SWOT report
The State of the World’s Sea Turtles
Volume XV

SPECIAL FEATURE
Sea Turtles of the Caribbean

INSIDE:
INDIAN OCEAN LOGGERHEADS
DRONES FOR CONSERVATION
JAGUARS
AND MORE ...
Editor’s Note

No Sea Turtle Is an Island

Wise men and women throughout history have shown us that, “there is power in unity and there is power in numbers” (Martin Luther King Jr., 1963). That is certainly the case with the State of the World’s Sea Turtles (SWOT) program, the world’s largest volunteer network of sea turtle researchers, conservationists, and enthusiasts. This volume of SWOT Report unifies an enormous cast: from the hundreds of researchers in more than 20 countries, whose collective efforts can be seen in the first-ever global-scale map of loggerhead sea turtle telemetry (pp. 32–33), to the beach workers from the Wider Caribbean Sea Turtle Conservation Network (WIDECAST) and beyond, whose labors are seen in this issue’s maps of sea turtle biogeography (pp. 24–27).

As you peruse these cartographic works of art, reflect for a moment on the time, effort, and passion that went into each of those tiny, tinted polygons of telemetry data or the myriad multicolored circles of nest abundance. Together they represent the labors of a multitude of beach workers, synergistically amassed to bring big-picture visualizations of sea turtle natural history to life as never before. As the famous saying goes, “No man is an island,” and when our personal efforts are bridged and bound to one another by a common vision, the results have global-scale impacts far beyond the sum of the individual contributions.

And no sea turtle is an island either. Sea turtles are tiny threads in an immeasurably complex tapestry of global biodiversity. We’ve seen some encouraging reports of stable and even growing sea turtle populations in recent years, reflected in the improved status of some on the IUCN (International Union for Conservation of Nature) Red List of Threatened Species. Yet we must never forget that permanent recovery of sea turtles can be ensured only when all the threads of a turtle’s existence are intact; when the oceans are healthy; and when nesting beaches, seagrass pastures, coral reefs, and migratory pathways remain safe and usable.

It was 65°F (18.3°C) in Antarctica as I wrote this, and an iceberg twice the size of Washington, DC, just broke off the Pine Island glacier there. Australia is reeling from devastating fires. Antiquated fishing techniques and management are pushing fish stocks to the brink of extinction and incidentally killing millions of turtles, seabirds, and marine mammals. All age classes of sea turtles everywhere are ingesting plastics. Drastic weather, rising and warming seas, and human development of once pristine ecosystems have become the norm. The tapestry is rapidly becoming threadbare.

So it is urgent that we now focus on saving not only sea turtles, but also the seas that sustain them. Changing the countless human behaviors that threaten the oceans is a complicated challenge, but it begins with a simple question—“How can I do better?” I urge our global “SWOT Team” to ask that question, begin the conversation, and use the power of our numbers and unity to move the needle on ocean health.

Roderic B. Mast
Chief Editor
meet the turtles

The seven sea turtle species that grace our oceans belong to an evolutionary lineage that dates back at least 110 million years. Sea turtles fall into two main subgroups: (a) the unique family Dermochelyidae, which consists of a single species, the leatherback, and (b) the family Cheloniidae, which comprises the six species of hard-shelled sea turtles.

Olive ridley (Lepidochelys olivacea)
IUCN Red List status: Vulnerable

Hawksbill (Eretmochelys imbricata)
IUCN Red List status: Critically Endangered

Leatherback (Dermochelys coriacea)
IUCN Red List status: Vulnerable

Kemp’s ridley (Lepidochelys kempii)
IUCN Red List status: Critically Endangered

Flatback (Natator depressus)
IUCN Red List status: Data Deficient

Loggerhead (Caretta caretta)
IUCN Red List status: Vulnerable

Green (Chelonia mydas)
IUCN Red List status: Endangered

Olive ridley (Lepidochelys olivacea)
IUCN Red List status: Vulnerable

Visit [www.SeaTurtleStatus.org](http://www.SeaTurtleStatus.org) to learn more about all seven sea turtle species!
Editor’s Note: No Sea Turtle Is an Island  |  3
Meet the Turtles  |  4

RESEARCH AND STATUS
Drones in Sea Turtle Conservation: The Sky Is the Limit  |  6
Do Sea Turtles See the Light? Developing Solar-Powered Illuminated Nets to Reduce Sea Turtle Bycatch  |  8
Where Turtles Meet Jaguars  |  12

SPECIAL FEATURES
Sea Turtles of the Caribbean  |  14
Feature Map: Nesting Biogeography of Sea Turtles in the Wider Caribbean  |  24
Feature Map: Sea Turtle Satellite Telemetry Data in the Wider Caribbean  |  26
Indian Ocean Loggerheads  |  28
Map: Global Loggerhead Turtle Satellite Telemetry  |  32

POLICY AND ECONOMICS
Changing the Future for Colombia’s Sea Turtles  |  34
Turtles Help Tackle Ocean Plastic Pollution in Europe  |  36

OUTREACH AND ACTION
Top Smartphone Apps for Sea Turtle Work  |  38
FAQs about Sea Turtles  |  40

THE SWOT TEAM
Acting Globally: SWOT Small Grants 2019  |  42
SWOT Data Citations  |  46
In Memoriam and Acknowledgments  |  54
Authors and Affiliations  |  55
Recent advances in drone technology—also called unmanned aerial vehicles (UAVs) or unmanned aircraft systems (UASs)—have made such devices increasingly cost-effective, easy to operate, and widely accessible. Alongside many other tools and techniques, drones are transforming sea turtle conservation and research. Yet even with drone technology advancing quickly, we have only begun to scratch the surface of its potential.

CURRENT USES OF DRONES IN SEA TURTLE CONSERVATION

A number of sea turtle studies involving drones have been published in the scientific literature since 2015, and they provide a range of novel insights. Drone studies carried out on sea turtles have primarily focused on obtaining estimates of population abundance, distribution, and density by using aerial imagery to count nesting females, their tracks or nests, or turtles in the water. To date, these studies have primarily taken place in breeding areas, where sea turtles predictably gather in large numbers in accessible, nearshore waters. From the initial, more basic studies that monitored turtles in the water and recorded behavior, drone research has progressed to collect increasingly advanced data. Some examples include (1) identifying the operational sex ratios of turtles gathering at the start of a breeding season or (2) incorporating semiautomatic counts of turtles aggregating offshore at an arribada (mass nesting) beach using artificial intelligence.

Although drones come in many different styles, shapes, and sizes, relatively small fixed-wing and rotary-wing aircraft are the types that are most frequently used for sea turtle research. Larger drones can be equipped with larger, heavier sensors such as compact thermal vision cameras, hyperspectral sensors, and laser scanning devices such as LiDAR (Light Detection and Ranging).

Beyond drones’ use in studying sea turtles themselves, drones were recently used to model a sea turtle population’s nesting beach using photogrammetry. Photogrammetry is the computationally intense process of generating detailed three-dimensional (3D) models from a series of overlapping images, whereby the relative location of different points on the various images are used to determine the shape of the photographed subject. Researchers created very accurate 3D models of sea turtle nesting beaches with less than 15 centimeters (6 inches) of elevation error. They then projected different sea-level rise scenarios resulting from climate change onto the model to estimate habitat loss caused by flooding and to assess the potential for the beach to retreat in the future. Such 3D models can also be updated yearly to detect patterns of coastal erosion, to better understand beach dynamics, and to ultimately predict how the habitat may shift over the next 50 or 100 years.

FUTURE DIRECTIONS FOR DRONES IN SEA TURTLE CONSERVATION

Drones carrying lightweight cameras and even multispectral sensors can provide professional mapping at a fraction of the cost of previous photogrammetric techniques that required piloted aircraft. Such studies can also be combined with information about sea turtle population sex ratios and remotely sensed surface temperatures to predict new suitable (and unsuitable) areas for nesting in the coming decades. By integrating research that predicts suitable nesting areas into coastal planning, we can better understand which areas should be protected from coastal development to make sure suitable sea turtle nesting habitats will be available as the impacts of climate change progress.

Other exciting innovations that have come about recently include the use of fluid lensing, an experimental algorithm that uses light wavelengths that transmit through water to analyze submarine structures and thereby create detailed underwater maps that are accurate to within a centimeter. The principle is the same as in the
photogrammetry study mentioned earlier, but fluid lensing technology makes it possible to map underwater habitat rather than beach habitat. Such maps could be used to monitor foraging areas used by sea turtles during their nesting period or to monitor known shallow, nonbreeding areas. Thus, they could help answer a range of research questions, such as why sea turtles prefer a particular area over another or how and why different species select certain habitats. When combined with other data types, for example, information from the remote tracking of sea turtles and fishing vessels, such underwater habitat mapping could provide a new understanding of threats to turtles, such as how they interact with local small-scale fisheries. Although this technology is too costly to be used widely today, the same could have been said about the use of drones just 10 years ago!

Another new and rapidly developing technique combines off-the-shelf drones with artificial intelligence to detect animals or objects in near real time. Data are interpreted while they are gathered through synchronization with a live video stream. The system is capable of working on a wide variety of devices, from cell phones to desktop computers, because it requires an extremely low frame rate of just two frames per second to accurately detect objects. It has been tested already with rhinoceroses and cars for different conservation-related purposes, but it has not yet been used for sea turtle conservation. Although this technology is too costly to be used widely today, the same could have been said about the use of drones just 10 years ago!

Despite the growing capabilities of drones in terms of sensor quality and flight times, some big challenges must also be overcome:

- **Data processing and storage.** The geospatial, imagery, and other sensor data collected by a drone can quickly grow to very large file sizes.
- **Costs.** Licenses for specialized processing software can be expensive.
- **Legal constraints.** Restrictions on the use of drones vary from location to location and include visual line of site obligations, no-fly zones, and so on.
- **Adverse weather conditions.** Drones can’t safely operate in bad weather, thus limiting their usability for certain tasks.

The combination of technological advances and the inventiveness of researchers will no doubt lead to more and more uses for drones in sea turtle conservation and research over the years ahead. When it comes to using drones in sea turtle conservation, the sky is the limit!
DO SEA TURTLES SEE THE LIGHT?

DEVELOPING SOLAR-POWERED ILLUMINATED NETS TO REDUCE SEA TURTLE BYCATCH

By Jesse Senko, Agnese Mancini, Mark Bailly, Jennifer Blain Christen, Lekelia Jenkins, and John Wang
small-scale or coastal fisheries are vital for food supply, food security, nutrition, income, and livelihoods worldwide. However, both overfishing and incidental catch (bycatch) of nontarget species in coastal fisheries can jeopardize their long-term viability and create problems for threatened species and sensitive habitats, as well as for the coastal communities that depend on those fisheries. Bycatch of sea turtles in gillnet and entangling net fisheries has been linked to declines in sea turtle populations worldwide and has also led to costly closures of fisheries in coastal communities that have few economic alternatives.

Unlike studies of industrial-scale fisheries, limited research has been done to evaluate bycatch and develop technologies that reduce bycatch impacts in coastal fisheries. But that is beginning to change. Recent research has found that net illumination—using battery-powered light-emitting diodes (LEDs) or chemical lightsticks—is capable of reducing bycatch of sea turtles (by 40–74 percent) as well as small cetaceans (by 70 percent) and seabirds (by 85 percent) in coastal net fisheries at night while maintaining catch rates of target fish species. Although the exact reasons why this technology is effective are not yet known, net illumination is believed to provide a visual cue that alerts sea turtles and other nontarget species to the presence of nets or otherwise deters them.

Testing of net illumination has expanded into multiple coastal fisheries worldwide, but broader implementation has been hindered by the lack of a sustainable method to illuminate nets that addresses energy demands, as well as a design that matches the specific needs of gillnet fishers. In particular, light levels in LEDs that are currently used begin to diminish after a few weeks of continual use, and the energy demand means that batteries must be changed monthly to maintain their effectiveness in reducing bycatch. This results in high costs for coastal fishers as well as environmental concerns over battery disposal. For example, LEDs used in previous bycatch-reduction research used two AA batteries per LED. One gillnet fishing vessel with 1 kilometer length of net with LEDs spaced every 10 meters would use 100 LEDs, so 200 AA batteries would be needed for every change of batteries. Moreover, previously tested designs of LED lights were not optimized for net fishery operations, causing frequent snags and weighing down the net.

 DEVELOPING SOLAR-POWERED NET ILLUMINATION
To address the challenges associated with current net illumination technology, we partnered with coastal fishers to develop a novel way to illuminate nets by harvesting renewable energy. Involving fishers in developing new gear and practices is an important step toward achieving fisher adoption and compliance of bycatch reduction technologies. Indeed, the most widely adopted gear modifications in commercial fisheries were developed by, or with strong input from, local fishers. Thus, in January 2018, we held our first of three workshops with local fishery leaders from northwestern Mexico to discuss developing a renewable-powered solution.

At the beginning, we considered both mechanical and solar energy sources. All of the mechanical energy designs that did not risk failure because of biofouling (for example, turbines) had low power outputs that precluded them from generating a reasonable intensity of light. We therefore chose to use photovoltaics, which have no moving parts, provide high power output compared with other renewable energy sources, and require little human intervention to operate effectively. However, we still needed to design a system that effectively oriented the solar cells, as well as establish a flash rate for the LEDs that would minimize energy consumption while still deterring sea turtles.

First, we decided to mimic the design of a float line buoy. The idea came from the first fisher
workshop we held, where several fishers suggested we build a lighted buoy. The light is designed to be threaded onto the float line of a gillnet and is buoyant just like a traditional buoy. This method seamlessly integrates the technology into existing fishing gear, making it easy to use and therefore improving the likelihood that fishers would adopt it. Because the light system also functions as a buoy, it can offset the costs of actual buoys, which make up about 20 percent of the total cost of building a gillnet.

Second, to design a light that could remain illuminated longer than 12 to 24 hours without needing to be charged, we needed to make the light flash intermittently. We chose a moderate flash rate that we believed would still effectively illuminate the net for sea turtles—a flash rate between an emergency light and a street sign or roadwork light. The light that we developed can self-charge in sunlight and can be programmed to automatically emit either static or flashing light. Depending on the configuration, it can remain charged for up to one week after 30 to 60 minutes of charging in direct sunlight.

We chose a clear cylinder shape to house the LEDs because it required the least amount of change from a tube, which is similar to the midsection of a traditional float line buoy. This shape was also the most conducive to solar panel integration, and the end pieces of each tube were designed to create a shock absorbing effect. In contrast to existing LEDs, which require a complex locking mechanism to replace batteries, our design is sealed and can run for years without opening.

Instead of the AA batteries that are used in current LED-illuminated net designs, we used rechargeable cells that can hold more than 500 charge cycles, with a lifetime cost of roughly 1 cent per charge. This choice substantially reduces costs over nonrechargeable cells, particularly over an entire fishing season. Converting from AA battery power to solar also made the whole unit considerably lighter, and it eliminated the need for a sealed release mechanism, which can be difficult to maintain, and often has a cumbersome waterproof seal that needs to be opened and resealed with each battery exchange. Moreover, placing the LEDs in a buoy allowed us to substitute high-efficiency green LEDs that consume less power at the same light output.

STUDYING HOW SEA TURTLES REACT TO SOLAR-POWERED LIGHTED BuoYS

Following the design phase, during the summer of 2019 we tested the solar-powered buoys with flashing green lights. For the test, we chose entangling net fisheries off the Gulf of California coast of Baja California Sur, Mexico. Initial field experiments found that the solar-powered illuminated nets significantly reduced sea turtle bycatch rates, by 65 percent at night, a finding that is in line with previous studies of net illumination that used battery-powered, static green light. Most importantly, these field tests showed that the flashing lights also reduced sea turtle bycatch, a necessary step for harvesting solar energy and eliminating the need to actively recharge or change the lights. Overall, our fisher partners were pleased with how the lights performed. We are excited by these preliminary results, which suggest that solar-powered net illumination and the use of flashing lights represent a promising solution for mitigating sea turtle bycatch, with global applicability for passive net fisheries.

To further evaluate the viability of the solar-powered buoys, we plan on testing the lights’ effects on target fish catch and composition during the spring of 2020.

FUTURE DIRECTIONS

Now that we have developed a solar-powered light with a flash rate that is energy efficient and reduces sea turtle bycatch, we are working to make solar-powered net illumination more accessible on a global scale. This next phase includes partnering with industry and fishing communities to develop a range of improved lights that can be tested in global sea turtle bycatch hotspots and eventually implemented at scale. These lights will leverage new, high-efficiency solar cells that are being developed by Arizona State University’s Solar Power Laboratory for SpaceX and NASA. Given their paper-thin width, light weight, and durability, these cells may allow us to develop a more streamlined buoy that is 30 percent to 50 percent smaller than the existing buoys while maintaining their current efficiency.
Sea turtles and jaguars are both flagship species, important icons for the conservation of oceans and tropical forests, respectively. However, where tropical forests come in contact with beaches in the Americas, jaguars sometimes prey on nesting sea turtles, which presents an unusual conservation challenge involving both animals.

Although such interactions have certainly occurred for millennia, the first published report of a jaguar attack on a sea turtle came from Suriname in 1963 at Bigisanti Beach in the Wia Wia Nature Reserve, where jaguars attacked green, olive ridley, and leatherback turtles. In the mid-1970s, jaguars were also reported to kill nesting leatherbacks in French Guiana and Guyana. The first reports of jaguar predation on sea turtles in Central America came from Costa Rica in the 1980s, specifically in Tortuguero National Park and Pacuare Nature Reserve in the Caribbean, as well as in Santa Rosa National Park (Nancite Beach) and Corcovado National Park in the Pacific. Elsewhere in the Americas, jaguar predation of sea turtles has been documented only in Mexico’s Yucatán Peninsula.

Directly observing jaguar behavior can be difficult because of their elusive nature. Camera traps simplify such studies; they are not intrusive, the technology is inexpensive, and they produce high-quality visual data. For those reasons, we were able to conduct a 10-year study (2010–2020) using infrared camera traps to document the deadly nighttime juxtaposition of these two flagship species at the interface of terrestrial and marine wilderness in a remote corner of Costa Rica.

The Guanacaste Conservation Area (Área de Conservación Guanacaste, or ACG) in the Pacific Northwest of Costa Rica encompasses Santa Rosa, Rincón de la Vieja, and Guanacaste National Parks. Lands that once were used for livestock and agriculture and subjected to large-scale deforestation and unregulated hunting were, in 1971, gradually consolidated into 43,000 hectares of terrestrial protected area and 12,000 hectares of marine protected area (166 square miles and 46 square miles, respectively) that now make up the ACG. Its 110 kilometers (68 miles) of coastline has nine sandy beaches, including Nancite Beach, one of only a handful of sites worldwide where olive ridley arribadas occur (SWOT Report, vol. X, pp. 18–23). Because the ACG’s beaches are remote—some of them
can be accessed only by boat—the resulting absence of human activities has allowed wildlife to flourish.

Jaguars, which are largely nocturnal, are the keystone predators in the ACG. Solitary animals for most of their lives, jaguars are rarely seen together, interacting only as family groups (cubs stay with their mother for usually two years) or coming together for courtship and mating.

When night falls on the ACG, lone jaguars patrol the beach in search of nesting sea turtles. While hunting, they often take breaks to sit or lie down for anywhere from a few minutes to several hours. When a jaguar discovers a nesting sea turtle, it usually attacks with a crushing bite to the head or neck that kills the animal instantly. The jaguar will then drag the carcass into the vegetation by biting the head, neck, or flippers and walking backward or by lifting it slightly and walking forward. Occasionally jaguars will drag their prey up to 300 meters (328 yards) inland! Jaguars do not eat the whole turtle at once; rather they consume part of the animal and then return later that night or over a period of several nights. At Nancite Beach, one jaguar was observed returning for five consecutive nights to feed on the same carcass!

When the jaguars abandon their kill, researchers can then enter to set up two or three camera traps, positioned to observe the animals as they gather to eat. Individual jaguars can easily be identified by the rosettes in their coat, or pelage; no two jaguars are alike, with unique patterns that are much like fingerprints. By observing these feeding events and comparing images to an existing database, researchers can rapidly develop an understanding of group structure and dynamics.

This study reveals jaguar social behavior that has been reported in only a very few locations across the Americas. For example, multiple unrelated jaguars feeding from the same carcass have now been recorded, including one observation where three different individuals (two of them males) shared a single carcass at the same time. And scenes have been documented of mothers teaching their cubs how to hunt and eat sea turtles.

CAN JAGUARS AND SEA TURTLES COEXIST?

Since 2010, at Nancite Beach (less than 1 kilometer, 0.6 miles, of shore), jaguar predations on sea turtles have averaged between 20 and 50 per year, and the project has identified around 20 individual jaguars. Although some may view these high numbers of jaguars as a reason for concern, the actual number of turtles killed represents less than 1 percent of the local nesting population. Between 2014 and 2019, an average of 37,000 sea turtles nested annually, but jaguars killed only 140. This finding suggests that sea turtles and jaguars can continue to coexist on Nancite Beach, demonstrating how both marine and terrestrial conservation efforts are linked to secure long-term survival of species and their habitats.
SEA TURTLES of the Caribbean
he countless tranquil beaches of the Caribbean, with their gently lapping waves and fringing palm trees, give the feeling of permanence. Although you could be excused for thinking that these ecosystems—and their sea turtle inhabitants—have remained largely untouched for millennia, this is far from the truth. Sea turtles have provided the people of the Caribbean with a source of food, wealth, and cultural inspiration for more than 2,500 years. They even helped feed the countless European explorers that arrived in the region more than 500 years ago, making foreign colonization possible.
Unfortunately, this pressure has led to considerable declines in the region’s sea turtle populations. It is estimated that green turtle populations in the Wider Caribbean Region (WCR) have declined by over 97 percent since precolonial times, and local extinctions of nesting turtles have been widespread in the region. On top of this, more contemporary threats, such as fisheries bycatch, marine pollution, and coastal development, have had a major impact on the turtles of the Caribbean. Yet despite it all, some populations have exhibited impressive recoveries. Today, a devoted network of conservation initiatives are working to restore Caribbean sea turtles to their historic abundance.

The WCR is bounded to the north, west, and south by the continental American landmass, extending from the Florida Peninsula to the northern coast of South America. Running through the center and extending to the east lie a sweeping arc of island states collectively known as the Greater Antilles and the Lesser Antilles. The largest of the Greater Antilles, Cuba, divides the WCR, with the Gulf of Mexico to the northwest and the Caribbean Sea to the southeast. The Gulf of Mexico is approximately 1.55 million square kilometers (about 600,000 square miles), and the Caribbean Sea is almost twice that size at approximately 2.75 million square kilometers (about 1 million square miles). Together with the Lucayan Archipelago (The Bahamas and the Turks and Caicos Islands) to the northeast and the Guianas (Guyana, Suriname, and French Guiana) to the southwest, the Caribbean Sea and the Gulf of Mexico are united in a geopolitically complex region of 43 states and territories known as the WCR.

Six of the world’s seven sea turtle species inhabit the diverse marine habitats of the WCR (only the flatback, endemic to Australia, is absent). Green turtles nest at more than 700 sites in the WCR, with Tortuguero, in Costa Rica, hosting the largest aggregation in the region, with more than 100,000 nests per year. Loggerheads primarily nest in the region’s northern and southern extremes; the largest nesting aggregation of loggerheads on Earth is found in Florida, U.S.A. Hawksbill turtles nest at more than 1,000 sites, yet most of these populations are very small, and only 10 beaches host more than 1,000 crawls per year. Leatherback turtles nest at more than 450 sites; however, recent reports confirm that nest numbers are declining. The Kemp’s ridley is largely confined to the Gulf of Mexico, with only minor nesting on the east coast of Florida, giving it the most restricted nesting range of any sea turtle species globally. Olive ridleys are the least common species, with significant nesting occurring only in French Guiana.

GULF OF MEXICO

The Gulf of Mexico is almost entirely encircled by the continental United States and Mexico, with a combined coastline that extends more than 4,500 kilometers (2,800 miles). The island nation of Cuba lies in the narrow mouth of the Gulf, spanning the gap between Florida and the Yucatán Peninsula. The geography of the Gulf of Mexico leaves it rather isolated from both the Atlantic Ocean and the Caribbean Sea. Thus, it may not be surprising that the Gulf of Mexico hosts its own endemic sea turtle species, the Kemp’s ridley (see sidebar, p. 18), which nests predominantly in Tamaulipas, Mexico, with a secondary nesting site in Texas, U.S.A. Kemp’s ridley numbers continue to slowly rise from historic lows, though the total nesting population is still a ghost of its 1947 estimated size.

The Gulf of Mexico also harbors some of the largest populations of green, hawksbill, and loggerhead turtles in the WCR. Loggerhead turtles primary nest on both coasts of the Florida Peninsula, hawksbills are more common on the Yucatán Peninsula, and green turtles are found throughout the Gulf. Leatherbacks feed extensively in the Gulf, yet they only nest sporadically on the Yucatán and Florida Peninsulas. The olive ridley has been reported in the region, but it is considered a very rare visitor.

The region’s entire continental shelf is a multispecies migratory corridor, foraging zone, and developmental habitat for hawksbills, greens, Kemp’s ridleys, and loggerheads. Post-nesting turtles are also known to congregate in several common foraging areas in both the northern and southern Gulf of Mexico, sometimes sharing these feeding zones with postnesting females from the Cayman Islands, Colombia, Costa Rica, and Cuba. The intrinsic spatial dynamics of the Gulf of Mexico as a multispecies, multiuse nexus of sea turtle connectivity for the WCR makes it a unique melting pot and a critical conservation priority.

Because of the abundance and diversity of sea turtles in the Gulf of Mexico, several conservation and monitoring programs have been active in the region for more than five decades. Those ongoing efforts, including a binational head-start initiative (1978–1999) for the Kemp’s ridley, have contributed key information on the biology and management of this endemic population while simultaneously helping to restore the once depleted populations of this species.

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AT LEFT: A critically endangered Kemp’s ridley sea turtle, a species endemic to the Gulf of Mexico, rests on the seafloor while surrounded by remoras near Penascola, Florida, United States. © Erin Chandler/@Girlmeetsshark.

PREVIOUS SPREAD: A loggerhead turtle swims amid sargassum in Belize’s Hol Chan Marine Reserve, with a remora hitching along. © Brian J. Skerry
THE GULF OF MEXICO’S ONLY ENDEMIC SEA TURTLE

The smallest sea turtle in the world, with the tiniest home range and the lowest overall population numbers, the Kemp’s ridley has the dubious distinction of being the world’s most critically endangered sea turtle.

The uniqueness of the Kemp’s ridley stems from the fact that its biology and ecology are fully adapted to the Gulf of Mexico. It is well known for inhabiting coastal and estuarine environments at the base of the numerous river systems that contribute water and nutrients to the Gulf of Mexico. Furthermore, it feeds on invertebrates such as blue crabs that flourish in those nutrient-rich estuarine environments. But the most distinctive aspect of the Kemp’s ridley is its reproductive biology. The entire species migrates to a single primary nesting beach near Rancho Nuevo, Mexico, where it exhibits a daytime mass nesting (arribada) behavior that can involve thousands of turtles coming ashore nearly simultaneously on one small stretch of beach. This unique phenomenon enhances the production and survival of hatching, which are carried by currents away from Rancho Nuevo and eventually into developmental habitats throughout the Gulf of Mexico and along the Atlantic coast of the United States.

The Kemp’s ridley also has a cultural history that spans the entire Gulf of Mexico. Although all major nesting occurs in the far western Gulf of Mexico, this species was initially described far to the east, in the Florida Keys, in 1880. The discovery started a scientific riddle (an abundant species with no known nesting beach?) that took more than 80 years to solve. By the time the Kemp ridley’s remote Mexican nesting beach was finally discovered by the scientific community in 1963, the population was already in steep decline, and by the mid-1980s the species was on the brink of extinction, with only a few hundred females nesting each year at Rancho Nuevo. Its spiral toward extinction launched one of the most comprehensive and successful conservation efforts on record.

The binational program included heroic efforts by a wide variety of agencies, organizations, and individuals; an expensive and risky binational experiment to establish nesting beaches in Texas, U.S.A.; and even a massive program to implement the use of turtle excluder devices on shrimp boats throughout the Gulf and southeast Atlantic coast of the United States. By the early 2000s, the effects of these valiant efforts were obvious; the Kemp’s ridley was on an exponential recovery trajectory that was expected to continue for decades. However, the recovery hit an unexpected slowdown in 2010. The reasons for this latest riddle in the ridley story are not clear, but the binational conservation efforts are continuing, and for now, the Gulf of Mexico continues to embrace its own unique species of sea turtle, the Kemp’s ridley.

Yet, as in the rest of the WCR, sea turtles in the Gulf of Mexico still face a variety of cumulative and growing threats, ranging from fisheries bycatch to sometimes extreme recreational use of beaches; urban and coastal infrastructure; pollution (solids, chemicals, and even light and sound); climate change impacts (increasingly intense storms, beach erosion, coral bleaching, and more); and devastating stony coral tissue loss disease. Perhaps the most alarming threat is the specter of large-scale hydrocarbon exploration and extraction, which in 2010 resulted in the disastrous Deepwater Horizon oil spill (see SWOT Report, vol. VI, pp. 16–21). The scale of that event was such that, even a decade later, its impacts on sea turtles are not yet fully understood.

CENTRAL AMERICA

The Caribbean coastline of Central America, stretching south about 3,875 kilometers (2,400 miles) from Cancún, Mexico, on the Yucatán Peninsula through Belize, Guatemala, Honduras, Nicaragua, Costa Rica, and Panama, forms the western boundary of the Caribbean Sea. In general, this coastline hosts relatively small nesting turtle populations, with the major exceptions of Costa Rica and Panama. In Costa Rica, Tortuguero hosts more than 100,000 nests each year, making it one of the largest green turtle nesting sites in the world. The conservation and research program at this site was initiated by Dr. Archie Carr and has been carried out continuously by the Sea Turtle Conservancy since 1959, making it the longest-running and one of the most iconic sea turtle conservation initiatives in the world.

In Panama, a cluster of beaches in the Bocas del Toro region hosts large nesting populations of both hawksbill and leatherback turtles. A monitoring program carried out by the Conservancy documents more than 2,000 hawksbill nests and more than 5,000 leatherback nests each year in the region.

The Caribbean coastline of Central America features countless estuaries, nearshore islands, coral reefs, and deep-ocean habitats, providing vital migratory corridors, nesting beaches, and foraging areas for sea turtles. The Mesoamerican Barrier Reef, which stretches more than 1,000 kilometers (620 miles) along the northernmost four countries of the region and the expansive continental coast of Nicaragua, provides extensive shallow-water foraging habitats for marine turtles. Indigenous and ethnic coastal communities have been fishing turtles for hundreds of years for subsistence, trade, and commerce, and very likely turtles were the first fishery export for many Caribbean nations. Although some of this activity is legal, illegal take also persists well beyond the exceptions for traditional use granted by authorities in Belize and Nicaragua. Today, at least 7,000 green turtles are killed annually in the Nicaraguan fishery, down from a high of 10,000 annually in the mid-1990s.

Turtles captured with tags from research and conservation programs throughout the WCR are carefully monitored by a dedicated team from the Archie Carr Center for Sea Turtle Research at the University of Florida.

Of particular concern for both sea turtles and their protectors is the overlap between sea turtle nesting and narcotics trafficking. In 2013, a dedicated volunteer, Jairo Mora Sandoval, was brutally murdered in Costa Rica while protecting leatherback nests. Drug trafficking in other Central American nations also hinders regular monitoring of nesting beaches and is often associated with illegal sea turtle commerce. Recent investigations by SEE Turtles and its “Too
The conservation and research program … was initiated by Dr. Archie Carr and has been carried out continuously … making it the longest-running and one of the most iconic sea turtle conservation initiatives in the world.

Rare to Wear” campaign found that the hawksbill shell trade remains a threat in Costa Rica and all countries in the region, even though the species is protected by law in most.

In general, active threats mirror those encountered elsewhere in the WCR, including unsustainable (and often illegal) fisheries bycatch; direct take for meat and eggs; habitat loss and degradation; and the less quantifiable impacts of climate change, pollution, and disease. In recent years, the region has experienced dramatic influxes of Sargassum, a genus of brown algae that has blanketed pelagic waters and beaches. These blooms, likely a result of increases in agricultural runoff, have smothered many WCR nesting beaches, caused turtle drownings, and made it difficult for adults to nest and hatchlings to crawl to the ocean. Long-standing issues with urban expansion and beachfront development continue to displace nesting females, artificial coastal lighting lures thousands of hatchlings to their deaths, and shoreline erosion and the erection of sea walls contribute to the disappearance of historic nesting grounds.

Many government agencies, nonprofits, and community organizations are working diligently to conserve the Mesoamerican sea turtle fauna; still, population recovery efforts often face seemingly insurmountable challenges and opposition from stakeholders, as well as legal loopholes that make protecting sea turtles and their habitats difficult. Making the case for conservation increasingly requires collaborative research—such as that undertaken by Pronatura Peninsula de Yucatán, Cineast Unidad Mérida, Universidad Autónoma del Carmen, ECOMAR, Marymount University, Hawksbill Hope, ProTECTOR Inc., Wildlife Conservation Society, and Sea Turtle Conservancy—into using satellite telemetry to monitor sea turtle migrations. Data from such research have helped to focus attention on migratory hotspots and other critical habitats.

NORTHERN SOUTH AMERICA

Extending east from the Isthmus of Panama, the nations of Colombia and Venezuela form the southern border of the Caribbean Sea. The annual southern Caribbean upwelling system brings nutrient-filled waters from the deep ocean onto the continental shelf, nurturing highly productive commercial and artisanal fisheries. While providing an important local source of nutrition and income, many of these fisheries also incur substantial sea turtle bycatch. Tackling this issue while safeguarding depleted nesting populations is among the many complex problems that must be addressed before sea turtle recovery can be achieved.

Historical reports indicate significant numbers of nesting sea turtles on the coasts of Colombia and Venezuela, yet today these numbers are very low and, despite persistent conservation efforts, continue to decline. For example, on the Paria and Guajira Peninsulas, several hundred loggerheads were estimated to have nested annually in the first half of the 20th century, yet today fewer than 50 individuals nest there annually. The widespread harvest of eggs and intentional take by artisanal fisheries are implicated in the demise (see pp. 34–35).

Current sociopolitical and economic challenges in Venezuela are hampering sea turtle conservation efforts nationwide. Nonetheless, several university groups, conservation organizations, and government agencies are striving to maintain vital protection efforts through a combination of nest monitoring, environmental education, and general outreach efforts. These organizations include the Ministerio del Poder Popular para el Ecosocialismo (formerly the Ministerio del Ambiente); the Centro de Investigación y Conservación de Tortugas Marinas (CICTMAR, the lead organization for the Wider Caribbean Sea Turtle Conservation Network [WIDECAST] in Venezuela); ConBiVe (Asociación Civil para la Conservación de la Biodiversidad Venezolana); Fundación La Tortuga; Grupo de Trabajo en Tortugas Marinas del Golfo de Venezuela; the University of Zuila; and other organizations in Colombia.

Offshore to the northwest of Venezuela’s capital city, Caracas, lie the “ABC” islands, the Dutch islands of Aruba, Bonaire, and Curacao. All three islands have strong local sea turtle research and conservation histories led by WIDECAST affiliates TurtugAruba, Sea Turtle Conservation Bonaire, and Sea Turtle Conservation Curacao, respectively. The longest running of these organizations has led in-water and nesting beach monitoring programs for decades in Bonaire and is now working to curtail the invasive seagrass Halophila stipulacea. Among its many creative endeavors, Sea Turtle Conservation Curacao is making significant strides in reducing pollution by taking local action in repurposing postconsumer plastic.

Unlike the shorelines of Colombia and Venezuela, the eastern countries of Guyana, Suriname, and French Guiana host substantial nesting populations of green, leatherback, and olive ridley sea turtles. These countries, collectively known as the Guianas, contain the largest remaining expanse of coastal wilderness in the tropics and are well known for their muddy mangrove coasts and shifting shorelines. Influenced by the North Brazil Current, entire stretches of beaches can be deposited or vanish within a matter of weeks, leading to significant geographic shifts in nesting habitat within and between seasons. Situated across the Gulf of Paria from Venezuela, Trinidad and Tobago host the hemisphere’s largest remaining nesting assemblage of leatherback turtles on Trinidad’s north (Grand Riviere) and east (Matura) beaches, monitored by community-based organizations.

The most significant anthropogenic threat to sea turtles along the northern tier of South America is from fisheries bycatch. Although the use of turtle excluder devices (TEDs) by shrimp trawlers has been required by law in Guyana and Suriname for more than 20 years, this requirement has only recently had the force of law in French Guiana.
Trawling has been illegal since 2009 in Venezuela, though artisanal fisheries are still responsible for notable sea turtle mortalities. Specifically, Wayuu indigenous communities capture more than 3,800 mostly juvenile green turtles each year on the Venezuelan side of the Guajira Peninsula (see SWOT Report, vol. XIII, pp. 34–35); the numbers may be higher on the Colombian side. Bycatch data are scarce for Colombia, which has been one of the main drivers for the recent creation of a National Comanagement Committee for Bycatch, led by the National Fisheries Authority (Autoridad Nacional de Acuicultura y Pesca, or AUNAP) and the Marine and Coastal Research Institute (Instituto de Investigaciones Marinas y Costeras, or INVEMAR), along with a number of Colombian nongovernmental organizations.

LESSEANTILLES AND AVES RIDGE

A sweeping island arc known as the Lesser Antilles forms the eastern boundary of the Caribbean Sea. A complex sociopolitical mix of nations and overseas territories, the Lesser Antilles provide nesting habitat for green, loggerhead, hawksbill, and leatherback turtles, as well as a variety of shallow- and deep-water habitats. The countries of the Lesser Antilles face many issues common to the WCR, including coastal development (loss of coastal vegetation and increased beachfront lighting), beach erosion, beach remediation activities that alter the incubation environment, direct and incidental capture by nearshore fisheries, pollution, and climate change. Research shows that biodiversity loss and the threat of localized extinction is heightened in small island developing states, where a diversity of cultural, political, and ecological landscapes add layers of complexity to conservation initiatives.

The coral island of Barbados hosts the largest nesting population of hawksbills in the Lesser Antilles, with more than 600 females recorded annually. The population has increased considerably over the past 30 years, a result of legislation banning direct harvest as well as ongoing conservation actions led by the WIDECAST-affiliated Barbados Sea Turtle Project (BSTP) at the University of the West Indies. Sea turtles are a major tourist attraction for the island, and BSTP’s Marine Turtle Tagging Centre provides free flipper tags, equipment, and training to field projects throughout the region.

Aves Island (Venezuela) hosts nesting green turtles in numbers that exceed all other islands in the Lesser Antilles and most locations on the South American continent, along with significant numbers of males and females that congregate for courtship and mating (see SWOT Report, vol. XIII, pp. 10–11). In less than 30 years, monitoring data collected by FUDENA (Fundación para la Defensa de la Naturaleza), the Ministerio del Poder Popular para Ecosocialismo, and the Venezuelan Institute of Scientific Research (Instituto Venezolano de Investigaciones Científicas, or IVIC) have shown that the number of nesting green turtles on Aves Island has doubled to more than 1,000 turtles per year.

Saint Vincent and the Grenadines has made significant progress in sea turtle conservation by legally protecting all life stages of all species of sea turtles in national waters since January 2017. The Ministry of Agriculture, Forestry, Fisheries, and Rural Transformation, in collaboration with the National Parks, Rivers, and Beaches Authority and partners such as the Saint Vincent and the Grenadines Environment Fund and the Saint Vincent and the Grenadines National Trust, is using best practices developed by the WIDECAST network in education, outreach, and sustainable livelihoods.

Saint Lucia is one of only a handful of nations in the WCR that still sanctions an annual open season (October–December) for hunting sea turtles. It is based on minimum size limits and includes...
all hard-shelled species. Marine protected area managers, in particular at the Pointe Sable Environmental Protection Area, are working to collect sea turtle and habitat monitoring data. The Saint Lucia National Trust shares nesting beach monitoring findings in infographic format to bring greater accessibility to data that can help to drive more sustainable sea turtle management practices.

Grenada hosts the largest population of nesting leatherbacks in the Lesser Antilles and also provides prime nesting, foraging, and developmental habitats for hawksbills, greens, and loggerheads. Over the past 20 years, several hundred leatherback nests have been recorded annually at Levera Beach by Ocean Spirits, a local nonprofit that relies entirely on volunteers. Ocean Spirits has a strong presence in local schools, and more than 7,000 students have heard its conservation message. National legislation has protected leatherback turtles since 2001, but Grenada has a seasonal fishery for hard-shelled species, and it is the only country in the region that legally allows the sale of turtle shell products.

Sint Eustatius in the northern Lesser Antilles hosts small nesting populations of green and hawksbill turtles. The island’s characteristic black volcanic sand beaches are hot, which has been found to give rise to a female hatching bias. Projections indicate that only 2.4 percent of green turtle hatchlings will emerge as male by 2030. The St. Eustatius National Parks Foundation (STENAPA) has been at the forefront of sand temperature research and the development of management strategies to artificially lower incubation temperatures by watering, shading nests, or relocating nest clutches to deeper depths.

Antigua hosts one of the region’s longest-running research and monitoring programs, the Jumby Bay Hawksbill Project, a WIDECAST initiative that has studied a protected population of nesting hawksbills since 1987 with funding from a local homeowners association. Recent data suggest that after more than a decade of growth, the population may be in significant decline, and understanding the cause of this decline is a crucial direction for future research.

Further north in the British Virgin Islands, in-water monitoring of hawksbills and other species is undertaken by the Association of Reef Keepers (ARK), with the involvement of the government and private sectors. ARK emphasizes social entrepreneurship for conservation.

Alongside these diverse local scenarios, there is a persistent tension with the region’s largest economic driver—tourism. “Swim with the turtles” and related hand-feeding operations are becoming an increasingly common method to artificially maintain localized turtle aggregations for viewing in water. Although these activities can bring sustainable livelihoods for local communities, turtles may suffer from improper diet, compromised migratory movements, and an affinity for humans that can lead to boat strikes, gear entanglement, injury, and disease. The social media thirst for “turtle selfies” is a complicating factor, making it difficult to manage this new tourism product.

**GREATER ANTILLES**

The Greater Antilles make up nearly 90 percent of the landmass of the entire West Indies, as well as over 90 percent of its population on the islands of Cuba, Hispaniola (Haiti and the Dominican Republic), Puerto Rico, and Jamaica, as well as the Cayman Islands. People in the region have been actively harvesting sea turtles for centuries, causing local extinctions in many areas.

The longest-running conservation program is in Cuba, which began monitoring the impacts of harvesting on four turtle species more than 40 years ago. Cuba closed its sea turtle fishery in 2008, and conservation efforts have increased considerably since then. Cuban and international partners have expanded outreach campaigns and undertaken studies of illegal trade, in addition to important research on genetics, migration, and climate change. Seventy-nine beaches are monitored, and upward trends are observed in some areas.

Among the islands of the Greater Antilles, Hispaniola has arguably seen the largest declines in nesting turtles. Today, only sporadic reports of nesting occur in Haiti, and a small rehabilitation center operated by the Haiti Ocean Project has recently opened to address issues of entanglement and injury. Several programs monitor and protect the

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**WIDECAST**

**The Wider Caribbean Sea Turtle Conservation Network**

WIDECAST, the Wider Caribbean Sea Turtle Conservation Network, is the largest regional network of sea turtle research and conservation actors in the world. Volunteer country coordinators serve in 45 nations and territories, and the network emphasizes science-based tools in research; policymaking; and community conservation, outreach, and microenterprise development.

Founded in 1981, WIDECAST is a Regional Activity Network of the United Nations Caribbean Environment Programme and serves as a framework to promote policies and practices that advance sea turtle recovery regionwide. The network develops and mentors projects, promotes standardized data collection and sharing, and promotes links between science, policy, and public participation at a variety of scales. With country coordinators strategically located throughout the Wider Caribbean Region, WIDECAST is uniquely positioned to facilitate conservation action within and between range states. By strengthening national and regional regulatory regimes, encouraging community engagement, and raising public awareness, the network has had measurable impacts on the protection and sustainable management of sea turtles.

In partnership with WIDECAST, most Caribbean nations have developed and implemented national sea turtle recovery action plans—and most important, these efforts are working. Steady declines have been seen in poaching and illegal product sales across the Caribbean, major nesting beaches are protected, and the region’s largest breeding colonies are regularly monitored. Moreover, through WIDECAST’s powerful network of country coordinators and local project affiliates, sea turtles are more likely to be considered in national policy debates, and alternative livelihood models are further reducing pressure on remnant populations.
nests of leatherback, hawksbill, and green turtles across the border in the Dominican Republic, and in-water surveys conducted since 1997 have identified hawksbill foraging areas on the southwest coast.

Puerto Rico has seen an increase in conservation efforts since the Department of Natural and Environmental Resources began delegating sea turtle management and conservation to community-based groups in 2010. The partnership has promoted beach cleanups, developed a stranding and rehabilitation response protocol, and expanded efforts to safeguard nests and adults from poachers and invasive species. Data from these local efforts have also contributed to the designation of protected areas, and long-term in-water surveys of green and hawksbill turtles at Mona and Culebra islands have greatly increased our understanding of sea turtle population dynamics in Puerto Rico and beyond. The collaboration between government agencies and community-based groups has been a powerful force for management and conservation, which we hope will lead to measurable population recoveries.

Green, hawksbill, loggerhead, and leatherback turtles once nested throughout Jamaica. Today, only 10 Jamaican beaches receive more than an occasional hawksbill nest. Green and leatherback nesting is very rare, and loggerheads are gone. Concern over the effects of an unregulated take was expressed at an early stage in Jamaica’s history

LUCAYAN ARCHIPELAGO

The Lucayan Archipelago consists of the Commonwealth of The Bahamas and the Turks and Caicos Islands (TCI), the latter a British Overseas Territory. The archipelago is instantly identifiable from satellite imagery owing to the Bahama Banks, which are shallowly submerged carbonate platforms that make the waters of the region appear a distinct peacock blue. The numerous seabed and mangrove systems are inhabited by abundant populations of juvenile green turtles. Loggerhead and hawksbill turtles are also common, although they are seen mainly in deeper coral reefs. Understandably, almost all sea turtle monitoring in the region has focused on in-water data collection. Although substantial numbers of tags have been deployed, most monitoring efforts are relatively opportunistic, and long-term datasets in fixed habitats are rare.

The Bahamas comprises 700 islands distributed over 259,000 square kilometers (100,000 square miles) of ocean. The archipelago has never been thoroughly surveyed for sea turtle nesting, but the data suggest that green, loggerhead, and hawksbill turtles nest at low densities at several sites: leatherbacks are rare. All have been fully protected since 2009. Threats include poaching of eggs and turtles, beachfront lighting, coastal development, seagrass and coral reef degradation, entanglement in fishing gear, and marine pollution. The Bahamas National Trust sponsors a broad portfolio of conservation and research projects, often in partnership with universities or the government. Such projects include a long-term study of foraging green turtles at Great Inagua, conducted with colleagues at the Archie Carr Center for Sea Turtle Research at the University of Florida. The Bahamian government is committed to protecting at least 20 percent of its nearshore marine environment by 2020, including many critical turtle foraging areas.

The 8 main islands and more than 22 smaller islands that make up the TCI have a total land area of only 616 square kilometers (238 square miles). There has been a long tradition of harvesting sea turtles for meat in the Lucayan Archipelago, and this practice is still legal in TCI, where a seasonal fishery for hawksbill and green turtles is bounded by minimum and maximum size limits. More progressive than the minimum size limits that typically characterize Caribbean sea turtle fisheries, maximum size limits offer a degree of protection to reproductively active adults, arguably the most ecologically valuable animals in any population.

A number of research projects have been conducted in TCI in recent years, often in partnership with the Marine Conservation Society, the Cape Eleuthera Institute, and the University of Exeter in the United Kingdom. The projects include mark and recapture; genetic sampling; mixed stock analysis; and studies of diet (stable isotopes), sex ratios, and seasonality of occurrence. The genetic sampling suggests that more than half of all foraging green turtles originate in Costa Rica, whereas the majority of hawksbills originate in Cuba and the U.S. Virgin Islands. The primary threat to stock recovery is the ongoing—legal and illegal—take of eggs and turtles. A new threat is the emergence of stony coral tissue loss disease affecting coral reefs of the territory.

CONCLUSION

The history of humans and sea turtles in the WCR is inextricably intertwined. Providing a staple food for both indigenous peoples and colonists, sea turtles became an important component of many local cultures. Yet direct harvest over hundreds of years has driven many sea turtle populations to near extinction. In recent decades, renewed commitment to protective legislation, safeguarding of habitat, and
antipollution initiatives have reversed the fortunes of many sea turtle populations, helping put them back on the road to recovery.

The hard work of conservationists has paid off in numerous policy accomplishments. Intergovernmental meetings devoted to addressing shared management concerns have been convening in the region for more than three decades. The majority of WCR nations and territories now fully protect sea turtles both on land and at sea. All six WCR sea turtle species are on the IUCN (International Union for Conservation of Nature) Red List of Threatened Species, with loggerheads, leatherbacks, and Kemp’s ridleys now listed at the regional management unit (subpopulation) scale. All species are also listed in Annex 2 (full protection) of the Protocol Concerning Specially Protected Areas and Wildlife to the Cartagena Convention, as well as Appendix 1 (full protection) of the Convention on Migratory Species and Appendix 1 of the Convention on International Trade in Endangered Species of Wild Fauna and Flora. They also fall under the aegis of the Inter-American Convention for the Protection and Conservation of Sea Turtles.

FEATURE MAPS
Biogeography of Sea Turtles in the Caribbean Sea

The maps on pp. 24–27 display available nesting and satellite telemetry data for the six sea turtle species found in the Wider Caribbean Region.

Nesting Map
The map of nesting biogeography (pp. 24–25) is based almost exclusively on nesting data that were provided by members of the WIDECAST network (see sidebar, p. 21) to create the Atlas of Sea Turtle Nesting Habitat for the Wider Caribbean Region (Eckert and Eckert 2019). That exhaustive digital inventory documented more than 1,341 nesting beaches representing 2,667 species-specific nesting sites among the 45 nations and territories that comprise the WIDECAST network.

For the purposes of the map on pp. 26–27, we chose to display data on all six species that nest within the Caribbean region on a single map. Although they were included in the WIDECAST Atlas, we chose to exclude Brazil and Bermuda in order to simplify the extent of the map (see SWOT Report, vol. XI, pp. 20–21 for a summary of nesting in Brazil). Additional data were incorporated from the SWOT database for large nesting sites (those with >10,000 crawls per year) to further distinguish between nesting sites with 10,001–100,000 crawls per year and those with greater than 100,000 crawls per year (from all species combined). Complete data citations for all source data can be found on pp. 46–51 of this report.

Nesting sites are represented by dots that are colored according to the species present. The proportion of nesting by each species is indicated by the colors shown within the dot. The dots are scaled according to the total nesting abundance for all species at that site.

For a more comprehensive presentation of sea turtle nesting data in the Wider Caribbean Region, including species-specific maps, trend data, and detailed supplementary information, see the WIDECAST Atlas at https://widecast.org/widecast-publications.

Satellite Telemetry Map
The map of sea turtle satellite telemetry data on pp. 24–25 summarizes all available telemetry data from tags deployed in the Wider Caribbean Region. The data consist of more than 350,000 locations from 626 individually tracked turtles and were contributed by more than 36 different partners (see data citations, pp. 46–51). Telemetry data are represented as polygons that are colored according to the number of locations and the composition of species they contain. 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. Telemetry data are displayed as given by the providers, with minimal processing to remove locations on land and visual outliers. As such, some tracks are raw Argos or GPS locations, whereas others have been more extensively filtered or modeled. For a complete list of data providers and available metadata, see pp. 46–51.

The maps on the lower right of p. 27 show the six regional management units (or subpopulations) of the six sea turtles residing in the Wider Caribbean Region, overlain with species-specific satellite telemetry data. The regional management units were defined by Wallace et al. in 2010 by combining telemetry, genetics, tagging, and nesting data.

We are deeply grateful to all of the data contributors and projects that participated in this effort, and especially to the WIDECAST network, Dr. Karen Eckert, and Adam Eckert for their collaboration. Please see the complete data citations for all maps beginning on p. 46 for details.
Nesting Biogeography of Sea Turtles in the Wider Caribbean

6 - Cayo Largo (Cuba)
5 - Guanahacabibes (Cuba)
9 - Grand Cayman (Cayman Islands)
2 - Northern Quintana Roo (Mexico)
4 - Cozumel (Mexico)
3 - Southern Quintana Roo (Mexico)
1 - Veracruz (Mexico)
0 - 300
600 km

total crawls for all species combined (most recently available year)
greater than 100,000
10,001–100,000
1,001–10,000
101–1,000
1–25
26–100
see note

hawksbill (Caretta caretta)
loggerhead (Caretta caretta)
green (Chelonia mydas)
leatherback (Dermochelys coriacea)
Kemp's ridley (Lepidochelys kempii)
olivertid (Lepidochelys olivacea)

data: Eckert and Eckert et al. 2019, WIDECAST, the SWCT team, and reviewed literature (see end of report for citations); Ocean Basemap—Esri, DeLorme, GEBCO, NOAA NGDC, and other contributors; boundary data—Esri Maps and Data for ArcGIS 2016.
notes: Data are older than 10 years, data are unquantified, or count was given as zero; species that comprise less than 5% of the clutches at nesting sites are not displayed on the map but are reflected in the citations; Saint Vincent and the Grenadines produced in partnership with: Oceanic Society, OBIS-SEAMAP, the IUCN- MTSG, and WIDECAST.
projection: Europe Albers Equal Area Conic
country borders

38 - Mesoamerica
37 - Costa Rica
36 - Panama
35 - Central Caribbean Colombia
34 - Guajira Peninsula (Colombia)
31 - Sucre State (Venezuela)
29 - Tobago
28 - Barbados
27 - South SVG and Grenada
22 - Guadeloupe
20 - Trinidad
10 - Jamaica
9 - Grand Cayman (Cayman Islands)
Sea Turtle Satellite Telemetry Data in the Wider Caribbean

- country borders
- Regional Management Units
- nesting sites

Telemetry color guide:
Cc - Caretta caretta
Cm - Chelonia mydas
Dc - Dermochelys coriacea
El - Eretmochelys imbricata
Lk - Lepidochelys kempii
Lo - Lepidochelys olivacea

Single species:
- Cc
- Cm
- Dc
- El
- Lo

Species combinations:
- Cc & Cc
- Cc & Cm
- Cc & Dc
- Cc & El
- Cc & Lo
- Cm & Cm
- Cm & Dc
- Cm & El
- Cm & Lo
- Dc & Dc
- Dc & El
- Dc & Lo
- El & El
- El & Lo
- Lo & Lo

scale: 1:23,500,000 projection: Mollweide (false northing 15N, central meridian 75W)
data: The SWOT team and reviewed literature (see end of report for citations); Ocean Basemap - Esri, DeLorme,
GECO, NOAA NGDC, and other contributors.
Notes: This map displays aggregated data from 625 individual turtles and a total of ~350,000 locations, sourced from more than 36 different projects. For details, see the data citations beginning on p. 47. Data are displayed as given by the providers and with minimal processing to remove locations on land and visual outliers. Some tracks are raw locations while others have been more extensively filtered or modeled. On the main map, polygons are colored according to the number of locations they contain and the combination of species present; color bins were determined by splitting the count data into quantiles. Darker colors represent a higher number of locations, which can indicate a high number of tracked turtles in that location or that turtles spent a lot of time there. Countries of origin are labeled in the map. The insets show the Caribbean 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 extant telemetry data or an authoritative source for the studies cited.

produced in partnership with: Oceanic Society, Duke University, OBIS-SEAMAP, WIDECAT, and the IUCN-MTG
Recent issues of the *SWOT Report* have contained articles about the natural history, status, and distribution of loggerhead turtles in the Pacific Ocean (vol. XIII), as well as in the Atlantic Ocean and Mediterranean (vol. XIV), including maps of at-sea biogeography for these three large ocean biomes. Data have now been compiled from the Indian Ocean as well, to complete the first global map of loggerhead telemetry (pp. 32–33). This is the unique story of Indian Ocean loggerheads, in the final chapter in this series of ocean-scale overviews.
Global distributions of the loggerhead have been divided into 10 regional management units, or RMUs (SWOT Report, vol. XII, pp. 30–33). Four of these RMUs are in the Indian Ocean, the largest being in the northwest (figure 1). The Northwest Indian Ocean RMU surrounds the islands of Masirah (Oman) and Socotra (Yemen), where several tens of thousands of females nest. Next in rookery size is the Southeast Indian Ocean RMU, around Western Australia, which has about 2,500 nesting females annually. Then comes the Southwest Indian Ocean RMU, whose rookeries are shared between South Africa and Mozambique, with fewer than 1,000 annual nesters. These three RMUs are globally ranked as second, third, and fourth, respectively, in terms of the abundance of nesting female loggerheads. The Northeast Indian Ocean RMU, in the Bay of Bengal, is ranked as the world’s smallest rookery, with likely fewer than 50 annual nesters.

The most conspicuous aspect of the movement of loggerheads among the largest three of these rookeries, as shown by telemetry studies, is the commonly observed movement of the turtles along a north-south transequatorial axis. This movement contrasts with the east-west migrations of loggerheads typical to the northern and southern hemispheres of both the Atlantic and Pacific Oceans, where turtles typically do not cross the equator. Rather, they follow the currents of their respective north and south oceanic gyres between feeding, breeding, and developmental habitats. The atypical loggerhead movement patterns in the Indian Ocean may derive from the fact that the Indian Ocean is the only major basin that is closed in the north by a continental shelf, thereby creating unique oceanographic and atmospheric phenomena.

This north-south migration of Indian Ocean loggerheads is best documented in juveniles from the Mascarene Plateau (55° S latitude), which have been tracked north to Oman and even to the Arabian Gulf, where they likely originated (SWOT Report, vol. VII, pp. 10–11; vol. XIV, pp. 6–7). Unsurprisingly, adult loggerheads in Western Australia also migrate northward with the Western Australian Current, taking them to the warmer waters of the Timor and Arafura Seas. Preliminary analysis of recent tracking of neonate loggerhead turtles indicates that they do not take the same path as adults. More peculiar is that the eastern edge of the Indian Ocean loggerhead distribution seems to truncate, and the animals do not venture into the Pacific Ocean. This border is where Southeastern Indian Ocean RMU loggerheads meet those nesting in Queensland, which forage off the Great Barrier Reef (the Southwestern Pacific RMU). This apparent abrupt separation may be due to the limitations of our loggerhead tracking efforts to date, or could be caused by some other unknown factor that restricts their distribution. However, given that this RMU boundary lies roughly along a north-south line formed by the Torres Strait Islands, a narrow waterway that was previously a land bridge between Papua New Guinea and Cape York in northern Australia, it is likely a biogeographic relic from before the last ice age, when these islands and the current maze of shallow reefs and surrounding seas were above sea level.

The situation along the Southern African continent is very different. The fast-flowing Agulhas Current hugs the coast, flowing in a southwesterly direction toward the colder coast at Cape Agulhas, the continent’s southernmost point. Here it spins off partially into the Atlantic Ocean, or turns on itself and flows eastward again, to just north of the Arctic Circumpolar Current (figure 2). Modern tools such as ocean particle modeling can be used to predict the distribution of posthatchlings from the time they leave the nesting grounds. In one such model based on 2018 conditions, southwestern Indian Ocean loggerheads were shown to disperse with the Agulhas Current and end up either in the Agulhas Retroflection or in the Benguela Current (on the west coast of South Africa), with a portion ending up in the cold Southern Ocean. These locations have a high probability of mortality.

Despite those useful modeling tools, there is still considerable uncertainty about the duration of the lost years or the location of the ontogenetic shift from the pelagic phase to the neritic, nor is it known with certainty which rookery these young loggerheads would reach as adults. However, what we do observe from global sea surface temperatures is that the western Indian Ocean is a much more
favorable habitat for loggerheads than either (a) the southern or southwestern edges of the African continent or (b) the southwest coast of Australia, since posthatchling turtles are unlikely to survive long-term or abrupt exposure in those cold waters. Indeed, the juvenile and adult turtles that have been tracked in the past tended to avoid the cold water of the Atlantic and Southern Oceans and appeared to be strong enough swimmers to navigate the currents and avoid the southern seas, which are notorious for their strong westerly winds and high waves.

Also curious to note is that the southwestern and southeastern Indian Ocean loggerhead rookeries are both located at about 27°S latitude, with the closest southernmost tips of their respective continental landmasses also lying at approximately the same latitude (that is, Cape Agulhas, South Africa, and a point near Albany, Western Australia, both at about 35°S latitude, the latter being the southwesternmost point of Australia). So far south are these two rookeries, when compared with other loggerhead rookeries globally, that it is easy to assume some migration of animals into the other ocean basins, yet such migration does not seem to happen.

Sea turtles that manage to avoid the troubled cold waters to the south and stay in the warmer seas of the Indian Ocean still face many challenges, two significant ones being fisheries bycatch and plastic pollution. Many of the sea turtle tracks from the southwest Indian Ocean that are presented in the global map (pp. 32–33) were from rehabilitated juvenile and subadult turtles caught in commercial fisheries near La Réunion. They are the lucky turtles, because they were rescued, rehabilitated at Kélonia (the sea turtle rescue center of Réunion), and released to the wild. However, an estimated 3,500 interactions between sea turtles and longline fisheries take place each year in the Indian Ocean, and whereas fishing pressures in the exclusive economic zones of most countries are managed, the high-seas impacts of turtle bycatch are believed to be shockingly high. Moreover, plastic pollution is ubiquitous throughout the Indian Ocean and presents a noteworthy threat to all age classes of loggerheads. Interestingly, studies have shown that a large amount of plastics found in the west actually originated on the eastern side of the ocean basin, where some of the most polluting countries are located. The impact of these turtle and plastic interactions has not yet been properly quantified, but unlike many of the fishing activities that are often size selective, with larger turtles being more vulnerable, plastic is an indiscriminate killer. Sea turtles of all sizes, including posthatchlings from their first days of feeding, have been seen to ingest or become entangled in plastics, which can result in malnutrition, disease, intestinal blockage, and often death.

Scientists working on loggerheads in both the Atlantic and the Pacific Oceans have generated vast amounts of original knowledge in recent decades, making those loggerheads among the best studied sea turtle populations on Earth. Meanwhile, the Indian Ocean still has many unique features to explain and rare mysteries to tackle, and her loggerhead turtles exhibit striking patterns not seen anywhere else. There is still much to learn about loggerhead turtles in this very special ocean basin, and new information is needed to implement effective cross-jurisdictional management actions for the priority threats to all Indian Ocean sea turtles.
Global Loggerhead Turtle Locations

**Notes:** This map displays aggregated data from 1,273 individual loggerhead turtles and a total of 650,000 locations, sourced from more than 80 different projects. For details, see the data citations beginning on p. 49. Data are displayed as given by the providers and with minimal processing to remove locations on land and visual outliers. Some tracks are raw 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 a high number of tracked turtles in that location or that turtles spent a lot of time there. Countries of origin are labeled in the map. The insets show the 10 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 extant telemetry data or an authoritative source for the studies cited. **Scale:** 1:73,000,000

**Projection:** Eckert IV (central meridian—80W)  **Data:** The SWOT team and reviewed literature; Est, DeLorme, GECBO, NOAA NGDC, and other contributors. **Produced in partnership with:** Oceanic Society, Duke University, OBIS-SEAMAP, and the IUCN-MTSG
Changing the Future for Colombia’s Sea Turtles


A HISTORY OF ABUNDANCE AND DECLINE

Spanish chroniclers nearly half a millennium ago spoke of an abundance of sea turtles in what is now the northern coast of Colombia, where nesting turtles were taken by native peoples for food, ornaments, and superstitious rites. The remains of sea turtles are still being unearthed by archaeologists alongside human remains, making it clear that they have always played an important role in the lives of people there.

Since the 1950s, scientists have noted drastic declines in Colombia’s sea turtles. Authors Nicéforo Maria, Federico Medem, Archie Carr, Larry Ogren, C. Tufts, E. Ramírez, Reinhard Kaufmann, and Jorge Hernández-Camacho were among the first to warn about the dire situation. In a study conducted in the mid-1980s to measure the socioeconomic value of sea turtles along Colombia’s Caribbean coast, Roderic Mast reported commonly hearing the phrase “Tortuga vista es tortuga muerta” (a turtle we see is a turtle that dies) from fishermen and villagers, who prized the turtles for their eggs, meat, oil, and shell. Up until the early 1990s, it was common to find sea turtle on the menus of restaurants, and a sea turtle slaughterhouse operated in Riohacha, where the infamous Doña Fefa sold green turtle meat, oil, and chicharrón (deep fried fat) to individuals, markets, and restaurants up and down the coast. Hawksbills were also widely harvested for their shell, which was used for jewelry, trinkets, and even furniture. In addition to direct capture, turtles were—and still are—caught incidentally by fishers. The Colombian National Natural Parks Service (locally referred to as Parques) estimates that an average of 129 turtles were caught annually just in the Corales del Rosario and San Bernardo National Natural Park from 1998 to 2003.

Loggerheads in the coastal states of Magdalena and Guajira have been especially hard hit. In the 1970s, Reinhard Kaufmann estimated that about 200 females nested on those beaches each year. By 1997, a study done by Wider Caribbean Sea Turtle Conservation Network (WIDECAST) Colombia, Parques, and the Palomino Fishermen Association counted as few as 25 nests in the same area, representing fewer than 10 nesting females. And later, the Sea Turtle and Marine Mammal Conservation Program (ProCTMM) observed an average of only five loggerhead nests annually from 2014 to 2018. The 1997 study also showed only eight nesting leatherbacks and three hawksbills, a distinct drop from numbers reported in the 1970s. Moreover, green turtles, which once nested in all seven Colombian coastal departments (states), now nest in only three and have the lowest nesting density of any species in Caribbean Colombia. By the early 2000s, the Marine and Coastal Research Institute (INVEMAR) had generated maps showing all known and historic nesting beaches and at-sea turtle sightings on the Caribbean and Pacific coast of Colombia, and these declines became empirically clear.

THE TIDE TURNS FOR SEA TURTLES

Despite centuries of pressure, four sea turtle species still thrive in Colombia’s Caribbean waters and nest on the country’s 1,626 kilometers (1,010 miles) of continental coasts and on adjacent islands: leatherback (known locally as caná, in reference to the deep canals between the carapace keels); hawksbill (called carey); green (verde o blanca); and loggerhead (gogo). All these species have been protected by law since the 1960s.

Today, many coastal residents whose parents or grandparents once may have killed “every turtle they saw” now actively protect nests, adults, and hatchlings in an unprecedented generational turnaround in attitudes and behaviors. Moreover, the use and commercialization of turtles in Colombia is far more controlled than it was just a few decades ago. Doña Fefa and her slaughterhouse have both passed on, sea turtle meat is seldom seen on restaurant menus, and trade in hawksbill shell has significantly dropped off thanks to decades of work done by Parques and many other institutions, including the Iniciativa Carey (Hawksbill Initiative), a program led by the World Wide Fund for Nature (WWF) and the Fundación Tortugas del Mar (Marine Turtle Foundation). Moreover, public aquariums serve an important role in the study of sea turtles in captivity, including the Research, Education, and Recreation Center (Centro de Investigación, Educación y Recreación, or CEINER), Mundo Marino at the Jorge Tadeo Lozano University, and the Rodadero Aquarium in Santa Marta. Parques monitors beaches and feeding grounds, enforces protection, and oversees broad education and outreach programs in nine federally protected areas that ensure critical habitat for sea turtles.
The Caribbean coast and surrounding islands also host important feeding grounds for green turtles in places such as the Guajira Peninsula and the San Bernardo Archipelago. Hawksbill nesting is sparse but widespread on dozens of Colombian beaches, and protected beaches in the Gulf of Darién form the core of what is considered the fourth-largest leatherback nesting population in the world. The San Bernardo Islands and coastal areas eastward to Cartagena and beyond have numerous active community-based groups dedicated to sea turtle protection. And all four sea turtle species found from Santa Marta eastward to Venezuela have conservation initiatives led by enthusiastic university students, government employees, ecotourism businesses, indigenous communities, and even the military.

TOP-DOWN AND BOTTOM-UP CONSERVATION

Like politics, virtually all conservation is local. Yet for decades, sea turtle research and protection in Colombia were overseen by national and departmental agencies in capital cities, whose policies, programs, and support did not always reach the field. Most of Colombia's sea turtle nesting beaches are in remote areas that are regularly accessed only by local fishers, farmers, and indigenous people, and many of these residents have also shifted from being poachers to conservation leaders in the past generation. Colombian citizens are now taking charge of conservation at the local level, working hand-in-hand with national agencies such as Parques and Minambiente (the Ministry of Environment and Sustainable Development), as well as seven autonomous regional corporations, including those of La Guajira (Corpoguajira), Urabá (Corpourabá), and Magdalena (Corpamag).

In Caribbean Colombia's extreme west, where leatherback research in the Gulf of Darién was led by Bogotá-based agencies in the 1980s, conservation is now overseen by local residents and nongovernmental organizations (NGOs); community councils including Cocomasur, Cocomaseco, and Cocomanorte; and the Darién and Mamá Basilia Foundations. Experts from the latter monitor Colombia's most important leatherback beach, La Playona, and lead education and tourism activities with help from Parques. On the opposite side of the Gulf of Darién, in the Regional Integrated Management District of Ensenada de Río Negro, a group of enthusiastic farmers, Acaetru, monitors Bobalito Beach and other nearby sea turtle nesting sites. This community-based group works alongside Corpourabá and the NGO Fundación Conservación Ambiental Colombia (the Colombia Environment Conservation Foundation).

In the Corales del Rosario and San Bernardo Natural National Park, patrolling and outreach led by an engaged fisherman, Bernardo Medrano, with support from CEINER, have significantly advanced a dialogue about sea turtle conservation among the region's fishers that has resulted in greater egg protection and nest oversight for hawksbills. This effort has also provided environmental education for youth that is motivating permanent interest in turtle protection and conservation.

Continuing eastward, between Barranquilla and Santa Marta, the Acepex Association has rescued and released more than 50 hawksbill and green turtles in the towns of Tasajera, Pueblo Viejo, and Ciénaga. And at the foot of the Sierra Nevada de Santa Marta, Colombia's highest mountain range, monitoring of sea turtle nesting beaches has been led by several groups, including the Fundación Tortugas Marinas de Santa Marta, WIDECAST Colombia, and ProCTMM, all of which have worked effectively alongside Corpamag and a local fishers' association. Similarly, in Dibulla and La Punta de los Remedios, fishers from the Asopamudi Association now voluntarily release sea turtles caught in their gillnets, while further to the east, another NGO, Campesina, has done similar work since 2015 in collaboration with ProCTMM and Corpoguajira.

The Guajira Peninsula, located in the far northeastern portion of the country, is also inhabited by the indigenous Wayuu people, whose ancestral territory overlaps the border between Colombia and Venezuela. Since 2009, members of this community, together with Conservation International—Colombia, Corpoguajira, and the international coal company Cerrejón, have participated in an effort to curtail turtle exploitation by helping the Wayuu to develop income alternatives through ecotourism and the sale of native products.

COMMITMENTS FOR THE FUTURE OF COLOMBIA'S SEA TURTLES

Over the years, Colombian government agencies, NGOs, and universities have dedicated significant resources in sea turtle research. They are also investing in the training of a new generation of scientists who will be adept at understanding genetics, climate change, hatchling sex ratios, foraging area delineation, and an array of tools and techniques for effective marine turtle conservation. Many of these groups and individuals have actively partnered with SWOT to gather, update, and publish information on the biogeography of Colombia's sea turtles (SWOT Report, vol. XI, pp. 14–27), and several have received SWOT small grants since 2006.

The National Program for the Conservation of Marine and Continental Turtles (2002) and the National Plan for Migratory Species (2009) emphasize the need to produce up-to-date, accurate, and comprehensive data on sea turtles and to implement a system of data management and data sharing. In response to this need, Minambiente formed the National Working Group on Sea Turtles in 2017.

In December 2018, a meeting organized by SWOT and the JUSTSEA Foundation was held among a variety of interested parties and organizations at the Fifth Colombian Zoology Congress to discuss a path forward for Colombian sea turtle conservation. The main achievement of the meeting was an agreement among Minambiente, INVEMAR, and SWOT to pursue a platform for the standardization and sharing of Colombian data that can better conserve sea turtles. If all goes as planned, in early 2020 a joint Framework Agreement for Cooperation (Convenio Marco de Cooperación) will be ratified by Minambiente, INVEMAR, and the Oceanic Society—as the legal representative of SWOT—to promote a series of national and regional efforts that aim to establish a standardized sea turtle monitoring program for Colombia. This program will include all the relevant national actors in the gathering of data for sea turtle conservation planning and monitoring, and it will ensure that these data serve not only Colombia’s conservation efforts, but also the efforts of other regional and global-scale sea turtle conservation programs.

All of Colombia’s sea turtle researchers, conservationists, and enthusiasts see a brighter future for sea turtles and fervently hope that this new program will blossom, grow, and serve as an example to other countries that are equally passionate and committed to ensuring that sea turtles continue to thrive in healthy oceans everywhere.
Turtles Help Tackle Ocean Plastic Pollution in Europe

By Claude Miaud and Gaëlle Darmon

A new directive adopted by the European Union aims to reduce marine litter impacts on sea turtles and other species throughout European waters. © Jérôme Bourjea
Plastic litter is now ubiquitous in the world’s oceans, and it has considerable impacts on marine wildlife. More than 700 species are known to be affected by litter, primarily through ingestion and entanglement, including all species and age classes of sea turtles globally.

To address this growing problem, and other threats to the marine environment across Europe, in 2008 the European Union (EU) adopted the Marine Strategy Framework Directive (MSFD), which commits EU member states to actions that improve ocean health. Among the 11 descriptors outlined by the MSFD, the aim is to tackle this scourge by reducing the amount of marine litter so that it “no longer cause[s] harm to the coastal and marine environment.” Several indicators were developed to assist in monitoring the distribution, abundance, and impacts of plastic litter in the oceans.

Sea turtles, especially loggerheads, are valuable indicators of ocean health in EU waters because they have large spatial distributions and use many different marine habitats throughout their lives. In the case of plastic litter, sea turtles ingest plastic both directly, by confusing it with their natural prey, and indirectly, when it is mixed in with their natural food items. Although plastic ingestion is rarely found to have been a certain, direct cause of death for turtles, it has many negative health impacts. Thus, sea turtles were chosen as a focal species for monitoring the marine litter component of the MSFD.

To support the MSFD, as well as the Regional Sea Conventions (the Oslo/Paris-Macaronesia Convention in the Atlantic Ocean, the Barcelona Convention in the Mediterranean, and the Helsinki Commission in the Baltic), a two-year, EU-funded project was launched in 2017 to evaluate marine litter impacts on sea turtles. The project, called INDICIT (Implementation of Indicators of Marine Litter on Sea Turtles and Biota in Regional Sea Conventions and Marine Strategy Framework Directive Areas) began by developing and disseminating standardized tools for monitoring litter impacts on turtles, including a multilingual monitoring protocol, observation forms, and other data recording tools. To help stakeholders use the new protocols, INDICIT launched an online video tutorial that detailed field and laboratory methods for properly handling turtles and recording data concerning ingested litter.

More than 100 institutions, including stranding networks, rescue centers, veterinary institutes, and research laboratories, participated in measuring litter impacts on sea turtles using the INDICIT protocol during 2017–19. Data were collected on the digestive tract contents of more than 1,000 sea turtles found throughout EU waters. Alarmingly, plastic litter was found in more than 60 percent of autopsied turtles, and locally the occurrence can reach 100 percent. The plastics were often single-use items and consisted of fragments of hard plastics, sheet-like packaging, plastic bags, and threadlike materials that generally come from fishing gear. INDICIT’s findings have clearly demonstrated the extent of marine litter impacts on wildlife in EU waters, and they provide a strong justification for European countries to take action to address the problems through a variety of actions, such as imposing limits on single-use plastics.

On the basis of these findings, the INDICIT consortium—made up of 10 partner institutions in seven countries, supported by an advisory board of member state representatives and experts—developed marine litter impact indicators to monitor the effectiveness of measures to address marine litter impacts on marine fauna. For the indicator of “litter ingested by sea turtles,” the consortium also proposed thresholds below which marine litter is supposed to no longer cause harm to individual sea turtles’ health (“good environmental status” may be reached).

A second two-year project, called INDICIT II, was launched in early 2019 to better understand how to deliver measurable impacts in lowering “litter ingested by sea turtles” by reducing plastic litter, such as through bans of single-use plastics. The project will also study the impacts of litter ingestion on individual turtles’ health. Beyond sea turtles, INDICIT II aims to develop indicators related to entanglement and ingestion of microplastic particles (smaller than 5 millimeters).

The greatest hope of INDICIT’s hundreds of partners across Europe is that their work can advance efforts to reduce the threats to the ocean posed by plastic litter and thereby improve the lives of sea turtles, ocean biodiversity, and people everywhere.

To access the monitoring tools developed by INDICIT and view a short documentary about the project, visit https://indicit-europa.eu/. The INDICIT II consortium is seeking new collaborators to help collect more data on litter impacts, not only in the areas targeted by the project, but also on a larger scale. To join, send an email to coordination@indicit-europa.eu.
Top Smartphone Apps for Sea Turtle Work

By Craig Turley

Smartphones and tablets have the potential to revolutionize the way we collect data on sea turtles and other species by putting powerful technology in the palms of our hands when and where we need it most. Although this field is still growing, a variety of mobile applications (apps) have already been developed to harness mobile technology for sea turtle research and conservation, taking advantage of the standard sensors and other tools that are found in today’s mobile devices.

Apps offer a number of advantages to traditional paper-based data collection. They can minimize data input errors; reduce time-consuming manual data entry; quickly and automatically generate spreadsheets; capture lots of data automatically (e.g., time, date, location, photos, videos, and sound recordings, as well as weather, moon phase, and more); and automatically upload data to the cloud to reduce the risks of data loss. They also offer features and potential uses that traditional data collection methods do not, such as the ability to create and use interactive maps, to facilitate collaboration by uploading data to a shared database, and to harness the power of citizen scientists on a large scale.

HOW TO CHOOSE AN APP

With a growing number of mobile apps on the market, it can be difficult and time consuming to research the strengths and weaknesses of each and to determine the best app to support your goals. Many projects consider developing their own apps, but it is worth first exploring what already exists. This article provides an overview of some of the most popular apps that are currently available for sea turtle research and conservation, and it can be used as a starting place for researchers looking to incorporate this technology into their programs. Here are a few important things to consider when choosing an app:

Data accessibility and storage. Some researchers may need exclusive access to their data to allow for a more detailed analysis and eventual publication. They may therefore want to avoid apps that make data publicly available through open-source databases. However, apps that do make data publicly available can offer the potential for greater collaboration and public outreach and can also attract broader contributions of useful data. Some open-source apps make higher-resolution data available by request, using data protection protocols that ensure exclusivity when needed.
Cost and convenience. App development can be costly and time consuming, and it often requires technical know-how beyond that of most sea turtle researchers. Using an off-the-shelf app that is available through the Google Play Store or the Apple App Store may be the best choice for budget-constrained projects. However, there will generally be trade-offs, and paying more for a customized experience definitely has its advantages. Beyond the apps themselves, buying (and replacing) mobile phones or tablets can be a large investment, and access to mobile networks can require subscription fees.

Stability, support, and longevity. Before committing to an off-the-shelf app, it is a good idea to do some homework about the app developer and to research how widely used the app is. Some apps have huge communities of users, robust technical support, and a developer that is committed to maintaining the platform (for example, iNaturalist), whereas others may have been built by a small team with no plans or funding for future maintenance and little or no capacity for user support. With the high frequency of updates to mobile operating systems and to mobile devices themselves, unsupported apps are more likely to develop bugs over time.

TODAY’S SEA TURTLE APP OPTIONS

The table below summarizes some of the apps now available for sea turtle research and conservation and provides a brief overview of key features. This guide is not exhaustive, and the pace of technology makes it a moving target, but it can be a starting place for researchers and conservationists exploring using this valuable technology to enhance their work in 2020. Nearly all of the apps can be found online or in either the Apple App Store or Google Play Store. Instructions are provided for requesting those apps that are not readily available.

<table>
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<tr>
<th>NESTING AND IN-WATER CENSUS</th>
<th>RASTR (Records Assistant for Sea Turtle Researchers)</th>
<th>This app collects data on nesting, bycatch, and turtle products, with fields for morphometry, biological samples, and more. (iOS)</th>
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<tr>
<td>Siren Turtles</td>
<td>This app is used to centralize and standardize nesting data for comparative studies using SWOT minimum standards. (Android)</td>
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<tr>
<td>Nest Tracker</td>
<td>Designed by the Cayman Islands Department of Environment (DOE) to monitor all turtle-related data collection (nesting, excavations, disorientations, and more), features include mobile network backup, as well as daily autogenerated spreadsheets sent directly to DOE staff. Available by request to <a href="mailto:nesttracker.ky@gmail.com">nesttracker.ky@gmail.com</a>. (iOS)</td>
<td></td>
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<tr>
<td>Clutch Keeper</td>
<td>Able to monitor all aspects of beach monitoring and nest tracking, this app uses an interactive map alert when excavation is required. (Android and iOS)</td>
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<tr>
<td>Iris</td>
<td>Designed for at-sea aerial surveys, this app allows users to simply and quickly record sightings data on multiple taxa, including sea turtles. For a copy, email <a href="mailto:info@mrf-asia.org">info@mrf-asia.org</a>. (Android)</td>
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<tr>
<th>CITIZEN SCIENCE</th>
<th>Turtles Uniting Researchers and Tourists (TURT)</th>
<th>This app is designed for use in reporting turtle sightings, and products using an interactive web-based map. (Android and iOS)</th>
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<tr>
<td>eTurtle</td>
<td>Users can report sea turtle sightings in the Mediterranean. (Android)</td>
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<tr>
<td>SEAAlly</td>
<td>This app allows users to report sea turtle and shark sightings, bycatch, and entanglement in the Mediterranean region, and is linked to an online interactive map. (Android and iOS)</td>
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<tr>
<td>Cero Carey</td>
<td>This app allows tourists in Cartagena, Colombia, to identify and report hawksbill products, in Spanish, directly to the environmental police. (Android)</td>
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<tr>
<td>iNaturalist</td>
<td>Not specific to sea turtles, this widely used app allows users to identify, report, and catalog biodiversity using a personal profile linked to a global network of other users. (Android and iOS)</td>
<td></td>
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<tr>
<td>HerpMapper</td>
<td>Used for reptile and amphibian sightings, this app can be customized for sea turtle–specific projects. (Android and iOS)</td>
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<tr>
<td>Ghost Gear Reporter</td>
<td>Designed for fishers, divers, and citizen conservationists, this app allows users to report sightings, bycatch, or ghost gear entanglement. (Android and iOS)</td>
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<th>CUSTOM PLATFORMS</th>
<th>Fulcrum</th>
<th>This highly customizable platform requires a monthly subscription and has 20 GB of cloud storage. (Android and iOS)</th>
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<tr>
<td>Open Data Kit (ODK) Collect</td>
<td>This free, open-source app is powerful and customizable. (Android &amp; iOS)</td>
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= AUTHOR’S PICK
With their specialized biology and their unique behaviors, sea turtles tend to inspire a lot of questions. Spend an hour with someone who is watching a turtle nest for the first time, and inevitably the questions will come: How old do they get? Where will she go after she leaves the beach? Where did she mate? When will she come back? How long until the babies become adults? And so on.

When it comes to turtles, however, the answers to such seemingly simple questions can be surprisingly elusive. Those of us who work with turtles have therefore grown accustomed to answering with phrases such as “We don’t really know, but …” or “Our best guess is that …” Although the lack of concise answers to basic questions about sea turtle biology can be frustrating, that lack is precisely what makes sea turtles so interesting to study. After decades of scientific study, sea turtles are still mysterious in many ways.

Increasingly, however, advances in technology and results of long-term studies are giving scientists the information they need to answer with increasing certainty some age-old questions about turtles. Some mysteries are being solved, yet others still are answerable only with our best guess. With such continuing mysteries in mind, last year we launched this new segment in SWOT Report by inviting experts to weigh in with current perspectives about some of the most frequently asked questions concerning sea turtles. This year we tackle two new questions. Read on to hear what the experts had to say.

IS THAT TURTLE A BOY OR A GIRL?
By Itzel Sifuentes-Romero and Jeanette Wyneken

How can we tell if a sea turtle is female or male? In adults, it’s relatively easy—a male has a long tail that extends well beyond the carapace, with a cloacal opening near the tip. In comparison, a female has a short tail with a cloacal opening near the base. With hatchling and sub-adult turtles, it’s not possible to determine their sex simply by looking at them; they are not sexually dimorphic, meaning that they do not have any external features to distinguish males from females. They lack such features because the hormones that are responsible for changing the anatomy are not present in high enough amounts to trigger those differences until they reach sexual maturity—and that can take decades!

Sexual identification of young sea turtles is further complicated by the fact that, unlike mammals, they don’t have sex chromosomes (no X or Y); therefore they lack sex-specific genes that could be used to determine sex with a DNA sample. In mammals, for example, the *Sry* gene is only on the Y chromosome, and its presence or absence can be used to determine sex. In contrast, sea turtles’ sex is determined by the incubation temperature they experience as embryos—warmer incubation temperatures produce females, and cooler temperatures produce males. But, if not through sex chromosomes, how does that system work? We have found that temperature is able to trigger a gender-specific cascade of genes that directs the embryo to differentiate the reproductive tract and gonads (ovaries or testes) and instruct the formation of ducts that will carry eggs or sperm later in life.

Though small, these gender-specific differences in turtles’ reproductive tracts can be seen by looking inside young, posthatchling turtles (120 grams, about 82–97 centimeter straight carapace length, depending on species) using a procedure called laparoscopy. In female posthatchling turtles, a laparoscope allows us to see a white ovary and a big, mobile, immature oviduct (called the Müllerian duct) with a very well-defined lumen. If the young turtle is a male, then we see cream-colored gonads, usually with a network of very small blood vessels. Male turtles also lack a complete Müllerian duct; it may be entirely absent or simply incomplete.

Unfortunately, hatchling turtles are too small for a laparoscope. So how can we tell if a hatchling is male or female? The answer relies on the sex-specific proteins that are induced by the incubation temperature. The majority of those proteins are produced in the gonads. We discovered that one protein, known as anti-Müllerian hormone, is released into the blood stream only in males. That hormone, therefore, makes it possible to identify the sex of hatchlings by analyzing a small blood sample. Currently, we know that this test works for loggerhead hatchlings, and we are beginning to test it on
other sea turtle species as well. Our next goal is to develop this assay into a field kit, so that measuring the primary sex ratio of any species can be done in the field and not just in the lab. This next step would be a huge breakthrough for sea turtle conservation research, because sex ratio is a fundamental piece of demographic information that will allow us to help plan future management strategies in the face of climate change.

**HOW MANY SEA TURTLES ARE THERE?**

By Bryan P. Wallace

Sea turtles swim in all of the ice-free areas of the world’s oceans. Their generations span several decades, so populations comprise turtles of many sizes and ages. What’s more, we humans catch only fleeting glances of them in the ocean, seeing mostly the females that come ashore to nest, so typically we can count just egg-laying adult females and their offspring. With all this in mind, making defensible estimates of the total number of sea turtles in the ocean requires math, modeling, assumptions, and a lot of creativity. But let’s give it a try!

Others have tried estimating the number of turtles in the sea when trying to paint a picture of what marine resources looked like historically. For example, studies of historical harvesting and fishing records from 300 to 500 years ago estimated that between 33 million and 39 million, or even as many as 91 million, adult green turtles existed in the Caribbean before Columbus’s fleet, and those that followed it, took their toll. The historical abundance of sea turtles is the stuff of legends: there were so many green turtles in the Caribbean that the sounds of turtles breathing and the bonking of their carapaces against the ships’ wooden hulls were cues used by sailors to navigate around islands when visibility was poor.

For Europeans invading the Caribbean, sea turtles were free, they were relatively easy to catch, and they could be kept alive for weeks with minimal care, thus serving as a seemingly endless source of fresh meat and eggs. Europeans were unfamiliar with the region, and most islands did not readily provide agricultural resources to support new settlements, so it is no exaggeration to say that sea turtles fueled European invasion, exploitation, and colonization of the Americas. Think about that; one of the most consequential turning points in human history might not have happened if the sea wasn’t full of turtles.

Historical depletion by European exploitation is now a well-documented theme in the Caribbean and elsewhere, so we know that today’s populations of green turtles—and all other species—are far smaller than before Europeans got a taste for them. But how much have populations been depleted? And how many are there today? There is no robust estimate, and for the reasons raised above, generating an accurate number is probably impossible. However, a 2011 paper (Wallace et al. 2011) provided defensible estimates of nesting population abundance (in average annual ranges) for all sea turtle regional management units worldwide. If we sum up the minimum and maximum values of those estimated ranges, we can calculate rough estimates of the total number of nesting females. With assumptions about sex ratios, we can even estimate the number of adult males too. (I will leave estimates of juvenile turtles to braver folks than I.)

The totals from this exercise show that, as of 2011, a maximum of 7.5 million adult females of all sea turtle species existed globally. Assuming a 3:1 ratio of females to males, fewer than 10 million adult sea turtles remained. For green turtles alone, there were perhaps 1.5 million females worldwide, and only 300,000 in the Caribbean. That’s quite a bit different than the historical estimates before European exploitation.

Despite the dramatic declines in turtle abundance since Europeans arrived, turtles have been hanging on. In some places, their numbers have increased in recent years. Over the past several centuries and even in recent decades, humans have done a great job of reducing sea turtle numbers through consumption and other activities. Now it’s up to today’s and tomorrow’s humans to do a great job at reversing those trends.

### TOTAL ADULTS (ASSUMING 3:1 FEMALE TO MALE RATIO)

<table>
<thead>
<tr>
<th>SPECIES</th>
<th>MIDPOINT</th>
<th>LOWER BOUND</th>
<th>UPPER BOUND</th>
</tr>
</thead>
<tbody>
<tr>
<td>Loggerhead</td>
<td>314,000</td>
<td>91,000</td>
<td>536,000</td>
</tr>
<tr>
<td>Green</td>
<td>1,002,000</td>
<td>245,000</td>
<td>1,759,000</td>
</tr>
<tr>
<td>Leatherback</td>
<td>426,000</td>
<td>133,000</td>
<td>1,289,000</td>
</tr>
<tr>
<td>Hawksbill</td>
<td>57,000</td>
<td>30,000</td>
<td>83,000</td>
</tr>
<tr>
<td>Kemp’s ridley</td>
<td>21,000</td>
<td>3,000</td>
<td>25,000</td>
</tr>
<tr>
<td>Olive ridley</td>
<td>4,618,000</td>
<td>558,000</td>
<td>5,600,000</td>
</tr>
<tr>
<td>Flatback</td>
<td>23,000</td>
<td>7,000</td>
<td>69,000</td>
</tr>
<tr>
<td>Global total</td>
<td>6,461,000</td>
<td>1,067,000</td>
<td>9,361,000</td>
</tr>
</tbody>
</table>

Female abundance estimates were derived from the midpoints and upper and lower bounds of ranges of average annual abundance in Wallace et al. (2011) Global conservation priorities for marine turtles, PLoS ONE 6(9): e24910. doi:10.1371/journal.pone.0024910. Average remigration intervals by species were used to estimate total numbers of adult females, and an assumed 3:1 sex ratio allowed for estimation of total numbers of adult males. These abundance estimates were generated for illustrative purposes only and should be interpreted accordingly. AT LEFT: One way to determine sex in adult sea turtles is to look at their tails. Males’ are long and extend past their carapace, as visible on the lone turtle (left) in this photo, whereas females’ are much shorter. © Nicolas J. Pricher
Acting Globally
SWOT Small Grants 2019

Since 2006, SWOT’s small grants have helped field-based partners around the world to realize their research and conservation goals. To date, 93 grants have been awarded to 67 applicants in more than 45 countries and territories for work addressing three key themes: (1) networking and capacity building, (2) science, and (3) education and outreach.

The following are brief overviews of our 2019 grantees. Visit www.SeaTurtleStatus.org/grants for application instructions and a list of all past SWOT grantees.

Arizona State University (U.S.A.)

Bycatch is a global threat to sea turtles and other marine species, and many efforts have been dedicated to mitigating bycatch by industrial-scale fisheries. Less attention has been focused on small-scale fisheries, even though many small fisheries have high rates of bycatch. Janie Reavis and collaborators at Arizona State University are researching novel bycatch reduction technologies (BRTs) for small-scale fisheries. Their aim is to decrease bycatch rates without negatively affecting fisheries, which is especially important in developing areas. Janie will use a 2019 SWOT grant to test and develop the efficacy of new BRTs that use sensory cues to discourage turtles from interacting with fishing gear. Her results will be applicable to small-scale net fisheries in Baja California, Mexico, and potentially elsewhere.

Bluefields Bay Fishermen’s Friendly Society (Jamaica)

The sea turtle monitoring program of the Bluefields Bay Fishermen’s Friendly Society (BBFFS) was established in 2006 to reduce the poaching of nesting females and their eggs. The monitoring program includes nightly patrols of Bluefields’ two main nesting beaches, tagging of nesting females, and education and outreach activities within the community. The wardens’ nightly presence at the nesting beaches provides a deterrent to poachers while also allowing them to collect data on the nesting activities taking place. Collected data are shared with the National Environment and Planning Agency, Jamaica's environmental regulatory agency. The BBFFS will use a 2019 SWOT grant to continue its beach monitoring efforts and improve communication and data sharing with nearby organizations.
Casa Congo (Nicaragua)

Río Escalante—Chacocente Wildlife Refuge lies on the Pacific coast of Nicaragua and harbors one of two beaches in the country where thousands of olive ridley turtles come to lay their eggs in a phenomenon known as an arribada. The refuge also provides nesting habitat for three other species of sea turtles—green, hawksbill, and leatherback. Located within and around Chacocente are 17 rural communities that are economically dependent on the extraction of fish and turtle eggs, despite the government’s efforts to halt poaching activities. Casa Congo facilitates community-based conservation in the area, running projects and programs alongside community members, researchers, interns, and volunteers. A 2019 SWOT grant will be used to construct and maintain a hatchery that not only will protect sea turtle nests but also will serve as an education tool for youth in the local communities.

Equilibrio Azul (Ecuador)

Puerto López beach on Ecuador’s Pacific coast is one of the few index nesting beaches for the critically endangered east Pacific population of hawksbill sea turtles. In the past few years, this nesting habitat has been heavily affected by an increase in construction on and around the beach. With the weight of its 12 years of nesting data, Equilibrio Azul will use a 2019 SWOT grant to inform the local community and government about the importance of conserving and recuperating the beaches that provide vital nesting habitat for these critically endangered turtles. Ultimately, Equilibrio Azul aims to create a sea turtle conservation zone on approximately 800 meters (one-half mile) of developed beach.

Haiti Ocean Project (Haiti)

Haiti is possibly one of the biggest exploiters of sea turtles in the Caribbean region, yet little data exist on Haiti’s artisanal fisheries. Basic ecological data on Haiti’s sea turtle populations are also lacking. The Haiti Ocean Project is a marine conservation, education, and research organization located in southwest Haiti that educates youth, fishermen, and their communities about their marine environment. With a 2019 SWOT grant, Haiti Ocean Project will study the rates of directed take and bycatch of sea turtles in the artisanal fisheries of the Nippes and Grand’Anse regions and will assess the extent of local fishers’ knowledge about sea turtles and fishery regulations. This study will help assess the scale of the threat that artisanal fisheries pose to Haitian sea turtle populations and will identify gaps in the knowledge of fishers and the Haitian public that could be targeted by future education programs.

ProTECTOR Inc. (Thailand)

Although it is confirmed that green and hawksbill turtles nest in the Gulf of Thailand, there is little up-to-date information on the state of sea turtle nesting in the gulf, and currently no coordinated efforts by government or local communities have been undertaken to remedy this lack. ProTECTOR will use a 2019 SWOT grant to establish a Gulf of Thailand Nesting Recovery Network (GoTNRN), starting by holding capacity-building workshops in three communities in the Gulf of Thailand (Koh Talu, Thap Sakae, and Dom Sam Ram). At those workshops, participants will discuss shared goals, standard methods, government assistance, data reporting, funding development, and expansion of the network into other areas. Through its efforts, ProTECTOR hopes both to increase awareness of sea turtles in the region and to create future opportunities to gather new sea turtle data throughout Thailand.

RASTOMA (Cameroon, Gabon, and São Tomé and Príncipe)

Plastic pollution, as well as the degradation of feeding and reproductive habitats, are causes of sea turtle mortality worldwide. To mitigate this threat to the five species of sea turtles that inhabit the coastal waters of Central Africa (green, leatherback, olive ridley, hawksbill, and loggerhead), RASTOMA (Réseau des Acteurs de la Sauvegarde des Tortues Marines en Afrique Centrale) has adopted a “Beaches without Plastic” plan. The organization will use a 2019 SWOT grant to help reduce the impact of plastic on sea turtles by holding workshops and outreach campaigns in Cameroon, Gabon, and São Tomé and Príncipe. The workshops will focus on repurposing plastic waste into goods that can help communities generate income and raise awareness about plastic pollution.

Turtle Foundation (Indonesia)

After visiting a beach on the west coast of Pulau Sipura in the Mentawai Islands and discovering the remains of slaughtered leatherback turtles and poached nests, the Turtle Foundation decided to take action. Little is known about the northeast Indian Ocean subpopulation of leatherbacks, which is listed as Data Deficient by the IUCN Red List. With help from a 2019 SWOT grant, the Turtle Foundation aims to address this data gap using satellite tracking of female leatherbacks that nest on Pulau Sipura. By following the turtles’ movements, the project aims to learn valuable information about migratory routes and about inter- and postnesting behavior that will be used to develop more efficient conservation strategies.
AZA-SAFE Grant Recipients

In 2019, SWOT partnered with the Association of Zoos and Aquariums (AZA) and its Sea Turtle SAFE (Save Animals from Extinction) program to make six additional grants available for projects related to the conservation of two of the top global priorities for sea turtle conservation—eastern Pacific leatherbacks and Kemp’s ridleys—throughout their respective ranges. The projects on this spread were awarded 2019 SWOT grants thanks to the AZA-SAFE program.

ZIHUATANEJO, IXTAPA, AND LA BARRITA, GUERRERO, MEXICO
Campamento Tortuguero Ayotlcalli

Several sea turtle populations that nest along the Pacific coast of Mexico are declining because of human activity. In particular, the eastern Pacific leatherback is affected. The decline has motivated several communities to create sea turtle rescue and conservation camps that aim to protect these endangered animals. However, many of these projects fail because they lack government and financial support. Campamento Tortuguero Ayotlcalli will use a 2019 SWOT grant to develop a collaborative regional network and action plan that will include environmental education programs, training opportunities, and data collection protocols. Members of the network will be nonprofits, schools, local businesses, fishermen, local government agencies, and media. By sharing experiences, methods, and support, the project aims to create more sustainable conservation efforts in local communities along Mexico’s Pacific coast.

BAHÍA SOLANO, CHOCÓ, COLOMBIA
Center for Environmental Management and Development (CIMAD)

To fill gaps in knowledge about the critically endangered eastern Pacific leatherback population, CIMAD has spearheaded research and community engagement efforts along the Pacific coasts of Panama and Colombia. Through the project, CIMAD aims to increase understanding of leatherback nesting locations, identify priority conservation areas, and attract local and global attention. CIMAD will use a 2019 SWOT grant to train community members to conduct nightly patrols and record sea turtle nesting activity, and it will use funds to financially support beach monitors. In addition, CIMAD will spread awareness about the project and connect with Colombian agencies and communities to increase awareness and support for their work.

REGION DE ARICA Y PARINACOTA, CHILE
Instituto de Fomento Pesquero

Incidental capture in small-scale longline fishing gear is the main threat to the green, loggerhead, olive ridley, and leatherback turtles that inhabit northern Chile’s coasts. Using sea turtles as flagship species, the Instituto de Fomento Pesquero will use a 2019 SWOT grant to conduct workshops, lectures, and events that will educate youth, fishermen, and communities of northern Chile and instill a deeper understanding and dedication to marine conservation. Specifically, fishermen will be educated about methods to minimize sea turtle bycatch and mortality, and local communities will be educated about sea turtle biology and about ways to protect sea turtles’ critical habitats.
ISLA ARENA, CAMPECHE, MEXICO
Universidad Autónoma del Carmen

Isla Arena is a small fishing community on the Yucatán Peninsula whose beaches provide nesting habitat for hawksbill turtles and whose marine zone is a hotspot where green, hawksbill, Kemp's ridley, and loggerhead turtles all coincide during their lifecycles. Historically, local inhabitants of the island consumed turtle eggs and meat, and more recently they began to harvest eggs and capture adults to sell, illegally, to mainland communities. A local women-run nonprofit called Fileteras del Petén aims to combat turtle consumption through beach monitoring, environmental education, and outreach to promote more sustainable practices in this small community. The Universidad Autónoma del Carmen will use a 2019 SWOT grant to support Fileteras del Petén in organizing workshops and outreach activities and strengthening its sea turtle monitoring project.

TEXAS, U.S.A.
Sea Turtle, Inc.

Sea Turtle, Inc., is a nonprofit sea turtle hospital in south Texas that rescues and rehabilitates sick and injured sea turtles for release back into the wild, educates the public, and assists with conservation efforts for marine turtles. Kemp's ridley conservation is a priority during nesting season, which coincides with peak tourist visitation on south Texas beaches that are open to vehicular access and are also home to the only nesting ground for this critically endangered species. Public awareness about the presence of sea turtle activity during the nesting season is critical to effectively protect nesting and hatching turtles. Using a 2019 SWOT grant, Sea Turtle, Inc., will place bilingual signs at vehicular beach access points to prevent sea turtle fatalities and increase nesting reports from beachgoers.

VALLE DEL CAUCA Y NARIÑO, COLOMBIA
JUSTSEA Foundation

Fisheries bycatch is considered the greatest threat to sea turtle populations globally. Although many efforts have sought to understand and minimize sea turtle bycatch, active participation of stakeholders in the process is lacking, especially in developing countries. To address this issue in Colombia, JUSTSEA began a project in 2016 to evaluate the nature, frequency, and impacts of fishing interactions with leatherback turtles. The project also will establish collaborative relationships with fishermen to promote data sharing and implementation of fishing practices that minimize sea turtle interactions and increase sea turtle survival after release. With a 2019 SWOT grant, JUSTSEA will lead workshops to raise awareness of leatherback turtle bycatch within the fishing community and will continue its collaborative fisheries observer program.
The data citations that follow correspond directly to the maps of Wider Caribbean sea turtle biogeography on pp. 24–27. To use these data for research or publication, you must obtain permission from the data providers.

**NESTING DATA CITATIONS: WIDER CARIBBEAN**


Following is a list of all of the data providers to the WIDERCAST Atlas and, therefore, to the nesting biogeography map on pp. 24–25, with names organized by territory. In addition to the data sourced from the WIDERCAST Atlas, supplementary data were used from the SWOT network for four nesting sites with very high nesting abundance (in Costa Rica, Mexico, Trinidad and Tobago, and the United States) to better differentiate among those sites. Those four data citations are listed at the end of this section.

For detailed nesting data citations and metadata, please refer directly to the WIDERCAST Atlas, available online at http://www.widecast.org/management/nesting-beach-atlas/
TELEMETRY DATA CITATIONS: WIDER CARIBBEAN

The following data refers to satellite telemetry datasets from tags that were deployed on sea turtles in the Wider Caribbean Region and were combined to create the map on pp. 26–27. They are organized by the country of deployment. For information regarding data processing and filtering, see the map introduction on p. 23. 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.


ANGUILLA

DATA RECORD 1

Project Title: Anguilla Marine Turtle Tracking

Partner Projects: Anguilla Department of Fisheries and Marine Resources and Anguilla National Trust, funded by the European Union Voluntary Scheme for Biodiversity and Ecosystem Services in Territories of Europe Overseas Territories Project.

Metadatas: 7 adult Caretta caretta; 3 Chelonia mydas


SWOT Contact: Louise St. John

BELIZE

DATA RECORD 2 | SWOT ID: 1284

Project Title: Hawkbill Turtle Tracking at Lighthouse Reef Atoll, Western Caribbean—MarAlliance


CAYMAN ISLANDS

DATA RECORD 4 | SWOT ID: 349

Project Title: Cayman Islands 2003: Loggerhead and Green Turtles

Partner Project: Marine Turtle Research Group, Cayman Islands Department of Environment

Metadatas: 1 adult female Caretta caretta; 2 Chelonia mydas


DATA RECORD 5 | SWOT ID: 349

Project Title: Cayman Islands 2004: Loggerhead and Green Turtles

Partner Project: Marine Turtle Research Group, Cayman Islands Department of Environment

Metadatas: 2 adult Caretta caretta; 3 Chelonia mydas


CUBA

DATA RECORD 11

Project Title: Cuban Hawksbills

Metadatas: 1 adult male and 10 adult female Eretmochelys imbricata


SWOT Contact: Félix Moncada

DOMINICA

DATA RECORD 12 | SWOT ID: 890

Project Title: Sea Turtles of Dominica

Partner Projects: Dominica Sea Turtle Conservation Organization, International Fund for Animal Welfare, and Dusky’s Friends for Change Project

Metadatas: 7 adult Dermochelys coriacea; 1 juvenile Eretmochelys imbricata


DOMINICAN REPUBLIC

DATA RECORD 13

Project Title: Dominican Republic Hawkbills

Metadatas: 9 nesting female Eretmochelys imbricata


SWOT Contact: Lucy Hawkins

FRENCH GUIANA (FRANCE)

DATA RECORD 14

Project Title: French Guiana Marine Turtle Tracking

Partner Project: CNRS

Metadatas: 10 adult Chelonia mydas; 20 adult Lepidochelys olivacea; 19 adult Dermochelys coriacea


SWOT Contact: Rafael Miranda

MEXICO

DATA RECORD 18

Project Title: Yucatán Marine Turtle Tracking

Metadatas: 12 adult female Eretmochelys imbricata; 6 adult female Chelonia mydas


SWOT Contact: Daniel Evans

PANAMA

DATA RECORD 19

Project Title: Panama Leatherback Tracking

Metadatas: 7 adult female Dermochelys coriacea; tags deployed in Guadalupe Islands


SWOT Contact: Daniel Evans

GUATEMALA (FRANCE)

DATA RECORD 15 | SWOT ID: 1022

Project Title: St. Barths—Cayman Islands and Saint Martin, French West Indies

Partner Projects: French State, Guadeloupe Region, and private sponsors

Metadatas: 4 adult female and 5 juvenile Chelonia mydas; tags deployed in Guadeloupe


MARTINIQUE (FRANCE)

DATA RECORD 1

Project Title: Martinique Marine Turtle Tracking

Metadatas: 2 adult Dermochelys coriacea


SWOT Contacts: Damien Chevaller and Philippe Chambaut

PHILIPPINES

DATA RECORD 17 | SWOT ID: 1197

Project Title: Movement Migratory of the Tortuga Carey, Islas del Parque Nacional Sistema Arrecifal Veracruzano, Acuario de Veracruz A.C.

Metadatas: tags deployed on female Eretmochelys imbricata


SWOT Contact: Daniel Evans

ANGLIA

DATA RECORD 1

Project Title: Anguilla Marine Turtle Tracking

Partner Projects: Anguilla Department of Fisheries and Marine Resources and Anguilla National Trust, funded by the European Union Voluntary Scheme for Biodiversity and Ecosystem Services in Territories of Europe Overseas Territories Project.

Metadatas: 7 adult Caretta caretta; 2 Chelonia mydas


SWOT Contact: Louise St. John
PUERTO RICO (UNITED STATES)
Data record 20
Project title: Puerto Rico Leatherback Tracking
Metadata: 1 adult female Dermochelys coriacea tags deployed between 2004 and 2016
SWOT contact: Daniel Evans

SAINT MARTIN (FRANCE)
Data record 22 SWOT ID: 1022
Project title: SEATAG—Guadeloupe and Saint Martin, French West Indies
Project partners: 3 adult female Chelonia mydas; 2 adult female Dermochelys coriacea
SWOT contact: Eric Deckro

SINT EUSTATIUS (THE NETHERLANDS)
Data record 21
Project title: Dutch Antilles Marine Tracking
Metadata: 8 nesting female Dermochelys coriacea
Data record: Scott Eckert

TRINIDAD
Data record 23
Project title: Trinidad Leatherbacks
Metadata: 8 nesting female Dermochelys coriacea
Data record: Scott Eckert

GLOBAL LOGGERHEAD SATELLITE TELEMETRY
The following data records refer to satellite telemetry datasets from tags that were deployed on loggerhead turtles worldwide and were combined to create the map on pp. 32–33. The data are organized first by ocean basin and then by country of deployment. For information regarding data processing and filtering, see the note on the map on p. 32. 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.


ARGENTINA
Data record 1
Metadata: 6 Caretta caretta; tags deployed in Argentina
SWOT contact: Victoria Gonzalez Garibay

BONAIRE
Data record 2
Metadata: 5 female Caretta caretta; tags deployed on nesting turtles
SWOT contact: Mabel Nava

BRAZIL
Data record 3
Metadata: 19 juvenile Caretta caretta; tags deployed at sea
SWOT contact: Mabel Nava

Data record 4
Metadata: 10 nesting Caretta caretta

ATLANTIC OCEAN

DATA RECORD 49 SWOT ID: 1142
Project title: Northeast Florida Green Turtle Tracking Project
Partners: Florida Sea Turtle and Fisheries Ecology Center.
Data download from OBIS-SEAMAP (http://seamap.env.duke.edu/dataset/658). (3) STAT.
SWOT contact: Erin Seney

DATA RECORD 30
Project title: Cape Canaveral Sea Turtle Tagging Project
Metadata: 22 male Caretta caretta; 3 Lepidochelys kempii
SWOT contact: Mike Arndt

DATA RECORD 31
Project title: Archie Carr Green Turtle Project
Metadata: 19 male and 8 female Chelonia mydas
Data record: Dean Bagley

DATA RECORD 32
Project title: Archie Carr Interesting Loggerheads
Metadata: 14 adult female Caretta caretta
SWOT contact: Simona Cerasi

DATA RECORD 33 SWOT ID: 658
Project title: Loggerhead Marinelink Center Tracking
Metadata: 7 adult, 3 juvenile, and 6 subadult Caretta caretta
SWOT contacts: Sarah Hersch and Charles Mariner

DATA RECORD 34
Project title: Gulf of Mexico Kemp’s and Green Turtles
Metadata: 9 Lepidochelys kempii; 15 Chelonia mydas
SWOT contact: Tasha Metz

DATA RECORD 35
Project title: More Additional Loggerheads Metadata: 7 adult male Caretta caretta
SWOT contact: Kristen Mazzarella

DATA RECORD 36
Project title: Green Turtles from Southwest Florida
Metadata: 10 adult female Chelonia mydas
Data record: Kelly Skena

SWOT Contact: Neca Marcondes

DATA RECORD 5
Metadata: 11 Caretta caretta; tags deployed in 2019.
SWOT Contact: Mike James

CANYAN ISLANDS
DATA RECORD 18 | SWOT ID: 349
Project Title: Cayman Islands 2003: Loggerhead and Green Turtles
Data Sources: (2) Silverthorn, T., M. E. Freeland, and M. E. Freeland. 200.

SWOT Contact: Ken Blumenthal

DATA RECORD 24
Metadata: 3 Caretta caretta
SWOT Contacts: Matthew Godfrey and Ken Beasley

DATA RECORD 25 | SWOT ID: 996
Project Title: North Carolina Rehabsitlated Sea Turtle Monitoring Project
Project Partners: Ken Beasley, Sea Turtle Research and Rehabilitation Center, and North Carolina State University
Metadata: Tags deployed at sea
SWOT Contact: Michael Coyne

DATA RECORD 26
Metadata: Canid Caretta caretta; tags deployed at sea
SWOT Contact: Kate Mansfield
Project Partners: Seaturtle org, the North Carolina Wildlife Resources Commission, and Duke University Marine Lab. 

Metadata: a: California. 

DATA RECORD 33 | SWOT ID: 1342

Project Title: Florida Loggerhead Migrations

Project Partner: National Marine Fisheries Service Office of Protected Resources.


DATA RECORD 34 | SWOT ID: 1490

Project Title: Juvenile Loggerhead Use of the Gulf Stream off Cape Hatteras, North Carolina

Project Partners: North Carolina Renewable Energy Program, Protected Resources Branch of the National Oceanic and Atmospheric Administration Beaufort Laboratory, University of North Carolina Coastal Studies Institute, North Carolina Aquarium at Pine Knoll Shores and Roanoke Island, and University of Central Florida

Metadata: 3 juvenile Caretta caretta; head-started turtles originally collected from North Carolina nests; tagged turtles released in Sargassum mats in the gulf stream off the coast of North Carolina in May.


DATA RECORD 35 | SWOT ID: 1547

Project Title: Meta Marine Lab Males

Metadata: 7 adult male Caretta caretta


DATA RECORD 36 | SWOT ID: 1627

Project Title: Actua Cart Interesting Loggerheads

Metadata: 14 adult female Caretta caretta


SWOT Contact: Simon Cerani.

DATA RECORD 37 | SWOT ID: 1633

Project Title: Loggerhead Marinelife Center Tracking

Metadata: 7 adult, 3 juvenile, and 6 subadult Caretta caretta


INDIAN OCEAN

AUSTRALIA

DATA RECORD 38

Project Title: Western Australia Loggerhead Migrations

Metadata: 31 Caretta caretta


DATA RECORD 39 | SWOT ID: 1045

Project Title: Movements of Late Juvenile Loggerhead Sea Turtles from Reunion Island (Caretta caretta)

Project Partner: Kéline and Ymer Mer"e

Metadata: 22 adult Caretta caretta; tags deployed in La Reunion, 2006–2009


DATA RECORD 40 | SWOT ID: 9994

Project Title: Zooplankton community in the Indian Ocean

Metadata: 2017 Caretta caretta; tags deployed in Japan


DATA RECORD 41 | SWOT ID: 1108

Project Title: Movements of Caretta caretta in the Southern Indian Ocean

Metadata: 10 adult Caretta caretta


SWOT Contact: Simon Cerani.

SOUTH AFRICA

DATA RECORD 42

Project Title: Nesting Leatherback and Loggerhead Turtles in South Africa

Metadata: 30 adult female Caretta caretta; tags deployed in South Africa

DATA RECORD 70 | SWOT ID: 1666
Project Title: CARESAT
Project Partners: Islamgul Group, Department of Biology, University of Pisa; Tartarughe Marine; Acquario di Grosseto (Italy)
Data Sources: (1) Islamgul Group and Department of Biology, University of Pisa: Loggerheads in the waters of Tuscany, Italy, from 2014 to 2016.
Data Sources: (2) Casale, P. 2018. CARESAT: Data downloaded from OBIS-SEAMAP (http://seamap.env.duke.edu/dataset/868) on December 4, 2018. (2) OBI-SEAMAP SWOT Contact: Paolo Casale

DATA RECORD 76 | SWOT ID: 1682
Project Title: Loggerheads in the Tyrrhenian Sea
Project Partners: Sea Turtle Network, WWF Italy

DATA RECORD 81 | SWOT ID: 1686
Project Title: Mediterranean Sea Fisheries Bycatch Research
Project Partners: Fisheries Bycatch Research Group Metadatagroup: NOAA, Kail Salmon, UNC
Data Sources: (1) Swimmer, Y. 2017. Spain-Tags Merged. Data downloaded from OBIS-SEAMAP (http://seamap.env.duke.edu/dataset/1494) on December 4, 2018. (2) OBI-SEAMAP SWOT Contact: Yonat Swimmer

DATA RECORD 92 | SWOT ID: 1310
Project Title: Spain-Balearic Islands 2015 Loggerhead Turtles
Project Partners: Fisheries Bycatch Research Group Metadatagroup: NOAA, Kail Salmon, UNC
Data Sources: (1) Swimmer, Y. 2018. Spain-Balearic Islands 2015 loggerhead turtles. Data downloaded from OBIS-SEAMAP (http://seamap.env.duke.edu/dataset/9985) on December 4, 2018. (2) OBI-SEAMAP SWOT Contact: Paolo Casale

DATA RECORD 95 | SWOT ID: 1313
Project Title: Tracking Small Loggerheads from Spain
Project Partners: Universitat Politècnica de València, Universitat de València, Valencia Marine Science Institute, UCLM, Para la Vida Girona, UAB
Data Sources: (1) Swimmer, Y. 2017. Tracking small loggerheads from Spain. Data downloaded from OBIS-SEAMAP (http://seamap.env.duke.edu/dataset/6100) on December 4, 2018. (2) OBI-SEAMAP SWOT Contact: Paolo Casale

DATA RECORD 99 | SWOT ID: 980
Project Title: Loggerheads in the Adriatic Sea
Project Partners: Islamgul Group, Department of Biology, University of Pisa and ADRIA-Watch
Data Sources: (1) Riccioni, M. 2018. ADRIA-Watch project. Data downloaded from OBIS-SEAMAP (http://seamap.env.duke.edu/dataset/980) on December 4, 2018. (2) OBI-SEAMAP SWOT Contact: Marco Rizzini

DATA RECORD 100 | SWOT ID: 981
Project Title: Loggerhead sea turtles
Project Partners: Islamgul Group, Department of Biology, University of Pisa and ADRIA-Watch
Data Sources: (1) Riccioni, M. 2018. ADRIA-Watch project. Data downloaded from OBIS-SEAMAP (http://seamap.env.duke.edu/dataset/981) on December 4, 2018. (2) OBI-SEAMAP SWOT Contact: Marco Rizzini

DATA RECORD 102 | SWOT ID: 1401
Project Title: Projecto: Conservación y Preservación de Tortugas Marinas
Project Partners: Fundación para la Conservación y Recuperación de Anfibios y Reptiles Marinos (CRAM), Universidad Politécnica de León, Universidad de Granada
Data Sources: (1) 3 juvenile and 3 adult Caretta caretta; tags deployed in Tarapag, Spain in 2018, dataset includes on adult male loggerhead that traveled across the Atlantic to waters east of Florida, USA.
Data Sources: (2) Fundación para la Conservación y Recuperación de Anfibios y Reptiles Marinos (CRAM), 2019. Investigation y presas. Data downloaded from OBIS-SEAMAP (http://seamap.env.duke.edu/dataset/1314) on December 4, 2018. (2) OBI-SEAMAP SWOT Contact: Eduardo Belda

DATA RECORD 104 | SWOT ID: 912
Project Title: SPACE-SEATURTLES.ORG

TURKEY DATA RECORD 96
Project Partner: Pamukkale University Sea Turtle Rescue Center (DÜKAMER)

INTERNATIONAL RECORD
Project Title: ADRIA-Watch Project
Project Partners: Islamgul Group, Department of Biology, University of Pisa and ADRIA-Watch
Data Sources: (1) Belda, E. 2017. Tracking small loggerheads from Spain. Data downloaded from OBIS-SEAMAP (http://seamap.env.duke.edu/dataset/1314) on December 4, 2018. (2) OBI-SEAMAP SWOT Contact: Marco Rizzini

DATA RECORD 98 | SWOT ID: 980
Project Title: Loggerheads in the Adriatic Sea
Project Partners: Islamgul Group, Department of Biology, University of Pisa and ADRIA-Watch
Data Sources: (1) Riccioni, M. 2018. ADRIA-Watch project. Data downloaded from OBIS-SEAMAP (http://seamap.env.duke.edu/dataset/981) on December 4, 2018. (2) OBI-SEAMAP SWOT Contact: Marco Rizzini
IN MEMORIAM

TIM DYKMAN (1946–2019)
Tim Dykman was an idol and an inspiration to the people that knew and loved him, and he catalyzed the conservation careers of many people around the globe, from Mexico to Panama, Mozambique, and beyond. He led by example, and his creativity, inclusivity, and above all hope galvanized conservation movements around the world that included ocean revolutionaries, indigenous leaders, field biologists, fishermen, and poets and artists. As the director of Ocean Revolution, he worked directly with the Bitonga people of Inhambane, Mozambique. In consort with Mozambique’s Ministry of Fisheries and Marine Police, he played a pivotal role in creating a network of nine community-managed, nonhunting protected areas, the first of their kind in that country. Tim’s absence will be felt by many people and ecosystems the world over, but his legacy lives on in the many people continuing to live by his example.

PHOTO: © Wallace J. Nichols

B. B. SOLARIN (1949–2019)
Dr. Bashir Bolu Solarin was a respected wildlife researcher and marine conservation advocate in Nigeria. B. B. worked 38 years (1978–2016) with the Nigerian Institute for Oceanography and Marine Research (NIOMAR) in Lagos, where he rose to the position of director and head of fisheries resources. He was devoted to developing and promoting bycatch reduction technologies to reduce impacts on megafauna, especially sea turtles, while increasing the efficiency of fishing. He published impactful research, and was a member of numerous societies, committees, and organizations through which he advocated for sustainable fishing practices and marine conservation. B. B. will be greatly missed by his family, his country, and the global marine conservation community.

PHOTO: © Tony Natovic

SUE TAEI (1962–2020)
Sue Taei launched her prolific career in 1994 as biodiversity adviser to the Secretariat of the Pacific Regional Environment Programme (SPREP), where she and her teams made great advances for ocean conservation. Later, as senior director for the Pacific Islands Program for Conservation International (CI), Sue led the design and oversight of many community-based, multiuse marine protected areas (MPAs). Sue’s voice reached key decision makers, governments, donors, and local communities, and she personally led conservation initiatives at the regional, national, and international levels, most notably the Phoenix Islands Protected Area (PIPA). Sue penned the dossier that led to the creation of PIPA, one of the world’s largest (and deepest) MPAs and a World Heritage Site. Sue was CI’s lead with the Pacific Island Leaders’ Pacific Oceanscape initiative, which was adopted in 2010, was endorsed by 22 island nations, and spans 38 million square kilometers. Sue will be remembered for her passion for the ocean, and she leaves us with a legacy of achievements that will continue to guide Pacific Ocean conservation.

PHOTO: © Conservation International

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