to being a cradle for sea turtle conservation science, the Atlantic also happens to contain the largest population of loggerhead sea turtles on Earth (consequences of recent misfortune, rather than achievement, see pp. 6–7). If the adage "Where much is granted, much is expected" applies, this statement makes the stewards of the Atlantic disproportionately responsible for our future with sea turtles. So how are we doing? Is our understanding of Atlantic loggerheads benefiting them? Well, let's just say, it's never too late to show responsibility.

Humans have had an extensive presence in the Atlantic Ocean and its coastlines. Since before recorded history, native people on both shores drew upon resources from Atlantic coastal waters. And then, just 10 or so loggerhead generations ago, Europeans began ocean crossings that broadly spread both human appetites and the industrial capacity to satisfy them. Especially in the past century, people have consumed from the Atlantic and changed for the worse the waters where loggerheads live.

Loggerheads aren't picky, which has led some to suggest that the sea turtles might be resilient to all this human presence and might comfortably persist with us in the Sea of Atlas. They are globally distributed marine animals that forage widely. Their nesting range is almost as broad and includes islands, barrier strands, and continental beaches. Loggerheads are also generalists in where they live and what they eat—from estuaries, coastal shallows, and oceanic waters, with associated habitats spanning seagrass pastures, hard bottom, coral reefs, and the open sea. Their diet is satisfied by prey that vary over many phyla, from jellies to heavily armored crabs, clams, and large marine snails.

Perhaps because of their liberal and accommodating conduct, loggerheads and their kin have a track record of persistence. Their direct forebears have endured for more than 100 million years, with generalist species like the loggerhead surviving the cataclysmic events that snuffed out the dinosaurs. They prevailed through multiple ice ages and warming trends that shuffled habitats and drove sea-level changes of more than 200 meters. So we might imagine that loggerheads, with a capacity to fill such varied niches and to survive global tumult, would be able to avoid adverse effects from a single, albeit tough, competitor. But we'd be wrong.

Conventional wisdom accepts that the majority of the world's sea turtle populations are depleted owing to human actions. Many of these actions involve direct harvesting of eggs and turtles. But aren't we past that era? Shouldn't loggerheads be on the rebound? The recent IUCN Red List assessment (2013), drawing from decades of extensive monitoring on nesting beaches all over the world, concluded that the species is still vulnerable. But the assessment is complex (see *SWOT Report*, vol. XII, pp. 30–33). Ten loggerhead subpopulations make up the global species, with three in the Atlantic (excluding the Mediterranean). Of those three, the Northeastern Atlantic subpopulation is considered endangered because of its small size and restricted distribution, whereas the two Western Atlantic subpopulations (north and south) are listed as being of least concern. In this context, least concern does not mean recovered; they remain depleted but are holding their own for now. Why aren't these Atlantic populations recovering?

Overall, we've shown considerable conservation progress within the range of Atlantic loggerheads—we value them, seek to understand them, and attempt to manage our detrimental actions. Loggerheads in the Atlantic enjoy life on and off the shores of wealthy nations that show high conservation awareness. The Bahamas, Brazil, European countries, Mexico, the United States, and others are testament to this concern in their rule of law at sea—all of those nations have banned direct harvest of sea turtles.

We've also studied and monitored Atlantic loggerheads for decades, leading to those populations serving as the discovery point for comprehending sea turtle life histories, population biology, and ecology. If we draw on an index of numbers of nests made on Atlantic beaches, then we know much about how many adult loggerheads there are. The trend is disappointing—not dire, but certainly no recovery. Why? Perhaps we're impatient. The eggs we protected from poaching in the 1980s produced turtles that are only now coming home to nest. But the greatest toll we've taken on loggerhead populations has come from effects on life stages that are the most valuable to the population—older juveniles and adults with the highest probability of breeding. After only a couple of decades of protecting these animals in the water, we should now be seeing effects on recovery. Why don't we? Ostensibly, an answer lies not in our success toward ceasing the harm being done to them on purpose but in our inability to address the harm that occurs by accident.

A juvenile loggerhead drifts among jellyfish in the North Atlantic Ocean off Pico Island, Azores. © MICHAEL PATRICK O'NEILL; PREVIOUS SPREAD: Newly hatched loggerheads enter the Atlantic Ocean on the coast of Florida, U.S.A. © BENJHICKS.COM

CONNECTIONS—LIFE HISTORY, ECOLOGY, AND HAZARDOUS INTERSECTIONS

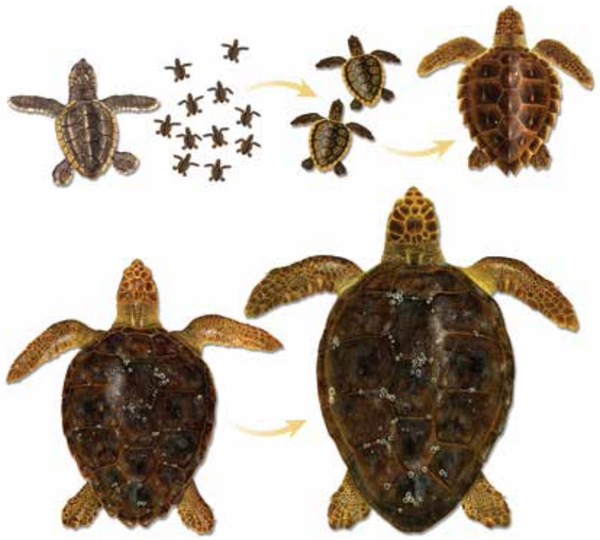
The loggerhead conservation puzzle finds clues in their connections to other organisms, ecological systems, human enterprise, and geopolitical states. Like all sea turtles, loggerheads are connected to the beaches where they lay their eggs. More so than with other sea turtles, loggerhead nesting covers many latitudes, with nests recorded as far north as New Jersey, on the U.S. coast, and as far south as the southern state of Paraná, Brazil. That range spans more than 3,700 nautical miles north to south. The southeastern coast of Florida is the center of nesting abundance, but considerable nesting also occurs in the remaining southeastern United States, on Mexico's Yucatan Peninsula, across Sergipe and northern Bahia states in Brazil, and in the Cabo Verde archipelago off western Africa.

Almost everywhere throughout the loggerhead's Atlantic nesting range, eggs are protected from poaching. But threats to nests and emerging hatchlings are common. Sources of mortality that are most severe stem from the incidental effects of coastal development. Human population centers close to beaches bring heavy-handed defense against erosion (sand pumping and seawalls), which leads to nesting habitat loss. However, the most injurious effects from development come from artificial lighting, which draws nocturnally emerging hatchlings away from the sea and causes high mortality on many beaches.

Hatchlings that survive the beach make a frenzied swim into the offshore Atlantic. This two-day sprint limits exposure to intense coastal fish predation and ends with little loggerheads settling in to the numerous surface features produced by converging ocean currents. The convergence zones collect the pelagic algae Sargassum, along with a host of small, slow-moving invertebrates that provide food for young sea turtles. Sargassum drift habitat is unique to the Atlantic, forming a massive oceanic habitat, with patches large enough to be viewed from space.

The currents that carry this drifting material manage to transport small loggerheads much more widely than they could disperse under their own swimming power. In the North Atlantic, the Gulf Stream and connected currents at the western edge of a clockwise, ocean-spanning North Atlantic Gyre carry neonate loggerheads across higher latitudes and into the eastern Atlantic. Hatchlings from Brazilian beaches may be transported even more widely, being either swept into the North Atlantic or circulated deeper into the South Atlantic and eastward toward Africa.

Until recently, a loggerhead's life in the open sea was almost completely unknown. How do they find their way? Answers came from Ken Lohmann and students at the University of North Carolina, who demonstrated that hatchlings use GPS-like cues from Earth's



Common appearances of life stages of loggerhead sea turtles in the Atlantic. Shown upper left to upper right are hatchlings, surface pelagic neonates, and oceanic juvenile, and from lower left to lower right are neritic juvenile and adult female.

magnetic field to derive their location from the bi-coordinate grid of magnetic field strength and the angle of that field relative to the Earth's surface. From Atlantic loggerheads we now know that the relatedness of female loggerheads on their nesting beaches can be explained by the similarity of magnetic field values where the turtles nest. So it seems, at least in part, that magnetic fields guide loggerheads home. In the Atlantic, there is also considerable support for the hypothesis that young loggerheads use their magnetic sense to swim toward favorable open-sea habitat. And in the case of southeastern U.S. loggerheads, this directed swimming increases the odds of reaching their next life-history milestone—continuing to mature in the foraging habitats in the eastern Atlantic and Sargasso Sea.

To graduate to larger oceanic juveniles, neonate loggerheads must survive threats inherent to being small. Fish predation is believed to be high in this stage, but for eons, loggerhead reproduction (having lots of young) and behavior (rapid dispersal past risky coastal waters) have minimized this mortality. However, recent threats are developing that are too abrupt for accommodation. In a single loggerhead generation (roughly 45 years), an extraordinarily pernicious, human-generated ingestion hazard has spread into every crevice of the Atlantic—plastic litter. And it is in those crevices where little loggerheads find their food. We don't know the lethal magnitude of this incidental human threat, but we do know it is pervasive. Nearly all of the neonate loggerheads swept dead onto Atlantic beaches during severe storms had ingested shards of degraded plastics, with compromised nutrition and gut blockage being a likely cause of death.

One of the greatest mysteries of a loggerhead's life at sea was how long they spent there. We first came to understand from Atlantic loggerheads that their enigmatic "lost year" in the open sea was more like a lost decade. In 1982, Helen Martins (University of the Azores) began tagging platter-size loggerheads found near the Azores archipelago in the eastern Atlantic. She forwarded the turtles' size data to Archie Carr, who used the information to lay out the case for a connection between loggerheads nesting in the western Atlantic and those swimming in eastern-Atlantic Azorean waters.

In what has now been a 35-year collaboration, the Archie Carr Center for Sea Turtle Research, the University of Florida (principally, Alan Bolten and Karen Bjorndal), and the University of the Azores have made advances in understanding loggerhead conservation challenges. Revelations include how fast loggerheads grow and compensate for periods of low growth, their extent of migratory movements, their ecological connections, and their odds of survival. This work also revealed important new findings on threats from plastic pollution, nutrient dilution, and—most important— bycatch in oceanic longline fisheries. The latter hazard is compounded by the decade that loggerheads endure as oceanic juveniles. Bycatch mortality is an onerous consequence of biology intersecting with economic enterprise; it occurs in both the northwestern and southwestern Atlantic loggerhead populations, whose open-ocean life stage makes up a third of the animal's maturation.

Following many years of growth in the open sea, most loggerheads return to the vicinity of their natal coast, a profound habitat shift accompanied by changes in behavior and diet. The turtle's mouth has grown along with its body size, making it capable of crunching a wide variety of shelled sea-bottom invertebrates. This shift is not always permanent. Some Atlantic loggerheads settle permanently into coastal waters, others move between coastal and offshore waters, and some remain largely oceanic while moving into shallow seas only during breeding migrations to their nesting beaches. Yet as most loggerheads grow closer to a mature size, they become more likely to occupy waters where they dive to the bottom for their food.

Coastal loggerheads are faithful to specific foraging grounds, but their fidelity is punctuated by seasonal migrations. Water temperature changes drive juveniles and adults into warming northern waters in the spring and south again in the fall as waters cool. Many North Atlantic coastal loggerheads move north and south of Cape Hatteras during such seasonal migrations, as they spend the winter over deep water along the western edge of the warm Gulf Stream current. Those turtles follow three-dimensional thermoclines within their habitats, remaining mostly at the surface during colder months, when ocean temperatures are more stratified, and feeding on the bottom once those deeper waters mix in the spring and summer.

Again, an unfortunate proximity of biology and human enterprise burdens larger loggerheads with exposure to a variety of coastal hazards. Perilous fisheries include trawling for shrimp and finfish, dredge fishing for scallops, and gill netting for finfish. Those fisheries are regulated throughout much of the loggerhead's Atlantic range, and fishers have made efforts to modify their gear and methods, yet incidental drowning in fishing gear remains a critical source of loggerhead mortality. Boat traffic in general constitutes another severe coastal threat to loggerheads, with boat strikes being the most common identifiable cause of death for sea turtles stranded on U.S. Atlantic shores.

Loggerheads that survive to adulthood are exposed to most of the same threats felt by younger coastal turtles. One additional array of threats experienced by adults may result from their breeding migrations. In the North Atlantic, breeding movements may be similar to coastal north-and-south travel seen seasonally in younger loggerheads. But some breeding migrations are more extensive, like the common route females take between Chesapeake Bay foraging grounds and Florida nesting beaches, and the route between the northern Gulf of Mexico and eastern Florida. These periodic coastal movements multiply the risk of lethal interactions with an array of coastal hazards.

Despite what we think we know about how loggerheads breed, some profound mysteries remain. One of those is the presumed threat from hybridization. Although there are sporadic reports of loggerheads worldwide hybridizing with other sea turtle species, only in the southwestern Atlantic do such observations occur at an alarming frequency (see *SWOT Report*, vol. XI, p. 19). In the northeastern Brazilian rookeries of Bahia and Sergipe, hybridization between loggerheads and hawksbills, and between loggerheads and olive ridleys, occur at rates of more than 20 percent. This hybridization is not sex-specific. Both male and female loggerheads mate with other species, and both male and female adult hybrids have been identified. Remarkably, the hybrids do not seem to be at a reproductive disadvantage relative to their parental species in regard to hatchling production, and hybrid hatchlings have similar viability to nonhybrids. The cause and consequences of this blurring of sea turtle species are unknown.

PREDICTIONS

Atlantic loggerheads exemplify the challenges and opportunities characterizing life for sea turtles in a prospering world. Much of our activity in pursuing that prosperity has unintentional consequences for loggerheads. Yet the achievement of economic success over much of the loggerhead's Atlantic range, as well as the political systems governing that success, allow the people who accidentally harm loggerheads the luxury of purposefully conserving them.

A juvenile loggerhead fitted with a satellite transmitter is about to be released. Only recently has technology made it possible to satellite-tag such small turtles.

One common thread weaving through the story of loggerheads in the Atlantic is that their lives span their ocean. Each knot in a loggerhead's life-history thread, which is tied in waters of dozens of different countries or in waters belonging to all, lengthens the strand. But each knot can also break. No single country or entity will save our Atlantic loggerheads.

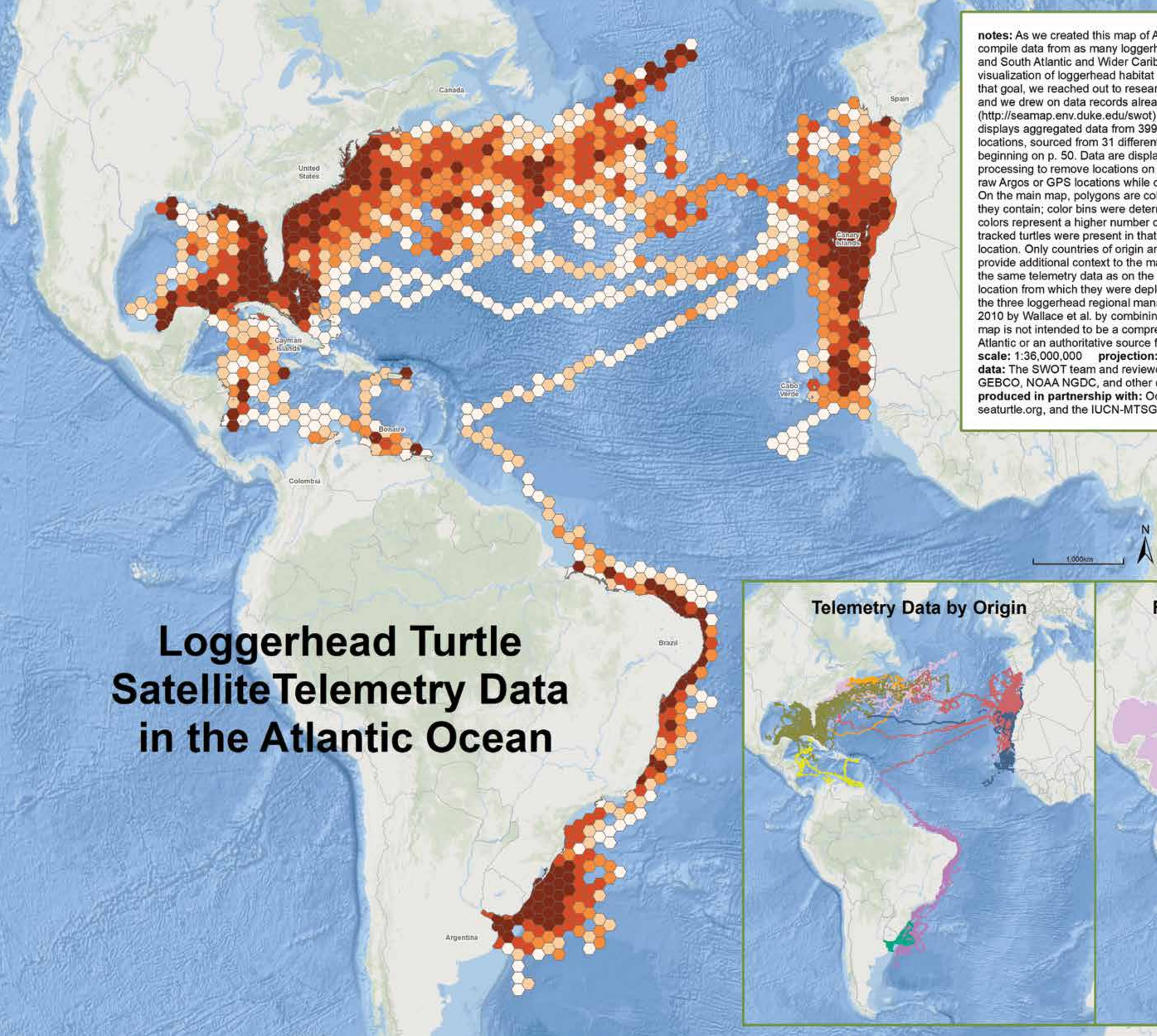
The international imperative for conserving sea turtles is most obvious when considering ubiquitous global threats. Climate change comes to mind, of course. But what are the implications for loggerheads? In short, climate change is expected to bring about widespread, abrupt, persistent changes in how marine ecosystems function (called ecological regime shifts). Those shifts will lead to altered growth rates, delays in graduation from life stages, and reduced population growth. Evidence for this cascade of effects comes from work on Atlantic sea turtles led by Karen Bjorndal. Her work revealed that somatic growth rates of loggerheads and two other sea turtle species throughout the region began to decline in the late 1990s as the result of an ecological regime shift. The decline continues to the present. Whether this environmental change is natural or anthropogenic matters not to our loggerheads. The result is the same—turtles endure risks for longer periods, delay their breeding, and contribute less to potential population growth. Do conservationists throw up their hands? No, they recognize the exigency and work harder.

Another daunting but crucial area of conservation work for loggerheads is management of global fisheries. Unlike climate-change solutions, resolving threats to fisheries requires sea turtles to play an inspirational role. Already, loggerheads and other sea turtles in the Atlantic are the impetus for global thought, local action, and global action. In the western Atlantic, the Inter-American Convention (IAC) for the Protection and Conservation of Sea Turtles, signed by 15 countries in the Americas and Caribbean, has provided a legal framework for protection as an intergovernmental treaty since 2001. And conservation diplomacy continues.

Recently, a South Atlantic Network was established, within which sea turtle biologists and conservationists in West Africa and South America exchange information and ideas. The latest development from this network is a loggerhead threats analysis conducted by colleagues in Argentina, Brazil, and Uruguay and will soon include West Africa. The work would build on a similar analysis developed by the Northwest Atlantic Loggerhead Turtle Recovery Team. Threat analyses like these will show where conservation action can be directed to provide the greatest benefit to loggerhead populations.

There is justifiable hope. Yes, Atlantic loggerheads suffer within the challenging "tragedy of the commons." The turtles are indeed a shared resource affected by individual users who act in their own self-interest and collectively behave contrary to the common good—in this case, by depleting the oceans' loggerheads. However, there are solutions to avoid the tragic outcome of such circumstances. They are the underlying goals of conservationists—cooperation and rule of law. To get there, to save our loggerheads, we'll need measurable progress on all fronts in the Atlantic region. Some will work toward advancing the conservation science. Others will work within the social sciences to understand required sociopolitical relationships. But we will also need guidance on the art of communication, of winning friends, and of generating influence. We are on our way. Go team! ■

Loggerhead Turtle Satellite Telemetry Data in the Atlantic Ocean



notes: As we created this map of Atlantic loggerhead satellite telemetry, our goal was to compile data from as many loggerhead turtles that have been satellite tracked in the North and South Atlantic and Wider Caribbean Region as possible. Thus we could create a visualization of loggerhead habitat use throughout the vast Atlantic Ocean. To accomplish that goal, we reached out to researchers throughout the region to invite their collaboration, and we drew on data records already within the SWOT online database (http://seamap.env.duke.edu/swot) and OBIS-SEAMAP database. This resulting map displays aggregated data from 399 individual loggerhead turtles and a total of 250,956 locations, sourced from 31 different projects. For complete details, see the data citations beginning on p. 50. Data are displayed as given by the providers and with minimal processing to remove locations on land and visual outliers. Therefore, some tracks are raw Argos or GPS locations while others have been more extensively filtered or modeled. On the main map, polygons are colored according to the number of loggerhead locations they contain; color bins were determined by splitting the count data into quintiles. Darker colors represent a higher number of locations, which can indicate that a high number of tracked turtles were present in that location or that turtles spent a lot of time in that location. Only countries of origin are labeled in the map.The maps below are intended to provide additional context to the main map. Below left, "Telemetry Data by Origin" displays the same telemetry data as on the main map but as individual tracks, color-coded by the location from which they were deployed. Below right, "Regional Management Units" shows the three loggerhead regional management units (or subpopulations) that were defined in 2010 by Wallace et al. by combining telemetry, genetics, tagging, and nesting data. This map is not intended to be a comprehensive representation of all telemetry data for the Atlantic or an authoritative source for the studies cited.

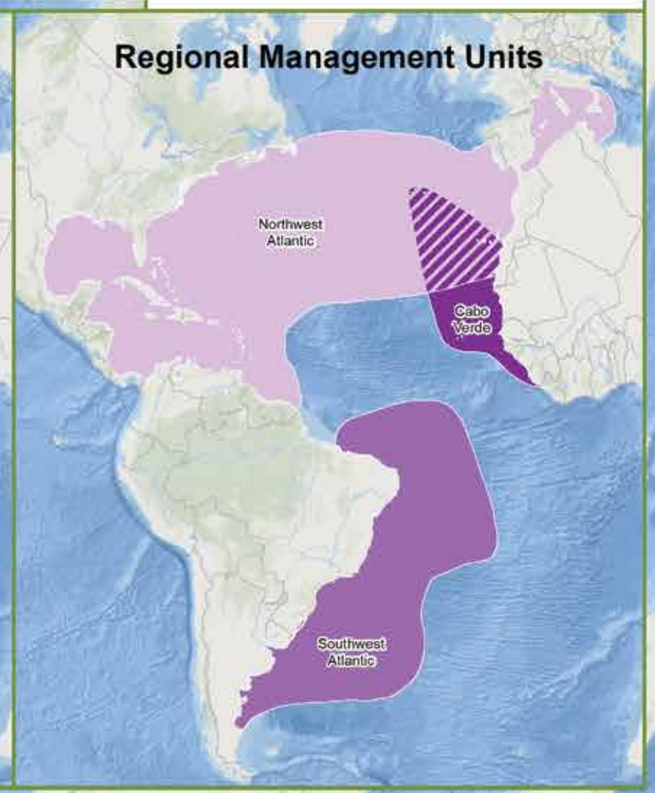
scale: 1:36,000,000 **projection:** World Polyconic (central meridian—50W)

data: The SWOT team and reviewed literature; Ocean Basemap—Esri, DeLorme, GEBCO, NOAA NGDC, and other contributors.

produced in partnership with: Oceanic Society, Duke University, OBIS-SEAMAP, seaturtle.org, and the IUCN-MTSG

count of locations
- 1–6
- 7–18
- 19–44
- 45–116
- 117–25k
- country borders

tagging origin
- Argentina
- Brazil
- Canada
- Canary Islands / Spain
- Cabo Verde
- Caribbean
- Florida / Gulf of Mexico
- U.S. Mid-Atlantic



SWOT Data Citations

LOGGERHEAD TURTLE SATELLITE TELEMETRY IN THE ATLANTIC OCEAN

The following data records refer to satellite telemetry datasets from tags that were deployed on loggerhead turtles in the Atlantic Ocean and were combined to create the maps on pp. 18–19. They are organized by country of deployment. For information regarding data processing and filtering, see the note on the map on p. 19. These data were generously contributed to SWOT by the people and partners listed subsequently. Records that have a SWOT ID can be viewed in detail in the SWOT online database and mapping application at http://seamap.env.duke.edu/swot, which contains additional information about the projects and their methodologies.

To save space, we have used the following abbreviations in the data source fields below: (1) "STAT" refers to Coyne, M. S., and B. J. Godley. 2005. Satellite Tracking and Analysis Tool (STAT): An integrated system for archiving, analyzing, and mapping animal tracking data. *Marine Ecology Progress Series* 301: 1–7; (2) "SWOT Online Database" refers to Kot, C. Y., E. Fujioka, A. DiMatteo, B. P. Wallace, B. J. Hutchinson, J. Cleary, P. N. Halpin, and R. B. Mast. 2015. The State of the World's Sea Turtles Online Database: Data provided by the SWOT Team and hosted on OBIS-SEAMAP. Oceanic Society, IUCN Marine Turtle Specialist Group, and Marine Geospatial Ecology Lab, Duke University. http://seamap.env.duke.edu/swot; and (3) "OBIS-SEAMAP" refers to Halpin, P. N., A. J. Read, E. Fujioka, B. D. Best, B. Donnelly, L. J. Hazen, C. Kot, K. Urian, E. LaBrecque, A. DiMatteo, J. Cleary, C. Good, L. B. Crowder, and K. D. Hyrenbach. 2009. OBIS-SEAMAP: The world data center for marine mammal, sea bird, and sea turtle distributions. *Oceanography* 22(2): 104–115. When listed, these sources indicate that the dataset was contributed online through STAT, SWOT, or OBIS-SEAMAP.

ARGENTINA

DATA RECORD 1

Metadata: 6 *Caretta caretta*; tags deployed in Argentina.
Source: González Carman, V., I. Bruno, S. Maxwell, K. Álvarez, D. Albareda, E. M. Acha, and C. Campagna. 2016. Habitat use, site fidelity and conservation opportunities for juvenile loggerhead sea turtles in the Río de la Plata, Argentina. *Marine Biology* 163: 1–13.
SWOT Contact: Carman González

BRAZIL

DATA RECORD 2

Metadata: 19 juvenile *Caretta caretta*; tags deployed at sea.
Source: Mansfield, K. L., M. L. Mendilaharsu, N. F. Putman, M. A. G. dei Marcovaldi, A. E. Sacco, G. Lopez, T. Pires, and Y. Swimmer. 2017. First satellite tracks of South Atlantic sea turtle "lost years": Trans-equatorial and seasonal implications for population connectivity. *Proceedings of the Royal Society B* 284: 20171730.
SWOT Contact: Kate Mansfield

DATA RECORD 3

Metadata: 10 nesting *Caretta caretta*.
Source: Marcovaldi, M. Â., G. G. Lopez, L. S. Soares, E. S. H. M. Lima, J. C. A. Thome, and A. P. Almeida. 2010. Satellite-tracking of female loggerhead turtles highlights fidelity behavior in northeastern Brazil. *Endangered Species Research* 12: 263–272.
SWOT Contact: Neca Marcovaldi

DATA RECORD 4

Metadata: 13 *Caretta caretta*; tags deployed in Brazil.
Source: Marcovaldi, M. Â. 2018. Personal communication. In *SWOT Report—State of the World's Sea Turtles*, vol. XIV (2019).
SWOT Contact: Neca Marcovaldi

DATA RECORD 5 | SWOT ID: 951

Project Title: Brazil Trawl-Caught Turtles
Project Partners: Fisheries Bycatch Research Group, Projeto Tartarugas no Mar
Metadata: 5 juvenile and 3 adult *Caretta caretta*; tags deployed in 2013 and 2014.
Sources: (1) Monteiro, D. 2018. Brazil Trawl-Caught Turtles. Data downloaded from OBIS-SEAMAP (http://seamap.env.duke.edu/dataset/951) on December 4, 2018. **(2)** STAT. **(3)** OBIS-SEAMAP.
SWOT Contact: Danielle Monteiro

DATA RECORD 6 | SWOT ID: 1148

Project Title: Neonates Tagged Off Brazil
Project Partners: Fisheries Bycatch Research Group, TAMAR, NOAA, UCF
Metadata: 4 juvenile *Caretta caretta*; tags deployed in 2013.
Sources: (1) Swimmer, Y. 2017. Neonates tagged off Brazil. Data downloaded from OBIS-SEAMAP (http://seamap.env.duke.edu/dataset/1148) on December 4, 2018. **(2)** STAT. **(3)** OBIS-SEAMAP.
SWOT Contact: Yonat Swimmer

BONAIRE

DATA RECORD 7

Metadata: 5 female *Caretta caretta*; tags deployed on nesting turtles.
Sources: (1) Nava, M. I., and Sea Turtle Conservation Bonaire. 2019. Personal communication. In *SWOT Report—State of the World's Sea Turtles*, vol. XIV (2019). **(2)** Becking, L. E., M. J. A. Christianen, M. I. Nava, N. Miller, S. Willis, and R. P. van Dam. 2016. Post-breeding migration routes of marine turtles from Bonaire and Klein Bonaire, Caribbean Netherlands. *Endangered Species Research* 30: 117–124.
SWOT Contact: Mabel Nava

CABO VERDE

DATA RECORD 8 | SWOT ID: 346

Project Title: Cabo Verde (Proyecto Aegina): Males and Female
Project Partners: Instituto Canario de Ciencias Marinas (ICCM), Gobierno de Canarias; Instituto Nacional de Desenvolvimento das Pescas (INDP); Direcção Geral do Ambiente; Ministerio de Ambiente, Agricultura e Pescas of the Republic of Cabo Verde
Metadata: 3 adult *Caretta caretta*.
Sources: (1) Cruz, N. 2018. Cabo Verde (Proyecto Aegina): Males and female. Data downloaded from OBIS-SEAMAP (http://seamap.env.duke.edu/dataset/346) on December 4, 2018. **(2)** STAT. **(3)** OBIS-SEAMAP.
SWOT Contact: Nuria Cruz

DATA RECORD 9 | SWOT ID: 1442

Project Title: Cabo Verde: LIFE *Caretta caretta*
Project Partners: LIFE *Caretta caretta*
Metadata: 4 adult *Caretta caretta*; tags deployed in 1999.
Sources: (1) Cruz, N. 2018. Cabo Verde. Data downloaded from OBIS-SEAMAP (http://seamap.env.duke.edu/dataset/1442) on December 4, 2018. **(2)** STAT. **(3)** OBIS-SEAMAP.
SWOT Contact: Nuria Cruz

CANADA

DATA RECORD 10

Metadata: 11 *Caretta caretta*; tags deployed at sea.
Source: James, M., and Sea Turtle Unit, Fisheries and Oceans Canada. 2019. Personal communication. In *SWOT Report—State of the World's Sea Turtles*, vol. XIV (2019).
SWOT Contact: Mike James

CANARY ISLANDS

DATA RECORD 11 | SWOT ID: 496

Project Title: Canary Islands: OAG
Project Partners: Observatorio Ambiental Granadilla; Sociedad de Estudio de Cetáceos en el Archipiélago Canario (SECAC); Centro de Gestión de Biodiversidad (BIOGES), Departamento de Biología, Universidad de Las Palmas de Gran Canaria; Centro de Recuperación de Fauna Silvestre, Cabildo Insular de Gran Canaria (CRFS)
Metadata: 18 juvenile and 1 subadult *Caretta caretta*; tags deployed between 2008 and 2010.
Sources: (1) Machado, A. 2017. Canary Islands: OAG. Data downloaded from OBIS-SEAMAP (http://seamap.env.duke.edu/dataset/496) on December 4, 2018. **(2)** STAT. **(3)** OBIS-SEAMAP.
SWOT Contact: Antonio Machado

DATA RECORD 12 | SWOT ID: 347

Project Title: Islas Canarias (Proyecto Aegina): Juvenile Loggerheads
Project Partners: Instituto Canario de Ciencias Marinas (ICCM), Gobierno de Canarias; Instituto Nacional de Desenvolvimento das Pescas (INDP); Direcção Geral do Ambiente, Ministerio de Ambiente, Agricultura e Pescas of the Republic of Cabo Verde
Metadata: 11 juvenile *Caretta caretta*; tags deployed in 2006.
Sources: (1) Cruz, N. 2018. Islas Canarias (Proyecto Aegina): Juvenile loggerheads. Data downloaded from OBIS-SEAMAP (http://seamap.env.duke.edu/dataset/347) on December 4, 2018. **(2)** STAT. **(3)** OBIS-SEAMAP.
SWOT Contact: Nuria Cruz

DATA RECORD 13 | SWOT ID: 1444

Project Title: Canary Islands: LIFE *Caretta caretta*
Project Partners: LIFE *Caretta caretta*
Metadata: 10 juvenile *Caretta caretta*; tags deployed between 1998 and 2000.
Sources: (1) Cruz, N. 2018. Canary Islands. Data downloaded from OBIS-SEAMAP (http://seamap.env.duke.edu/dataset/1444) on December 4, 2018. **(2)** STAT. **(3)** OBIS-SEAMAP.
SWOT Contact: Nuria Cruz

DATA RECORD 14 | SWOT ID: 1801

Project Title: Juvenile Loggerheads: Canary Islands Reintroduction Program—ADS Biodiversidad
Project Partners: Asociación para el Desarrollo Sostenible y Conservación de la Biodiversidad (ADS Biodiversidad), Centre of Cabildo de Fuerteventura (Morro Jable)
Metadata: 5 juvenile *Caretta caretta*; individuals are 7–8 years old and have been reared in captivity; tags deployed at Cofete Beach.
Sources: (1) Cruz, N. 2018. Juvenile loggerheads: Canary Islands reintroduction program. Data downloaded from OBIS-SEAMAP (http://seamap.env.duke.edu/dataset/1801) on December 4, 2018. **(2)** STAT. **(3)** OBIS-SEAMAP.
SWOT Contact: Nuria Cruz

CAYMAN ISLANDS

DATA RECORD 15 | SWOT ID: 349

Project Title: Cayman Islands 2003: Loggerhead & Green Turtles
Project Partners: Marine Turtle Research Group, Cayman Islands Department of Environment
Metadata: 1 adult *Caretta caretta*; tag deployed July 2003.
Sources: (1) Blumenthal, J. 2018. Cayman Islands 2003: Loggerhead & Green Turtles. Data downloaded from OBIS-SEAMAP (http://seamap.env.duke.edu/dataset/349) on December 4, 2018. **(2)** STAT. **(3)** OBIS-SEAMAP.
SWOT Contact: Janice Blumenthal

DATA RECORD 16 | SWOT ID: 350

Project Title: Cayman Islands 2004: Loggerhead & Green Turtles
Project Partners: Marine Turtle Research Group, Cayman Islands Department of Environment
Metadata: 2 adult *Caretta caretta*; tags deployed in 2005 and 2006.
Sources: (1) Blumenthal, J. 2018. Cayman Islands 2004: Loggerhead & Green Turtles. Data downloaded from OBIS-SEAMAP (http://seamap.env.duke.edu/dataset/350) on December 4, 2018. **(2)** STAT. **(3)** OBIS-SEAMAP.
SWOT Contact: Janice Blumenthal

COLOMBIA

DATA RECORD 17 | SWOT ID: 1292

Project Title: Caribbean Colombian Sea Turtle Satellite Tracking
Project Partners: Sea Turtles and Mammal Conservation Program, UTADEO–Colombian Caribbean, Universidad Jorge Tadeo Lozano (UTADEO); Mundo Marino Aquarium, Museo del Mar Foundation
Metadata: 1 neonate, 1 juvenile, and 1 adult *Caretta caretta*; tags deployed in 2016, 2017, and 2018, respectively.
Sources: (1) Sea Turtles and Marine Mammal Conservation Program (ProCTMM). 2018. Caribbean Colombian Sea Turtle Satellite Tracking. Data downloaded from OBIS-SEAMAP (http://seamap.env.duke.edu/dataset/1292) on December 4, 2018. **(2)** STAT. **(3)** OBIS-SEAMAP.
SWOT Contact: ProCTMM

SPAIN

DATA RECORD 18 | SWOT ID: 1146

Project Title: Spain Tags Merged
Project Partners: Fisheries Bycatch Research Group, NOAA, Kai Submon, UNCW
Metadata: 1 adult, 5 juvenile, and 20 subadult *Caretta caretta*; tags deployed between 2008 and 2012.
Data Sources: (1) Swimmer, Y. 2017. Spain tags merged. Data downloaded from OBIS-SEAMAP (http://seamap.env.duke.edu/dataset/1146) on December 4, 2018. **(2)** STAT. **(3)** OBIS-SEAMAP.
SWOT Contact: Yonat Swimmer

DATA RECORD 19 | SWOT ID: 1401

Project Title: Conservación y Preservación de Tortugas Marinas
Project Partners: Fundación para la Conservación y Recuperación de Animales Marinos (CRAM), Universitat Politècnica de València
Metadata: 3 juvenile and 3 adult *Caretta caretta*; tags deployed in Tarragona, Spain, in 2016; dataset includes an adult male loggerhead that traveled across the Atlantic to waters east of Florida, U.S.A.
Data Sources: (1) Fundación para la Conservación y Recuperación de Animales Marinos (CRAM). 2019. Conservación y preservación de tortugas marinas. Data downloaded from OBIS-SEAMAP (http://seamap.env.duke.edu/dataset/1401) on December 4, 2018. **(2)** STAT. **(3)** OBIS-SEAMAP.

UNITED STATES OF AMERICA

DATA RECORD 20

Metadata: 3 *Caretta caretta*.
Source: Godfrey, M. 2018. Rehabilitated sea turtles from Topsail Island, North Carolina. Personal communication. In *SWOT Report—State of the World's Sea Turtles*, vol. XIV (2019).
SWOT Contact: Matthew Godfrey and Karen Beasley

DATA RECORD 21 | SWOT ID: 996

Project Title: North Carolina Rehabilitated Sea Turtle Monitoring Project
Project Partners: Karen Beasley Sea Turtle Rescue and Rehabilitation Center, North Carolina State University
Metadata: 2 subadult *Caretta caretta*; tags deployed in 2009 and 2013 on rehabilitated individuals.
Sources: (1) Coyne, M. 2017. North Carolina Rehabilitated Sea Turtle Monitoring Project. Data downloaded from OBIS-SEAMAP (http://seamap.env.duke.edu/dataset/996) on December 4, 2018. **(2)** STAT. **(3)** OBIS-SEAMAP.
SWOT Contact: Michael Coyne

DATA RECORD 22
Metadata: 17 juvenile *Caretta caretta*; tags deployed at sea.
Source: Mansfield, K. L., J. Wyneken., W. Porter, and J. Luo. 2014. First satellite tracks of neonate sea turtles redefine the "lost years" oceanic niche. *Proceedings of the Royal Society B* 281 (1781): 20133039.
SWOT Contact: Kate Mansfield

DATA RECORD 23
Project Partners: College of William and Mary, Virginia Institute of Marine Science
Metadata: 21 juvenile and 10 adult *Caretta caretta*.
Sources: (1) Mansfield, K. L., V. S. Saba, J. Keinath, and J. A. Musick. 2009. Satellite telemetry reveals a dichotomy in migration strategies among juvenile loggerhead sea turtles in the northwest Atlantic. *Marine Biology* 156: 2555–2570.
(2) Mansfield, K. L. 2006. Sources of mortality, movements and behavior of sea turtles in Virginia. Dissertation. College of William and Mary, Marine Science School, Virginia Institute of Marine Science, Gloucester Point, VA.
SWOT Contact: Kate Mansfield

DATA RECORD 24
Metadata: 127 *Caretta caretta*; tags deployed on nesting females.
Source: Tucker, T., and K. Mazzarella. 2018. Personal communication. In *SWOT Report—State of the World's Sea Turtles*, vol. XIV (2019).
SWOT Contact: Tony Tucker

DATA RECORD 25 | SWOT ID: 410
Project Title: Virginia Aquarium Stranding Response Program
Project Partners: Virginia Aquarium Stranding Response Program, Virginia Aquarium & Marine Science Center, Seaturtle.org
Metadata: 17 juvenile, 3 subadult, and 1 adult *Caretta caretta*; tags deployed between 2007 and 2016 on stranded turtles.
Sources: (1) Lockhart, G. 2018. Virginia Aquarium Stranding Response Program. Data downloaded from OBIS-SEAMAP (http://seamap.env.duke.edu/dataset/410) on December 4, 2018. **(2)** STAT. **(3)** OBIS-SEAMAP.
SWOT Contacts: Gwen Lockhart and Susan Barco

DATA RECORD 26 | SWOT ID: 978
Project Title: Virginia Aquarium Sea Turtle Research
Project Partner: Virginia Aquarium & Marine Science Center Foundation
Metadata: 1 adult, 7 subadult, and 2 unknown-life-stage *Caretta caretta*; tags deployed on wild-caught or by-caught individuals in 2013 and 2015.
Sources: (1) Barco, S. 2018. Virginia Aquarium Sea Turtle Research. Data downloaded from OBIS-SEAMAP (http://seamap.env.duke.edu/dataset/978) on December 4, 2018. **(2)** STAT. **(3)** OBIS-SEAMAP.
SWOT Contact: Susan Barco

DATA RECORD 27 | SWOT ID: 1018
Project Title: Virginia Aquarium and U.S. Navy Sea Turtle Research Project
Project Partners: Virginia Aquarium Research and Conservation Department; U.S. Fleet Forces Command, Naval Facilities Engineering Command (NAVFAC) Atlantic
Metadata: 1 adult, 4 juvenile, and 11 unknown-life-stage *Caretta caretta*; tags deployed between 2013 and 2015.
Sources: (1) Lockhart, G. 2018. Virginia Aquarium and U.S. Navy Sea Turtle Research Project. Data downloaded from OBIS-SEAMAP (http://seamap.env.duke.edu/dataset/1018) on December 4, 2018. **(2)** STAT. **(3)** OBIS-SEAMAP.
SWOT Contact: Gwen Lockhart

DATA RECORD 28 | SWOT ID: 655
Project Title: North Carolina Long-Term Sea Turtle Monitoring Project
Project Partners: Seaturtle.org, the North Carolina Wildlife Resources Commission, Duke University Marine Laboratory
Metadata: 8 adult *Caretta caretta*; tags deployed in 2010, 2012, and 2013.
Sources: (1) Coyne, M. 2017. North Carolina Long-Term Sea Turtle Monitoring Project. Data downloaded from OBIS-SEAMAP (http://seamap.env.duke.edu/dataset/655) on December 4, 2018. **(2)** STAT. **(3)** OBIS-SEAMAP.
SWOT Contact: Michael Coyne

DATA RECORD 29 | SWOT ID: 1342
Project Title: Florida Loggerhead Migrations
Project Partners: National Marine Fisheries Service Office of Protected Resources
Metadata: 38 adult *Caretta caretta*; tags deployed between 1998 and 2000.
Sources: (1) Schroeder, B. 2018. Florida Loggerhead Migrations. Data downloaded from OBIS-SEAMAP (http://seamap.env.duke.edu/dataset/1342) on December 4, 2018. **(2)** STAT. **(3)** OBIS-SEAMAP.
SWOT Contact: Barbara Schroeder

DATA RECORD 30 | SWOT ID: 1490
Project Title: Juvenile Loggerhead Use of the Gulf Stream off Cape Hatteras, NC
Project Partners: North Carolina Renewable Ocean Energy Program, Protected Resources Branch of the National Oceanic and Atmospheric Administration Beaufort Laboratory, University of North Carolina Coastal Studies Institute, North Carolina Aquariums at Pine Knoll Shores and Roanoke Island, University of Central Florida
Metadata: 3 juvenile *Caretta caretta*; headstarted turtles were originally collected from North Carolina nests. Tagged turtles released in Sargassum mats in the Gulf Stream off the coast of North Carolina in May 2017.
Sources: (1) Dubbs, L. 2017. Juvenile loggerhead use of the Gulf Stream off Cape Hatteras, NC. Data downloaded from OBIS-SEAMAP (http://seamap.env.duke.edu/dataset/1490) on December 4, 2018. **(2)** STAT. **(3)** OBIS-SEAMAP.
SWOT Contact: Lindsey Dubbs

MEDITERRANEAN

We are grateful to all who generously contributed their sea turtle data for inclusion in the maps on pages 28–29. For information about how the maps were created, please see page 26. We are especially grateful to Lucy Omeyer for her assistance in researching and compiling data from published and unpublished sources.

GUIDELINES OF DATA USE AND CITATION

The data that follow correspond directly to the maps on pages 28–29. In the case of nesting data, every data record is numbered to correspond with its respective point on the map. To use these data for research or publication, you must obtain permission from the data providers.

NESTING DATA CITATIONS

DEFINITIONS OF TERMS

Clutches: A count of the number of nests of eggs laid by females during the monitoring period. **Nesting females:** A count of nesting female turtles observed during the monitoring period. **Crawl:** A female turtle's emergence onto the beach to nest. Such counts may or may not include false crawls. **Year:** The year in which a given nesting season ended (e.g., data collected between late 2015 and early 2016 would be listed as year 2016).

Nesting data are reported here from the most recent available nesting season or as averages for the years reported. Beaches for which count data are not available are listed as "unquantified." A reported count of "N/A" indicates that no data were reported for that species at the respective site. Additional metadata are available for many of the data records and may be found online at http://seamap.env.duke.edu/swot or by viewing the original data source (if published).

ALBANIA

DATA RECORD 1
Data Source: Piroli, V., and I. Haxhiu. 2018. Nesting of loggerhead turtle (*Caretta caretta*) confirmed in Southeast Adriatic. In Lazar, B., and M. Jancic (eds.), *Book of Abstracts: 6th Mediterranean Conference on Marine Turtles*. Croatian Natural History Museum, Zagreb, Croatia.
Nesting Beaches: Divjaka, Kepi i Rodonit
Year: 2016
Species and Counts: *Caretta caretta*—1 clutch at each beach

CYPRUS

DATA RECORD 2
Data Source: Andrews, E. 2014. *Cyprus Turtlewatch 2014 Final Report*. University of Glasgow.
Nesting Beaches: Akrotiri, Episkopi
Year: 2014
Species and Counts: *Chelonia mydas*—2 and 0 clutches, respectively; *Caretta caretta*—89 and 17 clutches, respectively

DATA RECORD 3
Data Source: Broderick, A. 2017. Loggerhead nesting in Cyprus. Personal communication. In *SWOT Report—State of the World's Sea Turtles*, vol. XIV (2019).
Nesting Beaches: (1) Alagadi, **(2)** Ayphilon, **(3)** Balalan, **(4)** Dipkarpaz South, **(5)** Dolphin, **(6)** Doune, **(7)** Esentepe, **(8)** Golden, **(9)** Greenfields 1, **(10)** Greenfields 2, **(11)** Guzelyali, **(12)** Kantara, **(13)** Kaplica, **(14)** Lost, **(15)** Melons 1, **(16)** Melons 2, **(17)** Message in a Bottle, **(18)** Military, **(19)** Monster, **(20)** Monster North, **(21)** One Goat, **(22)** Peach, **(23)** Ronnas, **(24)** Secret, **(25)** Smalls, **(26)** Tatlisu, **(27)** Thyme, **(28)** Two House, **(29)** West 1 and 2, **(30)** Wolf 1, **(31)** Wolf 2, **(32)** Tatlisu Belediya
Year: 2017
Species and Counts: *Caretta caretta*—**(1)** 42, **(2)** 1, **(3)** 0, **(4)** 1, **(5)** 5, **(6)** 0, **(7)** 0, **(8)** 8, **(9)** 0, **(10)** 0, **(11)** 36, **(12)** 5, **(13)** 8, **(14)** 3, **(15)** 0, **(16)** 1, **(17)** 8, **(18)** 0, **(19)** 37, **(20)** 26, **(21)** 1, **(22)** 7, **(23)** 6, **(24)** 32, **(25)** 6, **(26)** 20, **(27)** 4, **(28)** 0, **(29)** 46, and **(30–32)** 0 clutches; *Chelonia mydas*—**(1)** 221, **(2)** 74, **(3)** 0, **(4)** 36, **(5)** 32, **(6)** 12, **(7)** 1, **(8)** 42, **(9)** 0, **(10)** 0, **(11)** 0, **(12)** 1, **(13)** 2, **(14)** 31, **(15)** 15, **(16)** 20, **(17)** 42, **(18)** 0, **(19)** 14, **(20)** 8, **(21)** 5, **(22)** 9, **(23)** 283, **(24)** 4, **(25)** 0, **(26)** 2, **(27)** 15, **(28)** 1, **(29)** 43, **(30)** 15, **(31)** 17, and **(32)** 0 clutches

DATA RECORD 4
Data Sources: (1) Casale, P., A. Broderick, J. A. Camiñas, L. Cardona, C. Carreras, A. Demetropoulos, W. J. Fuller, B. J. Godley, S. Hochscheid, Y. Kaska, B. Lazar, D. Margaritoulis, A. Panagopoulou, A. F. Rees, J. Tomás, and O. Türkozan. 2018. Mediterranean sea turtles: Current knowledge and priorities for conservation and research. *Endangered Species Research* 36: 229–267. **(2)** Demetropoulos, A., and M. Hadjichristophorou. 2010. Cyprus-Region B. In Casale, P., and D. Margaritoulis (eds.), *Sea Turtles in the Mediterranean: Distribution, Threats and Conservation Priorities*, pp. 53–64. IUCN, Gland, Switzerland.
Nesting Beaches: Chrysochou Bay, West Coast
Years: 2011–2015
Species and Counts: *Caretta caretta*—658 and 249 average clutches per year, respectively; *Chelonia mydas*—N/A and 108 average clutches per year, respectively

EGYPT

DATA RECORD 5
Data Source: Clarke, M., A. C. Campbell, C. Simms, and W. S. Hameid. 2002. Observations on the ecology of marine turtles nesting on the Mediterranean coast of Egypt. In Mosier, A., A. Foley, and B. Brost (compilers), *Proceedings of the Twentieth Annual Symposium on Sea Turtle Biology and Conservation*, pp. 257–258. NOAA Technical Memorandum NMFS-SEFSC-477, National Marine Fisheries Service, Miami, FL.
Nesting Beaches: Beaches between Rhafa and Port Said
Year: 1999
Species and Counts: *Caretta caretta*—27 clutches

FRANCE

DATA RECORD 9
Data Source: Sénégas, J.-B., S. Hochscheid, J.-M. Groul, B. Lagarrigue, and F. Bentivegna. 2009. Discovery of the northernmost loggerhead sea turtle (*Caretta caretta*) nest. *Marine Biodiversity Records* 2: 1–4.
Nesting Beach: St. Elme (St. Tropez)
Year: 2006
Species and Counts: *Caretta caretta*—1 clutch
SWOT Contact: Flegra Bentivegna

DATA RECORD 10
Data Source: Delaugerre, M., and C. Cesarini. 2004. Confirmed nesting of the loggerhead turtle in Corsica. *Marine Turtle Newsletter* 142: 17–18.
Nesting Beach: Palombaggia (Corsica)
Year: 2002
Species and Counts: *Caretta caretta*—1 clutch
SWOT Contact: Michel Delaugerre

GREECE

DATA RECORD 11
Data Source: Casale, P., A. Broderick, J. A. Camiñas, L. Cardona, C. Carreras, A. Demetropoulos, W. J. Fuller, B. J. Godley, S. Hochscheid, Y. Kaska, B. Lazar, D. Margaritoulis, A. Panagopoulou, A. F. Rees, J. Tomás, and O. Türkozan. 2018. Mediterranean sea turtles: Current knowledge and priorities for conservation and research. *Endangered Species Research* 36: 229–267.
Nesting Beach: Southern Kyparissia Bay
Years: 2013–2015
Species and Counts: *Caretta caretta*—1,403 average clutches per year

DATA RECORD 12
Data Source: Casale, P., and D. Margaritoulis (eds.). 2010. *Sea Turtles in the Mediterranean: Distribution, Threats and Conservation Priorities*. IUCN, Gland, Switzerland.
Nesting Beaches: (1) Bay of Chania, **(2)** Bay of Messara, **(3)** Beaches adjacent to Kyparissia Town, **(4)** Koroni, **(5)** Kos Island, **(6)** Kotychi, **(7)** Lakonikos, **(8)** Lefkas Island
Year: 2010
Species and Counts: *Caretta caretta*—**(1–6)** 50–100, **(7)** >100, and **(8)** 50–100 average clutches per year

DATA RECORD 13
Data Source: Comis, C., and N. Vallianos. 2014. Loggerhead nesting in Kefalonia, Greece. Personal communication. In *SWOT Report—State of the World's Sea Turtles*, vol. XIV (2019).
Nesting Beaches: (1) Kalamia, **(2)** Agia Kyriaki, **(3)** Agios Georgios, **(4)** Agios Ioannis, **(5)** Ai Chelis,