SWOT report

Volume XVII

The State of the World's Sea Turtles

SPECIAL FEATURE hawksbill turtles

INSIDE:
CABO VERDE | CONSERVATION GENETICS
PARACHUTE SCIENCE | AND MORE ...

A green turtle swims below a school of sardines in the Philippines. © Henry Jager / www.conartix-photo.ch; FRONT COVER: A hawksbill turtle inspects a shallow reef off of islands in the southeast corner of Fiji. © David Fleetham

Mating black (green) turtles in the sea adjacent to Colola, Michoacán, Mexico, photographed as part of a global project led by photographer Tui De Roy for a coffee table book about sea turtles to be published by Princeton University Press in 2024. © Tui De Roy / Roving Tortoise Photos

Editor’s Note

Uplifting Successes and Daunting Gaps

When COVID travel restrictions lifted, I headed to Pacific Mexico to visit some success stories in sea turtle conservation that have blossomed during my lifetime. These uplifting experiences provided solace, but also reminders of the many challenges ahead for our community.

Playa Escobilla in Oaxaca is the largest nesting aggregation of olive ridleys on Earth. There, while the females waited offshore for their mysterious cues to begin nesting, I met with local turtle folks and helped gather images of hatchling releases, turtles at sea, captive rehabilitating turtles, and the historic turtle slaughterhouse in Mazunte. Right on cue, the arribada began at sunrise on October 31, 2021, hitting its stride just as Mexico was celebrating the colorful *Día de los Muertos* holiday with candlelit gatherings in cemeteries and flowery street festivals. I saw thousands of nesting females on the beach that first day, yet one of my most vivid memories was the masses of aggressively curious turtles at sea the day prior.

In anticipation of their big event, the ridleys pursued, nudged, and nipped at us like attention-craving puppies. Masked, snorkeled, and face down in a calm, deep blue sea with 60 feet of visibility, my colleagues and I lolled in a pulsing slurry of iridescent jellies, ctenophores, salps, and tunicates, with hundreds of turtles all around us. It felt like I was floating atop a blue soup of life and gazing down into lasagna-layers of turtles, all descending or rising from the depths both near and far. It was an unforgettable scene, backlit by the sun’s rippling “god rays.” Back on the beach I learned that these abundant, seemingly healthy animals are victims of extreme heavy metal contamination (see pp. 10–13) and that experts are only beginning to sample turtles globally, leaving daunting gaps in our understanding of this threat.

We also visited the renowned black (green) turtle project in Colola, Michoacán, on a breathtaking beach I had first seen decades ago, when the rookery was fighting for survival. Project head Carlos Delgado reports that this volunteer-led effort registered all-time records of some 80,000 nests and more than 5 million black turtle hatchlings in its 2021–2022 season. I marveled at the commitment of the local community members, yet I wondered how long they could sustain their valiant efforts while the pesos for every meal and gallon of gas for patrol vehicles were such a struggle to acquire. I look forward to returning to Michoacán to help them celebrate 40 years of this remarkable project and to help find solutions about how to keep it thriving.

Lest we think we have sea turtle conservation all figured out, the articles and maps herein on hawksbills (see pp. 22–31) and genetics (see pp. 16–21) remind us not only about how far we have come in our grasp of sea turtle status on a global scale, but also about the significant gaps that remain. Meanwhile, local solutions abound, like how Puerto Rico has dealt with light pollution (see pp. 32–33), or how a community has come together for turtle conservation in Cabo Verde (pp. 6–9). Our challenge must be to help others learn from and replicate those examples, while also striving to continually improve our practices, such as by moving away from colonialist practices (see pp. 36–37).

Thanks for being part of our global movement working to simultaneously tackle sea turtle and ocean conservation from the global-down and local-up perspectives.

Roderic B. Mast
Chief Editor

meet the turtles

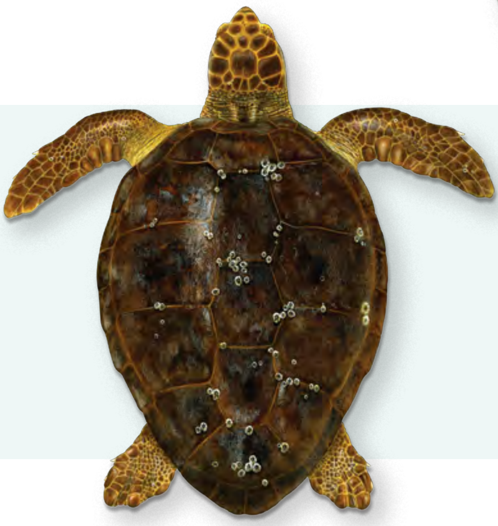
The seven sea turtle species that grace our oceans belong to an evolutionary lineage that dates back at least 110 million years. Sea turtles fall into two main subgroups: (a) the unique family *Dermochelyidae*, which consists of a single species, the leatherback, and (b) the family *Cheloniidae*, which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

Kemp's ridley
Lepidochelys kempii
CR

Olive ridley
Lepidochelys olivacea
VU

Hawksbill
Eretmochelys imbricata
CR

Flatback
Natator depressus
DD

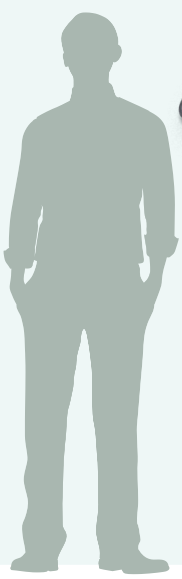


Loggerhead
Caretta caretta
VU

Green
Chelonia mydas
EN

IUCN RED LIST STATUS:

- CR Critically Endangered
- EN Endangered
- VU Vulnerable
- DD Data Deficient



Leatherback
Dermochelys coriacea
VU

Visit **www.SeaTurtleStatus.org** to learn more about all seven sea turtle species!

ILLUSTRATIONS: © Dawn Witherington

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VOLUME XVII

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Brian J. Hutchinson
Patricia Elena Villegas
Ashleigh Bandimere

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SWOT
The State of the World's Sea Turtles

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State of the World's Sea Turtles
Oceanic Society
P.O. Box 844
Ross, CA 94957
U.S.A.

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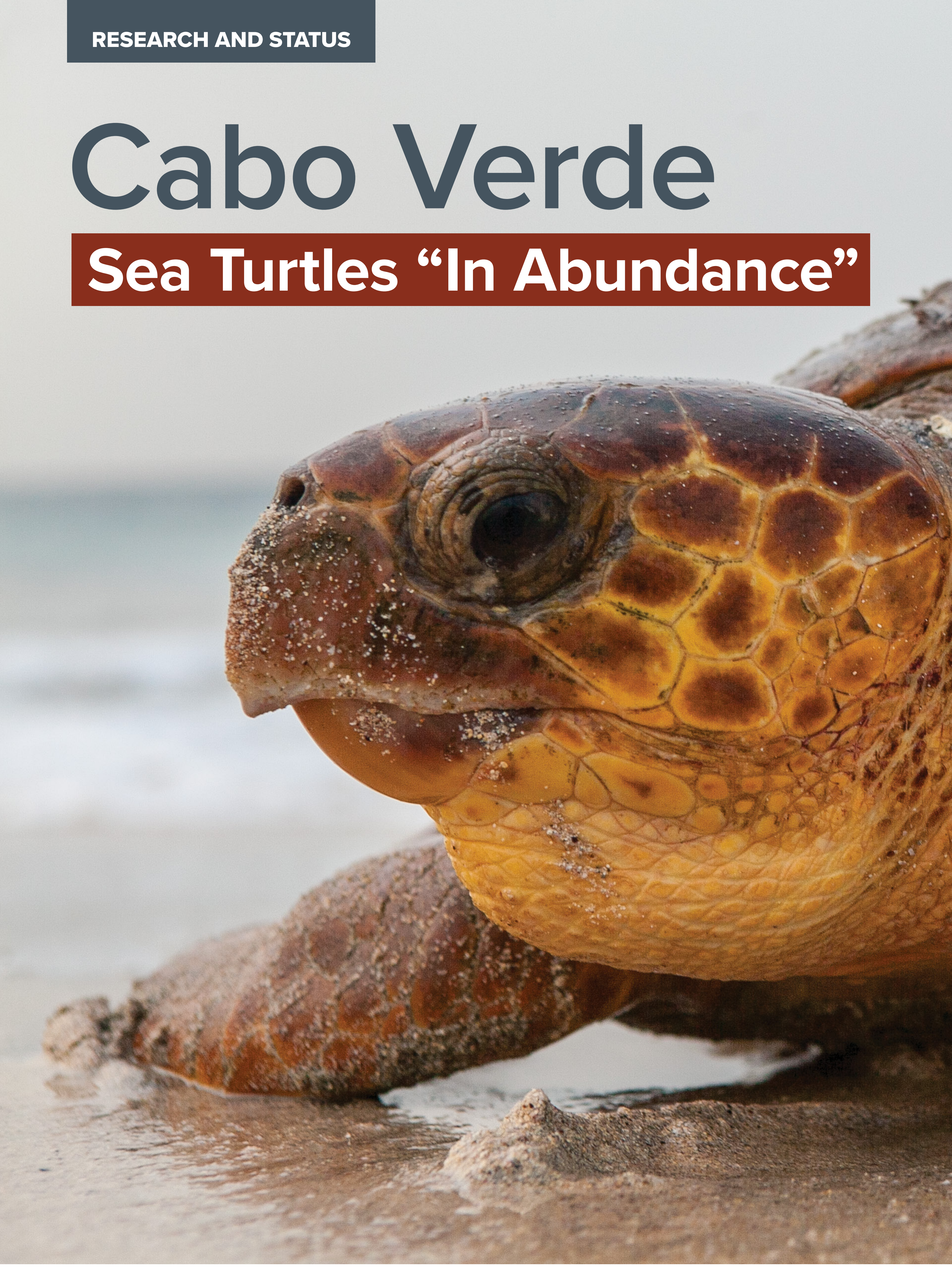
Find Mr. Leatherback! How many times can you spot Mr. Leatherback's distinctive silhouette in this issue of *SWOT Report*? Check the SWOT website at www.SeaTurtleStatus.org for the correct answer!

THIS PAGE: Hawksbill turtle feeding on corallimorphs in a shallow coral reef of the Natural Marine Reserve of Reunion Island, Southwest Indian Ocean. © K. Ballorain

RESEARCH AND STATUS

Cabo Verde

Sea Turtles “In Abundance”



By Albert Taxonera Amoros, Kirsten Fairweather, Airton Jesus, Albertino Gonzalves, Alberto Queiruga, Amandio Lima, Ana Varela-da-Veiga, Caro Oujo, Carla Lopes, João Henrique Gomes da Cruz, João Pina Lomba, Juan Patiño, María E. Medina Suárez, Nilson Ramos Brás, Patricia Rendall, Sandra Correia, Silvana Roque, Valdir Rodrigues, Christophe Eizaguirre, Adolfo Marco, Zofia Radwan, and Manjula Tiwari

Situated approximately 600 km (373 mi) off the western coast of mainland Africa, the nation of Cabo Verde is a volcanic archipelago composed of 10 islands and several islets encompassing 4,033 sq km (1,557 sq mi) of land and 35,963 sq km (13,885 sq mi) of maritime territory. First discovered in 1456 and subsequently colonized by the Portuguese, the country became known for its role in the slave trade throughout the 16th and 17th centuries; it served as a stopover for ships traveling between Africa, the Americas, and Europe. The Venetian merchant Alvise da Cadamosto first reported the presence of sea turtles in Cabo Verde in 1460, noting that they occurred "in abundance."

Of the five species of sea turtles found there, the loggerhead is the only one that regularly nests in the archipelago, along with sporadic nesting of greens and olive ridleys. Records indicate that green turtles were once Cabo Verde's most abundant nesters, specifically on the island of Boa Vista, though these may have been misidentified loggerheads. Juvenile greens that nest elsewhere in the Atlantic are indeed abundant year-round foragers in local waters, and leatherbacks, locally called "strongby," can also be found in deeper waters. Leatherbacks have historically nested in Cabo Verde, though the last known nest on Santiago island was documented in a 1997 photograph.

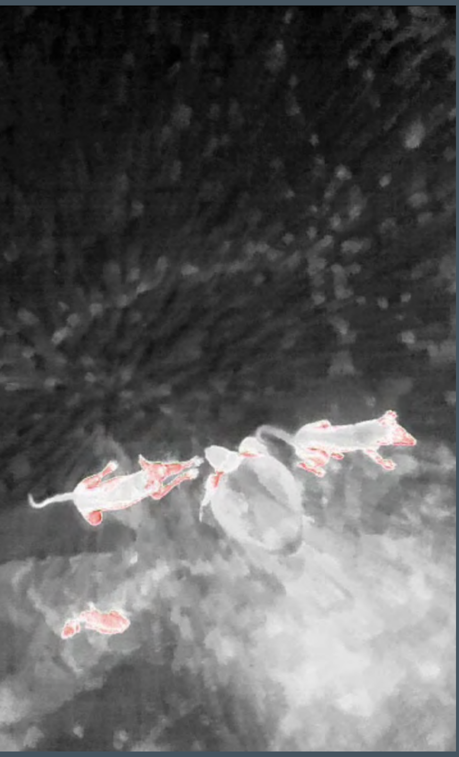
Sea turtles have been protected by law in Cabo Verde since 1987, but they were initially protected only on beaches and during nesting season. Over time, new decrees protecting all sea turtles were approved, though those laws remained weak and unenforced for almost 40 years. Year-round protections were enacted in 2018, including prohibitions on possessing sea turtle meat and products as well as habitat and nesting site protections, with strong penalties for those who violate the laws.

The plight of Cabo Verde's sea turtles was brought to global attention in a 2000 paper authored by Dr. Luis Felipe López Jurado; it marked the start of the country's modern sea turtle conservation efforts. Soon thereafter, Dr. Sonia Merino, who is another Cabo Verdean biologist and is from the National Institute for the Development of Fisheries, led the first community-based sea turtle conservation initiative in fishing communities of the island of São Vicente. In 2003, Dr. Jurado established Cabo Verde Natura 2000 on the island of Boa Vista—the country's first sea turtle conservation nongovernmental organization (NGO). It was followed by the emergence of several other NGOs and community-based sea turtle conservation efforts across the archipelago. Importantly, Cabo Verde's National Environment Directorate (Direção Nacional do Ambiente), in coordination with island councils, led a number of important national awareness campaigns. Sónia Araújo (the agency's sea turtle campaign coordinator) spearheaded those hugely successful efforts, which brought global attention to the plight of Cabo Verde's sea turtles.

Today, each of Cabo Verde's islands has at least one NGO or community group working to conserve loggerheads. Boa Vista's Fundação Tartaruga Cabo Verde, BIOS Cabo Verde (BIOS.CV), and the Varandinha Community Association work with Cabo Verde Natura 2000 to protect the country's main nesting loggerhead rookery, which comprises 60–70 percent of Cabo Verde's sea turtle nesting population. The second-largest rookery is on Sal Island, where Projeto Biodiversidade operates, followed by the rookery on Maio Island, which is monitored by Fundação Maio Biodiversidade. Santa Luzia, the only uninhabited island of the archipelago, supports the fourth-largest nesting aggregation, which is monitored by Biosfera I.

Other islands that host smaller nesting populations and sea turtle projects are (a) São Nicolau, monitored by the Associação

BELOW: A thermal image taken by drone reveals feral dogs near a nesting loggerhead. © Project Biodiversity; **PREVIOUS SPREAD:** A loggerhead turtle in Cabo Verde. Loggerheads are the most abundant turtle species found in Cabo Verde and the focus of a wide range of conservation programs. © Adilson Ramos / Project Biodiversity



A Community Affair

The success of sea turtle research and conservation in Cabo Verde derives largely from the hard work of numerous local NGOs and community groups located throughout the archipelago. Many of those groups have received awards, grants, and international recognition for their leadership and innovation, including five SWOT grants since 2008 (learn more at www.seaturtlestatus.org/swot-grantees).

Since 2006, the community of Cruzinha on the island of Santo Antão has led a program to convene youth volunteers for sea turtle beach patrols; similar efforts are under way on São Vicente. On the islands of Maio and Sal, a homestay program tied to turtle conservation provides an alternative income to families that host student and international volunteers in their homes; the students experience local customs while participating in educational activities. On Maio, Sal, and Boa Vista, the nonprofit Guardians of the Sea works with local fishers on marine megafauna research and engages them in reporting illegal activities in marine protected areas. In return, fishers receive education, technical support, and safety and monitoring equipment. The strengthened connection between NGOs and fishers has also expanded into turtle protection. Many watermen help report and release turtles caught in ghost fishing nets, and they volunteer to support night patrols during the nesting season.

Innovative conservation research led by Fundação Tartaruga Cabo Verde and Projeto Biodiversidade uses thermal imaging drones to monitor vast stretches of beach to detect poachers, to find lost turtles, and to control feral dogs. On Boa Vista, researchers combine the use of drones with trained tracking dogs to better manage feral animals. This group has recently been awarded a SWOT grant that will allow members to lead swimming lessons integrated with environmental education for the children of Boa Vista, with the goal of deepening the children's connections to endangered sea turtles and their habitats (see p. 41).

de Biólogos e Investigadores de Cabo Verde; (b) Santo Antão, where TerriMar and the community of Cruzinha work together to monitor sea turtles; (c) São Vicente, monitored by the Marine Research Institute (Instituto do Mar); (d) the islets of Rombo and Fogo island, monitored by Projecto Vitó; (e) Santiago, the country's largest and most populous island, monitored by the organizations Lantuna, Associação Ambiental Caretta Caretta, and Flora and Fauna de São Francisco working together with the National Directorate of Environment; and (f) the small and steep island of Brava, monitored by Biflores (though sea turtle nesting is rare at this location).

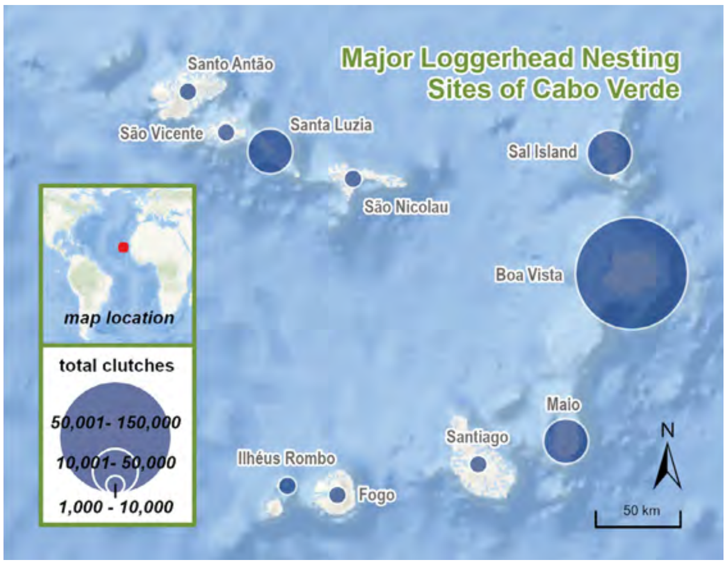
The expansion of sea turtle conservation initiatives around Cabo Verde came in parallel with the birth of TAOLA, Cabo Verde's national network for sea turtle conservation. The name TAOLA came from the Creole words ***ta***_rtaruga cri_***ola*** (Creole turtle). This network has been supported and promoted by the Marine Turtle Conservation Fund of the U.S. Fish and Wildlife Service since 2009, when Dr. Manjula Tiwari brought together representatives of all the aforementioned entities involved in Cabo Verde's sea turtle conservation efforts. Since then, TAOLA has met annually to achieve national milestones, including standardized data collection protocols, awareness campaigns, social research, and training, as well as preparation of the first national overview of Cabo Verde's sea turtle abundance. But, unquestionably, TAOLA's greatest achievement to date has been the 2018 governmental approval of a new decree to protect sea turtles in Cabo Verde.

Many research projects are also under way throughout Cabo Verde, some of which have sparked new local initiatives and helped to build a better understanding of the North East Atlantic loggerhead subpopulation. Research groups and universities (such as the Estación Biológica de Doñana– Consejo Superior de Investigaciones Científicas in Spain, Queen Mary University of London, the University of Cabo Verde, and Universidad de las Palmas de Gran Canaria, among others) have supported local NGOs and the Cabo Verde government.

Tracking of male and female loggerheads has revealed migration patterns between nesting seasons to the West African coast between Senegal and Sierra Leone. Other telemetry studies have shed light on the distribution and movements of females during the nesting season. Moreover, the use of drones has helped to document the abundance of both female and male loggerheads in the archipelago.

A nationwide genetic sampling initiative launched in 2010 revealed the complex genetic makeup of the Cabo Verde loggerhead population, thereby underscoring the importance of conserving all of the country's nesting aggregations. Those findings added to the previous recognition of Cabo Verde's loggerheads as a genetically unique population, which is considered a distinct regional management unit by the IUCN-SSC Marine Turtle Specialist Group. In recent years, research has focused on understanding hatchling sex ratios in relation to increasing incubation temperatures and their potential implications for conservation practices such as the use of hatcheries, which is a common tool on some islands.

Persistent threats such as poaching and coastal development continue to drive the need for loggerhead conservation in Cabo Verde. The killing of sea turtles for the consumption of their meat, organs, fat, blood, and eggs has been recorded since the discovery of the country, and documented historical use is associated with the belief that consuming sea turtle products can cure ailments such as yellow fever, leprosy, and syphilis.



Map showing major loggerhead nesting sites in Cabo Verde. Data are presented by island and may consist of multiple nesting beaches per island. For complete data sources, see p. 54.

Collecting sea turtles was a staple practice for ships passing through Cabo Verde, because the turtles could survive for extended periods outside the water and thus provide a continuous source of fresh meat at sea. Consumption of turtles also helped save Cabo Verde's inhabitants from hunger during times of drought or isolation, such as during World War II. Sea turtle recipes can be found in the first Cabo Verdean cookbooks; as recently as 1990, tourist brochures advertised pickled sea turtle eggs. Although illicit, the poaching of sea turtles for consumption, especially loggerhead females during nesting, persists in all of Cabo Verde's islands.

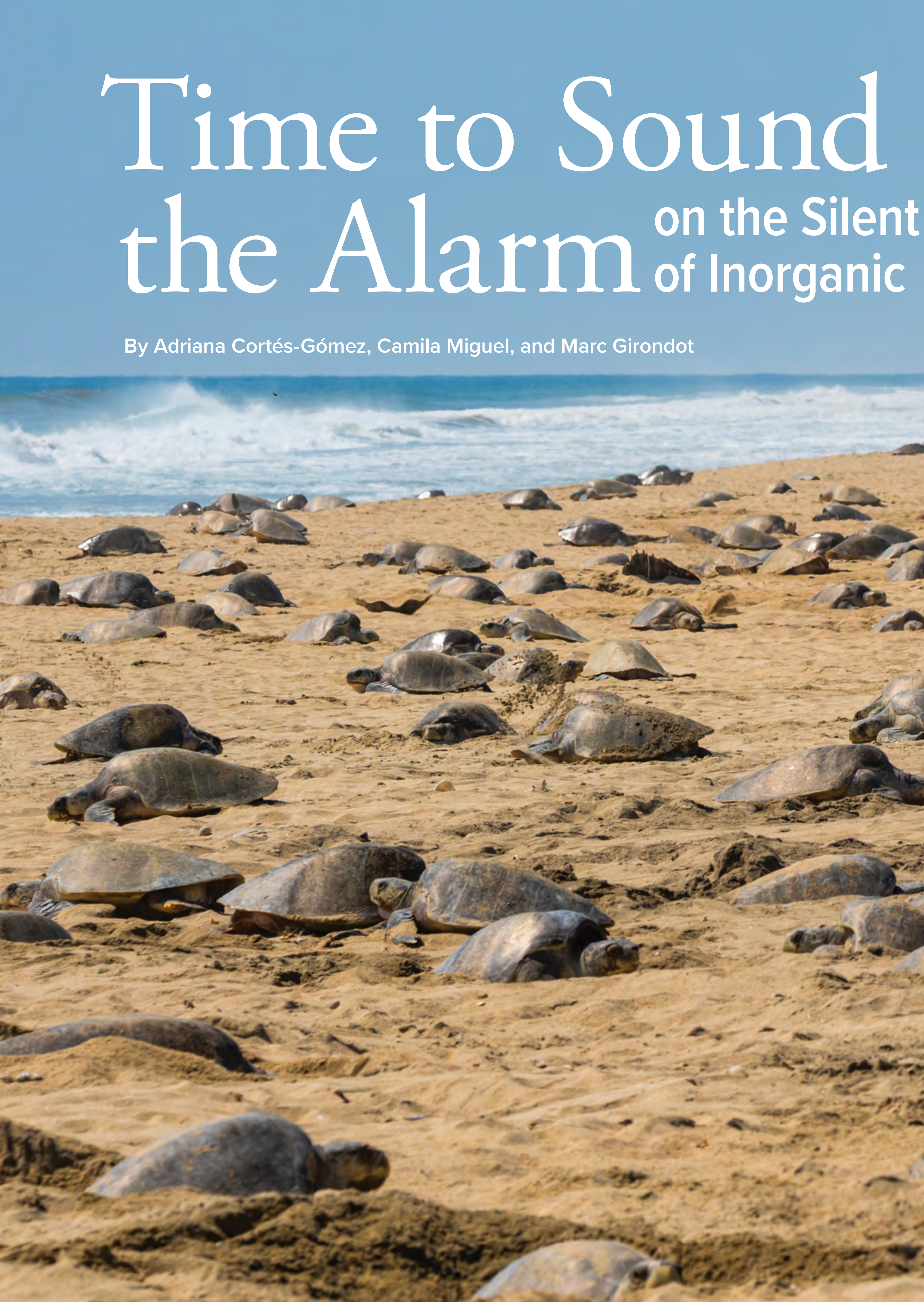
Coastal development, especially on the islands of Sal and Boa Vista, is drastically reducing loggerhead nesting habitat. The tourism industry of Cabo Verde has grown rapidly, with more than 820,000 tourists recorded in 2019. With such growth has come an increase in beachfront construction that impacts nesting habitats directly, as well as additional light pollution (learn more about this threat on p. 38). Conversely, low-impact ecotourism activities such as turtle watching provide an income source for local people and give tangible value to protecting the sea turtles.

Feral dogs that attack nesting females and depredate nests are a major threat on the islands of Maio, São Vicente, Santiago, and especially Sal, where tourists feed feral dogs near the nesting beaches. This problem has intensified under COVID-19 travel restrictions. With fewer tourists feeding the dogs, dog predation of turtles increased, severely injuring and killing many turtles.

Despite some persistent threats, what once appeared to be a doomed future for the sea turtles of Cabo Verde has now brightened after 20 years of conservation efforts throughout the archipelago. Populations are recovering, and current numbers suggest that this tiny island nation may indeed host the largest loggerhead aggregation worldwide, followed by the United States (Florida) and Oman. Nevertheless, as this population is one of the 11 most threatened populations of sea turtles worldwide (see *SWOT Report*, vol. VII, pp. 22–33), conservation must continue without pause. The past decade has shown a vastly increased consolidation of local, national, and international partners working together to ensure that Cabo Verde's sea turtles remain in abundance for the future. •

Time to Sound the Alarm on the Silent of Inorganic

By Adriana Cortés-Gómez, Camila Miguel, and Marc Girondot



Threat
Pollutants

Pollution is considered to be one of the top global threats to sea turtles and has been the focus of growing concern in recent years. Although much attention has been given to ocean plastic pollution and other forms of visible waste, invisible forms of pollution have been growing in scale and can now be found in virtually all of Earth's waters, where they affect the well-being of marine creatures great and small.

One particularly insidious type of contamination is that of heavy metals, such as lead and cadmium; such contamination typically originates from industrial activities. When unnaturally high amounts of such metals enter an environment, they can accumulate in animal tissues and biomagnify as they are passed up the food chain. In many animals as well as in people, even slightly elevated levels of some heavy metals are known to cause cancers, developmental malformations, and numerous pathologies—including reproductive problems and kidney failure. In one well-studied population of killer whales (orcas) in Scotland, researchers observed over many years that the accumulation of such pollutants led to the deaths of several individuals and is now causing many animals to become infertile.

Cadmium in Ridley Turtles from the Mexican Pacific

Heavy metal pollution is specifically implicated as a threat to the health of olive ridley turtles at La Escobilla in Oaxaca, Mexico. This 15-kilometer (9.3-mile) stretch of beach is the site of one of the most remarkable success stories in global sea turtle conservation, and it now sees in excess of one million nesting ridleys annually—more than anywhere else in the world (see *SWOT Report*, vol. XVI, pp. 24–33). On some nights during mass nesting arribadas, miles of shoreline are covered in an unbroken vista of flying sand and heaving shells as turtles lay their eggs. It wasn't always like this at La Escobilla. Nesting had declined significantly following decades of egg and turtle harvest and rebounded only after harvesting was outlawed in the 1990s. Today, with tens of millions of hatchlings emerging each year, La Escobilla is key to the future of this once declining species.

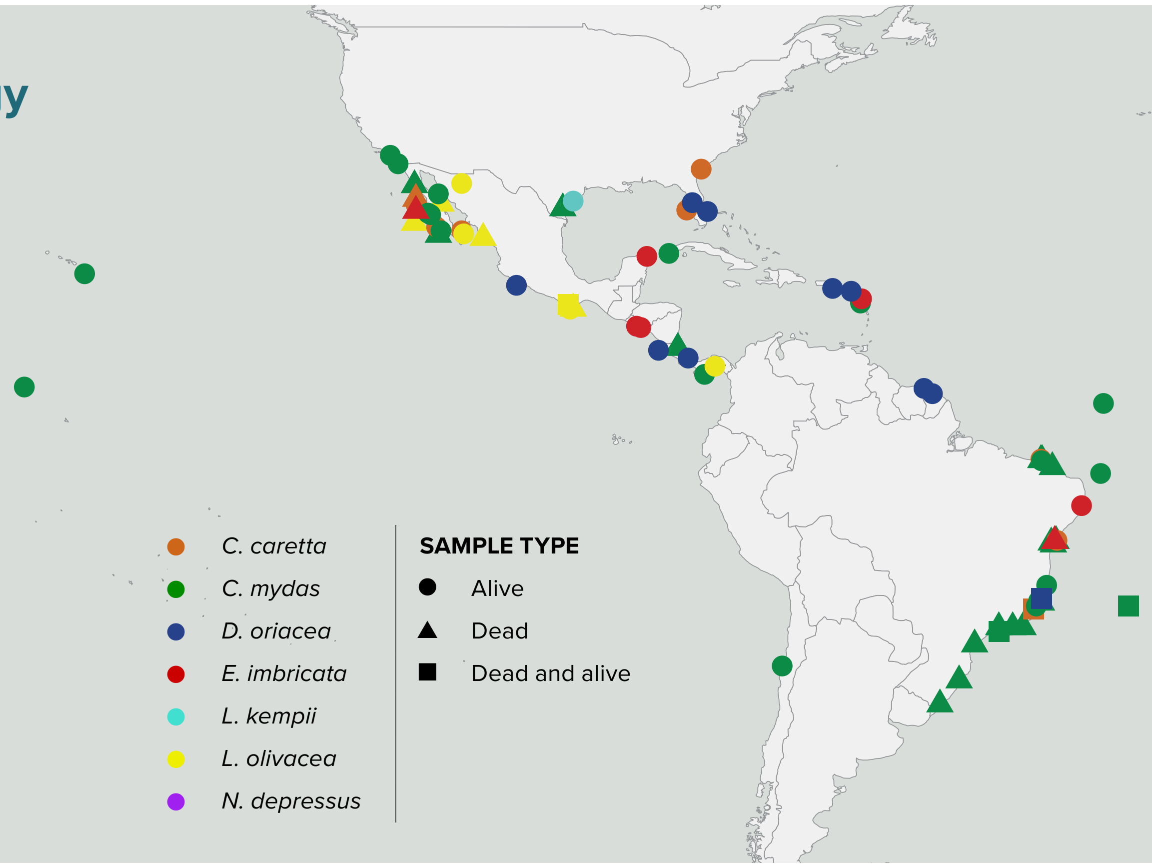
However, research underway since 2012 has revealed shockingly high levels of accumulated cadmium in turtle tissues, a contaminant that may drastically impact both current and future generations of turtles. Samples collected from 46 animals in 2012 showed mean cadmium levels of 150 ppm/wet weight, the highest levels ever reported for a large marine animal. Researchers had hoped this finding was caused by a one-time pollution event, but further sampling showed that by 2019, cadmium had grown to 243 ppm in turtles' kidneys. To put this observation in perspective, levels above 15 ppm in humans can cause chronic problems that, if not treated, can lead to death.

Although there are no such established thresholds in turtles, biomarkers such as oxidative stress, stress proteins, and asymmetry, as well as histopathological studies, indicate that the sampled animals experienced significant health effects. In some cases, cadmium can be implicated as the direct cause of death. Other species sampled near La Escobilla have also been affected; record cadmium levels were found in tissue samples from an adult leatherback, an immature dolphin, and a baby sea lion, urging researchers to sound the alarm and call for immediate actions to reverse this threat.

It has been difficult to identify a source for this contaminant in Pacific Mexico. Cadmium, mercury, and other heavy metals can occur naturally in the environment from erosion, weathering, movement of dust, and volcanic activities. But rapid urban development, increases in fertilizer and pesticide use, mining

Sea Turtle Toxicology Sampling Overview

The map at right shows the locations and types of published toxicological studies involving sea turtles. The map has been developed from a review of 110 publications from 2000 to present; see p. 55 for a list of data sources. Note that most studies have been on blood from live sea turtles—mostly greens, but also from loggerheads and olive ridleys. Sea turtle populations in some parts of the world have never been sampled, including many in Africa, the Indian Ocean, the Middle East, and Southeast Asia. Only a small number of studies have ever collected samples from Kemp's ridley, flatback, leatherback, and hawksbill turtles.



and smelting, fossil fuel residues, and industrial discharge have drastically raised the amounts of such elements in ecosystems worldwide.

Mining Disaster Continues to Impact Green Turtles in Brazil

In November 2015, a dam collapsed in Minas Gerais, Brazil, releasing an estimated 43 million cubic meters of iron ore tailings into the Doce River in what is considered one of the global mining industry's biggest environmental disasters (see *SWOT Report*, vol. XII, pp. 36–37). The resulting mudflow spread 668 kilometers (415 miles) downstream, killing dozens of people and sweeping away everything in its path before reaching the Atlantic Ocean, where it contaminated coastal areas important for sea turtle nesting and feeding.

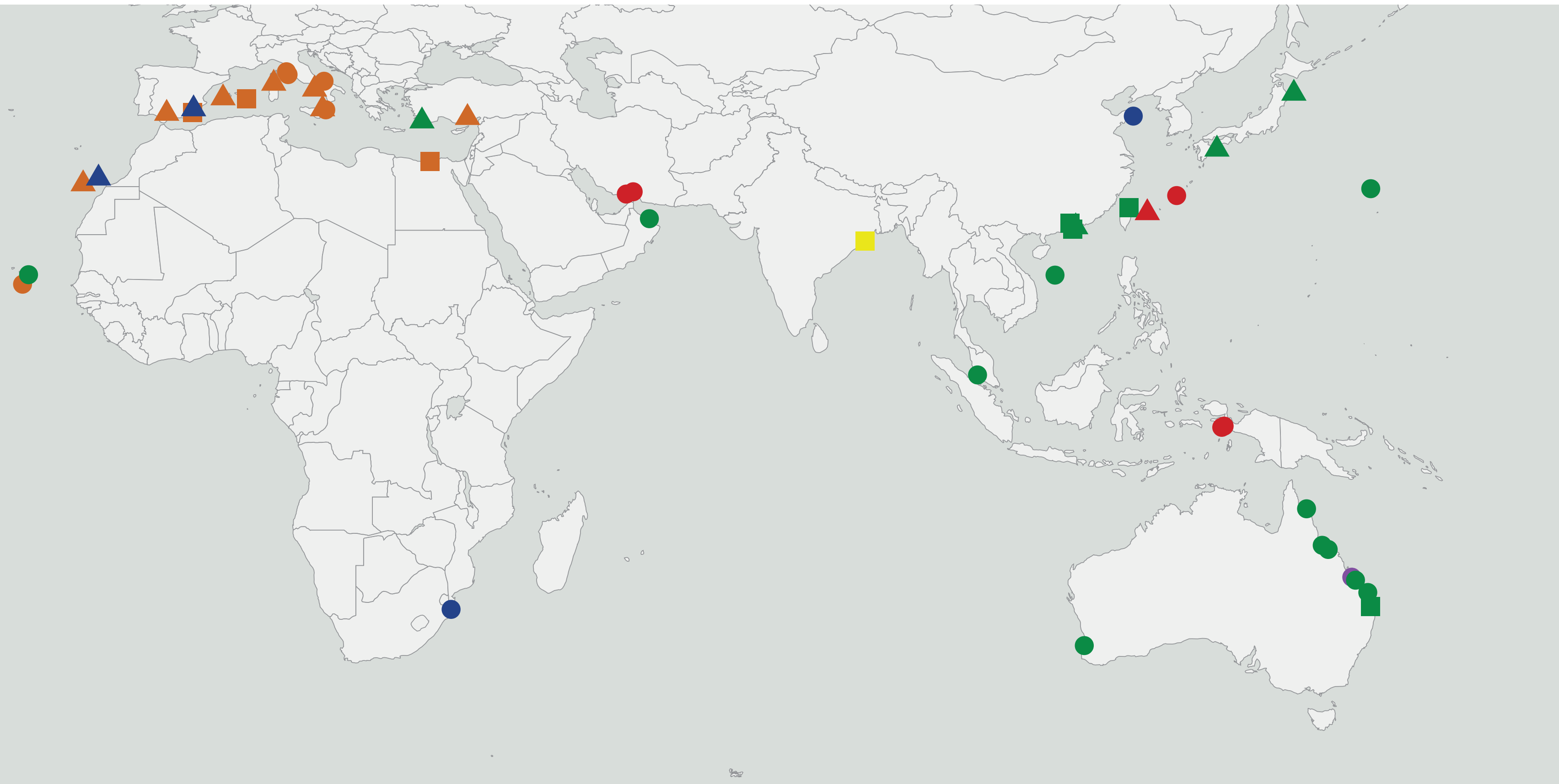
Since the disaster, researchers from the Chelonia Mydas Project at the Marcos Daniel Institute have been monitoring the impacted areas and focusing on the health of juvenile green turtles that inhabit the Santa Cruz district in the state of Espírito Santo. That area was most directly affected by the tailing plume. During the two-year period from 2018 to 2020, the health of the turtles there was compared with that of green turtles residing at Coroa Vermelha Island in the state of Bahia, the nearest green turtle feeding area that was not directly impacted by the contaminant plume.

Results showed that the Santa Cruz green turtles suffered from notably worse nutritional conditions, as well as a higher incidence of anemia, immunosuppression, fibropapillomatosis tumors, and ectoparasite load, in addition to possible hepato-renal pathologies. There is strong evidence to show that the pollution caused by the chemical tailings is responsible for the observed health differences, and a high priority is to continue monitoring in order to observe the contamination's longer-term impacts on the animals and to better understand the health impacts they experience.

A Desperate Need for More Data

Sea turtles are surprisingly susceptible to ocean-borne pollutants in a variety of natural forms (such as red tides) and manmade forms. Extended exposure to contaminants can compromise turtles' physiology, cause abnormalities in their embryos, impair their reproductive success and immune function, disrupt their endocrine systems, cause them chronic stress, and increase their susceptibility to diseases. Although the impacts of heavy metal exposure on sea turtles are just beginning to be understood, findings from the sea turtle case studies outlined here as well as elsewhere (see *SWOT Report*, vol. XIII, pp. 8–9) suggest that there is much reason for alarm. Because sea turtles are long-lived and slow to mature, it may take years of continuous study before researchers are able to understand the full impacts of such exposure. More and longer-term research is critically needed to comprehend the scale of this problem and to implement solutions. Sea turtles are an excellent flagship species to draw attention to this important issue, which has drastic impacts on countless other species—including humans. It is imperative that researchers worldwide begin at once to conduct more and broader sampling of the tissues of sea turtles and other species and that they pay greater attention to the sources of heavy metal and other contaminants in order to find ways to stop this invisible threat. •

PREVIOUS SPREAD: The Día de los Muertos 2021 arribada at Playa Escobilla, Oaxaca, Mexico (see Editor's Note), photographed as part of a global project led by photographer Tui De Roy for a coffee table book about sea turtles to be published by Princeton University Press in 2024. © Tui De Roy / Roving Tortoise Photos



Precipitous Declines in Caribbean Leatherbacks

By Karen Eckert and Katharine Hart

In 2013, the leatherback turtle was categorized on the IUCN Red List of Threatened Species as vulnerable globally, and its seven subpopulations were separately assessed for the first time (see *SWOT Report*, vol. XI, pp. 28–31). The Northwest Atlantic (NWA) subpopulation was initially listed as least concern, but in 2019 it was reassessed to be endangered following work done the year prior by the NWA Leatherback Working Group, which noted precipitous declines in major nesting assemblages in the southern Caribbean.

The NWA leatherback subpopulation ranges throughout the northern Atlantic Ocean (and, rarely, into the Mediterranean Sea), from nesting areas in the Wider Caribbean Region (WCR) to foraging areas that extend northward into temperate latitudes. The Wider Caribbean Sea Turtle Conservation Network's (WIDECAST) most recent atlas reveals that of the nearly 500 known leatherback nesting beaches in the WCR, only six, in French Guiana, Panama, and Trinidad, host more than 1,000 crawls per year. Twelve more beaches with 500–1,000 crawls per year are distributed in Colombia, Costa Rica, the Dominican Republic, French Guiana, Grenada, Panama, Puerto Rico, Suriname, Trinidad, and the United States (Florida). The remaining smaller aggregations, with fewer than 25 crawls per year, comprise 63 percent of the total.

Regional trends in nest counts have declined significantly at both local and regional scales. Moreover, in shorter-term (2008–2017) and longer-term (1990–2017) periods, declines have exceeded 90 percent in French Guiana (at Awala-Yalimapo), as well as in Suriname since the mid-1990s. Those dropoffs are particularly alarming in French Guiana, which at the turn of the twenty-first century hosted the largest nesting assemblage of leatherbacks in the region and an estimated 40 percent of the world's total. In Trinidad, which is now home to the region's largest nesting colony, the number of nesting females at Matura

Beach experienced a smaller but sustained decline of 4.7 percent per annum between 2006 and 2017.

Fisheries interactions in nearshore waters are implicated in those declines in both Trinidad and the Guianas (see *SWOT Report*, vol. XVI, pp. 6–7), but insufficient knowledge of other potential drivers and possible synergistic effects have stymied efforts to identify conservation priorities at scale. In an attempt to fill this gap, WIDECAST collected information from stakeholders in 33 of the 34 WCR countries where leatherbacks nest. The survey compiled best estimates on the frequency and magnitude of threats to leatherback nests and adults on nesting beaches, as well as in nearshore inter-nesting habitats, offshore waters, and the high seas, thus offering the first comprehensive overview of potential drivers of observed declines. Experts were asked to characterize the frequency of a particular threat as well as its magnitude and the proportion of the turtle population that was mortally affected by it.

Results showed that abiotic factors (including flooding, beach erosion/accretion, and climate-related risks), pollution, egg collection, and habitat loss were the most prevalent and impactful threats to leatherbacks on land. In as many as one in four countries, those threats can have an impact on the survival of 20 percent or more of the nests. For nesting females, the most prevalent and significant threats were habitat loss, the *sargassum* influx, and harassment, which sometimes affected more than 20 percent of the annual nesting cohort. Smaller numbers of countries reported artificial lighting, beach obstacles, sand mining, human killing of adult turtles, and beach armoring as “frequent” threats.

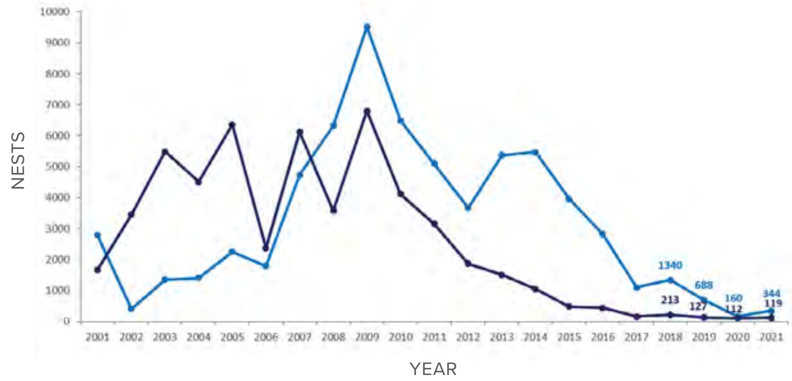
At sea, the threat landscape is dominated both in frequency and magnitude by net fisheries, pollution, and entanglement, which in some countries could threaten the survival of 20 to 50 percent or more of adult (typically gravid) leatherbacks every year. Fishery interactions were particularly pronounced in Trinidad and the Guianas, where three of the four countries (75 percent versus only 15 percent of regionwide countries) cited net fisheries as a “frequent” threat in inter-nesting habitats. The survey also highlighted significant levels of uncertainty. Although 25 to 50 percent of respondents were unable to accurately characterize the frequency of threats in nearshore waters, the number rose to 55 to 85 percent in offshore waters, and 90 to 100 percent in international waters.

Synergies among threats can also dramatically influence a turtle population’s status and dynamics. A greater understanding of such synergies—for example by evaluating the impacts of individual threats in a population-level context—can help guide the allocation of conservation resources. Sustained recovery of the NWA leatherback subpopulation will require strategic investment that integrates considerations of those priority threats with population size and stock diversity. A regional action plan designed to guide such an investment is currently moving through an extensive stakeholder-led process and will be released later this year. •

AT LEFT: A severely entangled leatherback turtle in Grenada. Fisheries interactions are implicated in the decline of Caribbean leatherback populations. © Ocean Spirits Inc. / www.oceanspirits.org

Why Are French Guiana Leatherbacks Declining?

By Michel A. Nalovic, Laurent Kelle, Audrey Chevalier, Benoit de Thoisy, Mathilde Lasfargue, Ronald Wongsopawiro, and Damien Chevallier



Graph showing leatherback nests recorded on French Guiana’s eastern (light blue line) and western (dark blue line) beaches from 2001 to 2021. Figure courtesy of the authors.

Understanding the decrease in leatherbacks nesting in the Guianas, particularly in French Guiana’s once booming population at Awala-Yalimapo, is an ongoing challenge to turtle conservation efforts. With the exception of a slight rise over the past two years, the number of nesting leatherbacks has plummeted since the mid-1990s.

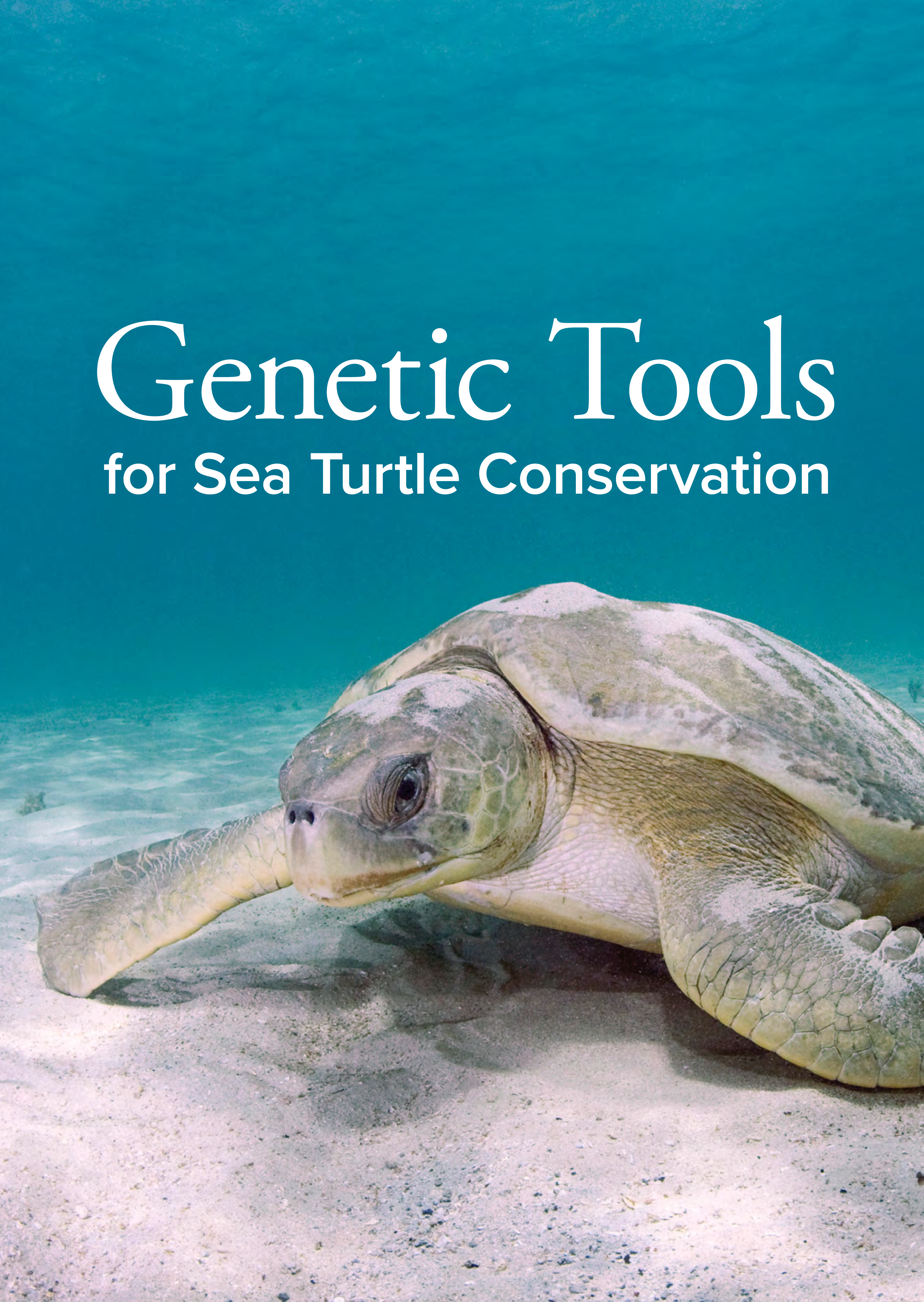
Although many imperfectly quantified threats are to blame, the most significant and intractable threat is the sheer level of fishing effort occurring in all the world’s oceans, and the collateral toll fishing extracts in the form of bycatch. From high seas industrial fleets to coastal artisanal vessels, there are more boats, hooks, floats, ropes, and nets operating simultaneously than ever before.

Complicating the matter for leatherbacks navigating the waters of the Guianas is the high degree of illegal, unreported, and unregulated (IUU) fishing activity. Such IUU fishing effort in French Guianese waters was estimated in 2012 to be twice that of legal fisheries, thereby negating all of the well-intentioned advances made by regional, national, and international authorities to minimize fishery impacts through gear improvements, time or area closures, stock management schemes, and other efforts.

Threats posed by feral dog predation of eggs and by cyclical beach erosion have also been underestimated in the past. A recent study by Damien Chevalier suggests that up to 40 percent of leatherback nests were lost to erosion at Awala-Yalimapo between 2012 and 2014 alone, something that undoubtedly added to the nesting declines observed there from 2001–2018.

The World Wide Fund for Nature (WWF), the French Guiana Regional Fisheries Committee (CRPM Guyane), and their Guiana Shield partners have begun work to prevent the further expansion of IUU fisheries, as well as to address the issue of nesting beach erosion. Much work is left to be done—and *must* be done—to eliminate IUU activities and to reduce fishery bycatch if we humans are to ensure the long-term survival of the majestic leatherbacks in the Guianas.

Genetic Tools
for Sea Turtle Conservation



By Michael P. Jensen, F. Alberto Abreu-Grobois, Brian M. Shamblin, Kelly R. Stewart, Erin L. LaCasella, Nancy N. FitzSimmons, and Peter H. Dutton

On tropical and subtropical beaches around the world, female sea turtles have come ashore to lay their eggs for millennia. When the young turtles scurry down the beach to the ocean, they carry their parents' DNA. If they survive to adulthood, the females return to the same spot to lay their eggs in a process known as natal homing, which was first hypothesized by Archie Carr in 1967. As a result, females nesting in the same region are genetically similar to one another and dissimilar to those in other regions.

Over the past 30 years, genetic tools have helped researchers to understand how sea turtle populations are connected across time and space and have further taught us that the precision of natal homing varies among species and regions. Researchers are learning how demographic, behavioral, and environmental forces shape gene flow among rookeries, plus the implications this information has for identifying appropriate population units for conservation purposes. Rapid advances in genomic technologies and analytic methods have given scientists a means to differentiate among genetically distinct sea turtle groups at increasingly finer scales.

AT LEFT: A flatback turtle in Australia. Researchers have identified seven genetically distinct flatback management units. © Doug Perrine

Defining Management Units

Sea turtles have complex life histories; they are long-lived and take decades to reach sexual maturity. Throughout their lives, they occupy widely dispersed oceanic and coastal areas as their ecological needs change. Young turtles from the same nesting beach may end up in distant foraging areas, and foraging areas may host a mix of turtles from widely dispersed rookeries. Addressing such complexity for successful conservation and management is challenging because individual populations need to be identified, evaluated, and monitored across all life stages and habitats. Tagging and satellite telemetry partially address those challenges but can be impractical. Genetics therefore plays a vital role in obtaining reliable, detailed information about sea turtle population structure and behavior.

Natal homing behavior promotes the differentiation of DNA between rookeries, which can help to define genetic stocks or management units (MUs). The MUs are based on significant differences in the distribution of mitochondrial variants (haplotypes) inherited from the mothers or from nuclear DNA (nDNA) alleles inherited from both parents. MUs represent the appropriate scale for monitoring changes in population abundance and assessing threats because individuals lost in one MU are unlikely to be replaced by individuals from another MU. Therefore, the first step in informing effective management decisions is to determine which rookeries to consider as part of a single breeding population and which to consider as separate populations.

A 1992 landmark study led by Brian Bowen provided the first global view of the genetic variation in sea turtles; since then, our understanding of population structure for all sea turtle species has improved enormously. For green turtles, we researchers have advanced from 14 MUs in 1992 to more than 76 MUs today (see map on p. 20). Early studies suggested that rookeries less than 500 km (311 mi) apart were not genetically distinct, but more comprehensive sampling continues to reveal more complex patterns of female natal homing and dispersal. We now know that genetic diversity and population structure can vary greatly between species and regions and at unexpectedly fine scales, such as between hawksbill rookeries on either side of Barbados (a distance of 30 km or 19 mi) or green turtle rookeries on opposite sides of a single Florida inlet!

At the same time, olive ridleys nesting in arribadas at Ostional, Costa Rica, are indistinguishable from those nesting at Escobilla, Mexico, more than 1,300 km (808 mi) away. Widespread leatherback turtles are characterized by low genetic diversity globally, and they have fewer rookeries than other marine turtle species. Green turtles, meanwhile, are one of the most globally abundant and widespread of all sea turtles, which is reflected in more MUs (76 and counting) and greater genetic diversity.

A genetic marker is a DNA sequence with a known physical location on the genome. Our use of novel genetic markers improves how well we can detect population structure. Thirty years ago, the first studies about genetic structure in sea turtles used expensive restriction enzymes to cut mitochondrial DNA (mtDNA) and to define haplotypes that were based on gel band patterns, although much of the genetic variation remained hidden. This effort improved with sequencing technology in the late 1970s but was still difficult and expensive; the generation of even short stretches of sequences (approximately 400 base pairs [bp] at first) was a reason to celebrate! This approach later expanded to approximately 800 bp of the mtDNA control region. More recent work found variation in a hypervariable repeat segment inside the control region that revealed a population structure among Mediterranean green turtle rookeries that was undetectable before.

Now, with sequencing of the entire mitogenome (16,000 bp), a variation that subdivides control region–defined haplotypes into additional variants can be seen. We now know, for instance, that Caribbean green turtles with the 400 bp haplotype CM-A5 represent at least 30 different female family lines, thereby providing even more power for the fine-scale definition of nesting populations.

Making Connections

Once the genetic signature of rookeries has been characterized, the data can be used to determine the origins of turtles sampled far away from the nesting beaches in migratory routes or foraging areas or from live or dead animals impacted by humans. For example, studies show that loggerheads encountered as fishery bycatch in the North Pacific and in foraging grounds off the coast of Baja California, Mexico, all originate from rookeries in Japan. Research on green turtles foraging at Australia's Great Barrier Reef has been used to show how recruitment of juvenile turtles into foraging areas has changed over time and how the changes can be directly linked to reduced hatching success at Raine Island.

Monitoring: Collaborations Are Key

Knowing what proportion of turtles from different MUs is present in shared habitats is vital for conservation planning, because the mortalities in such areas may affect several distant MUs. The power of genetic tools and methods depends on how well sea turtle monitoring can fulfill two key criteria: (a) sampling all or most of the MUs found in shared habitats and (b) ensuring the accuracy of all MU definitions. Such knowledge underscores the importance of continued genetic sampling of all sea turtles wherever they occur, a task that requires global-scale collaboration among a multitude of partners.

Data for several key nesting populations are currently unavailable, too old, or limited by small sample sizes, thereby preventing reliable assessments of MU boundaries. As more laboratories embark on their own sea turtle research, all researchers must strive to work together to develop the highest levels of technical capacity, to create standardized methods, to share research protocols and priorities, and to identify funding so that we can ensure that the most critical conservation challenges are being addressed.

Most importantly, networks among experts must continue to thrive in order to encourage data sharing and to support global marine turtle management and protection efforts. An excellent example of one such network is the Asia–Pacific Marine Turtle Genetics Working Group, which convenes dozens of researchers from across that vast region through frequent workshops and other networking opportunities to enhance in-country capacity for marine turtle genetic studies.

A researcher draws a blood sample from a flatback turtle on Curtis Island, Queensland, Australia. Tools for genetic analysis have both advanced and become vastly cheaper in recent years, making detailed genetic studies much more feasible than before. © Doug Perrine

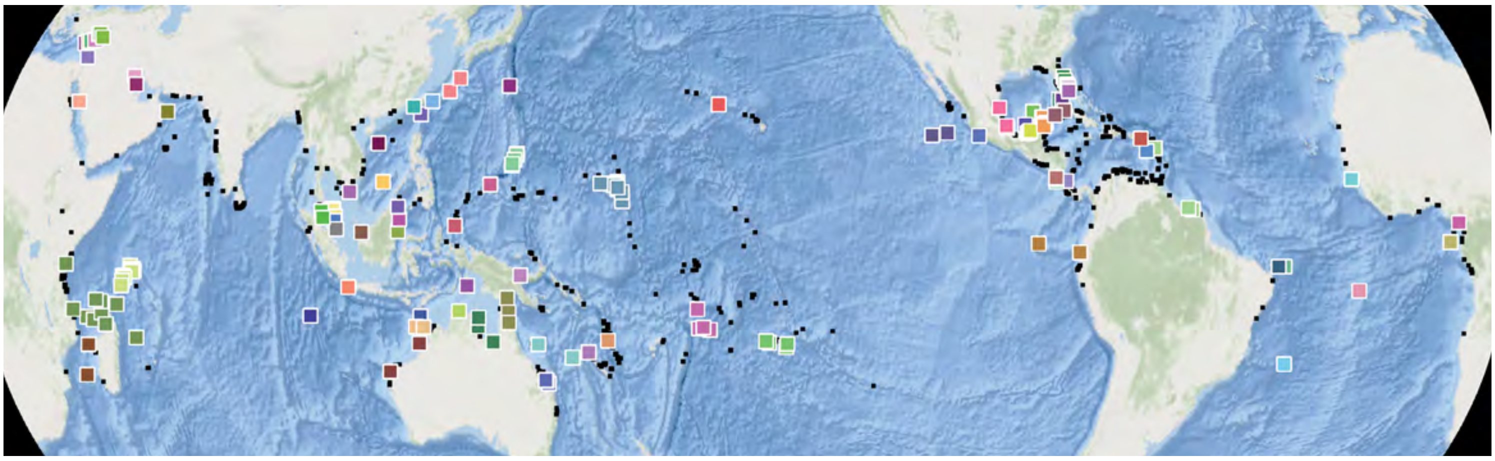
Ensuring the Future of Stock Identification

Genetic research has come a long way since the cumbersome days of restriction fragment length polymorphism or radioactive staining of microsatellite loci! Only 20 years ago, sequencing the sea turtle genome would have taken 13 years and cost US$300 million. Today, a complete genome costs as little as US$1,000 and can be sequenced in a single day on a machine that fits in the palm of a hand. As genetic tools become more affordable, the capacity of researchers to do detailed studies is no longer restricted to a few well-funded laboratories. High-quality reference genomes have been published for green and leatherback turtles (see *SWOT Report*, vol. XVI, pp. 12–13); genomes for all other sea turtle species are expected to be completed within the next two years. Those advances will usher in a new era of whole-genome sequencing and the development of inexpensive assays that will democratize the use of genomics for sea turtle biology and conservation. It will allow us to vastly refine our understanding of sea turtle boundaries and the impacts of threats and to focus sea turtle conservation efforts in targeted ways that were impossible in the not-too-distant past. •

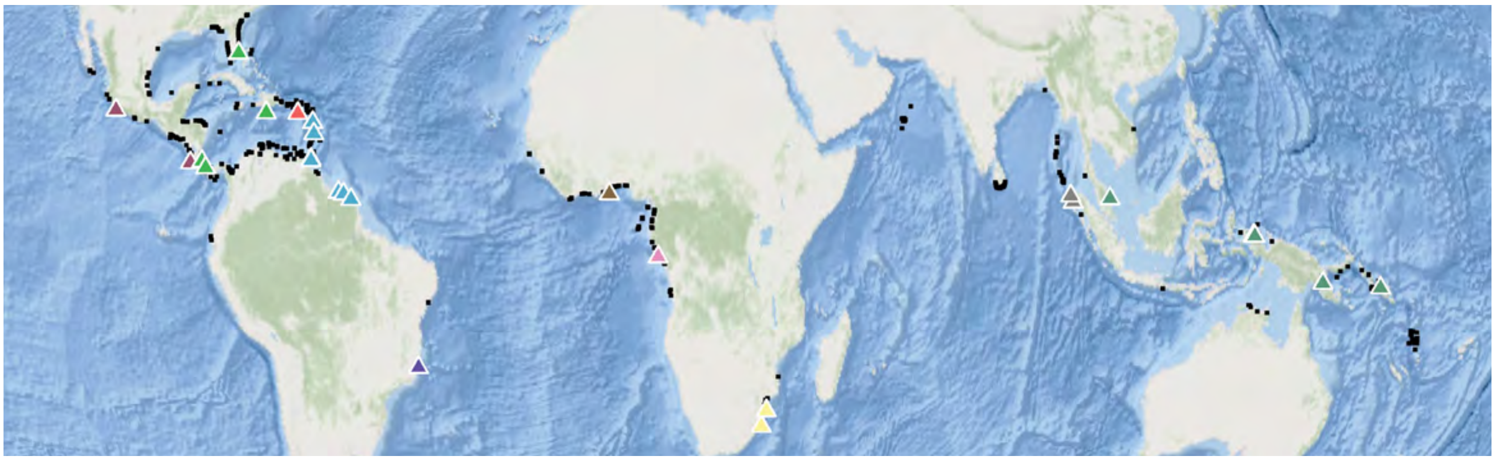
Global Management Units for Sea Turtles

The following maps display global nesting sites and known management units (MUs) for each sea turtle species based on mitochondrial DNA. Individual nesting sites with available genetic information are shown with colored symbols; sites that belong to the same MU share a color. Given the large number of MUs globally, colors may repeat both within and between species maps. Management units can be explored in detail at the SWOT Online Map application (http://seamap.env.duke.edu/swot). Sites that have been sampled but not yet assigned to an existing stock are colored gray. Data for the maps were sourced from the SWOT team and reviewed literature; for complete citations see pp. 53–54.

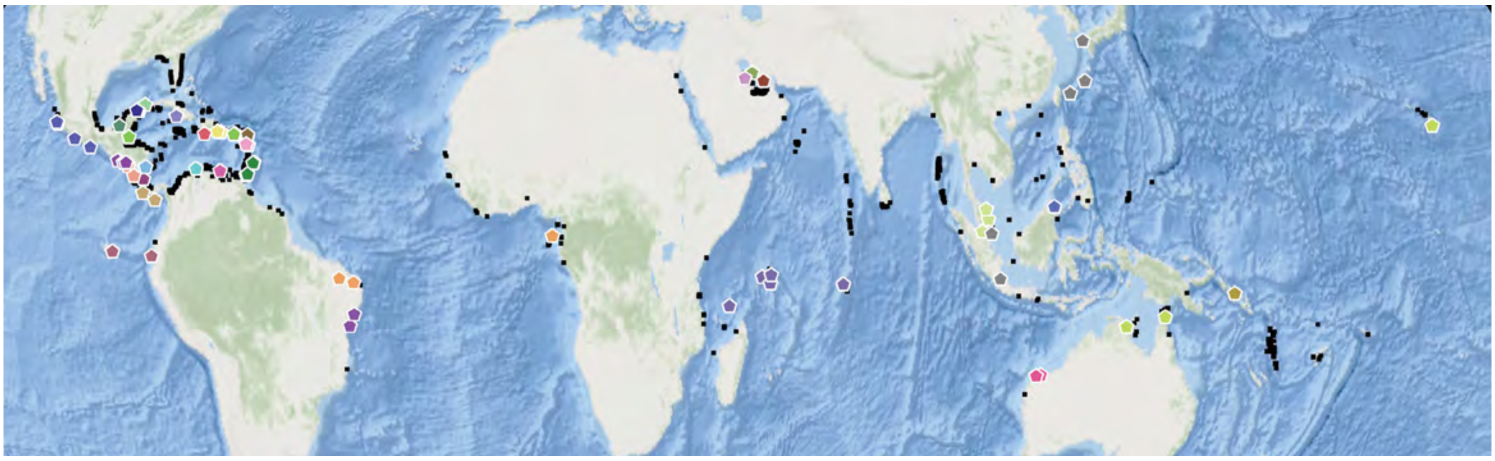
Loggerhead turtle management units. Of 805 documented nesting sites, 62 rookeries have been genetically sampled, and 26 MUs have been identified. Undersampled regions include the Northeast Indian Ocean.



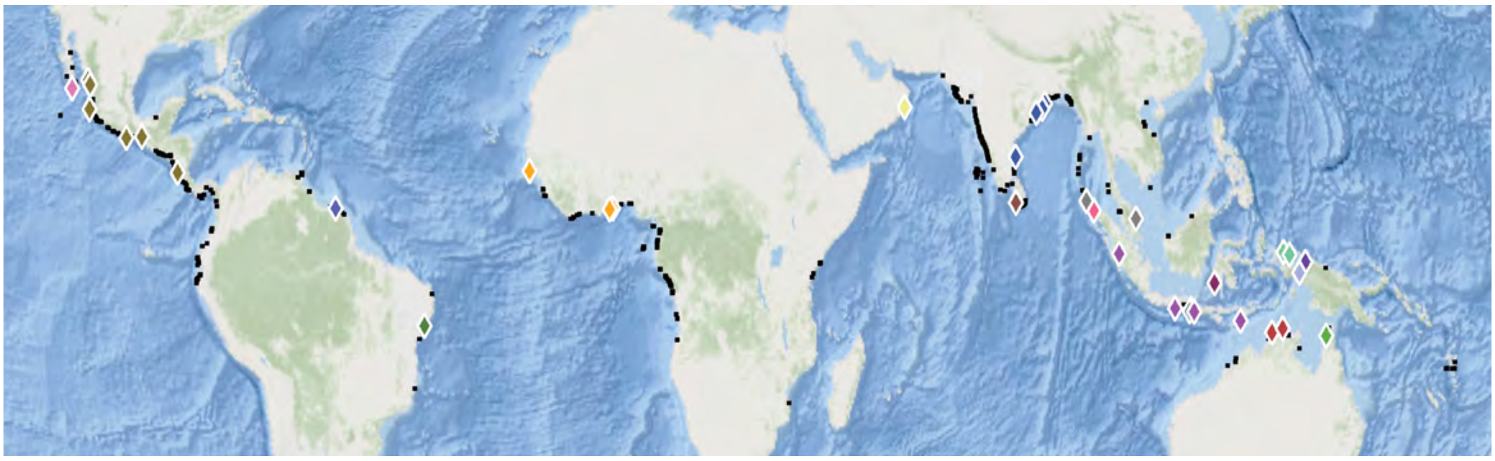
Green turtle management units. Of 1,568 documented nesting sites, 164 rookeries have been genetically sampled, and 76 MUs have been identified. Undersampled regions include parts of Southeast Asia, the Red Sea, the Northeast Indian Ocean, East Africa, and the East Pacific.



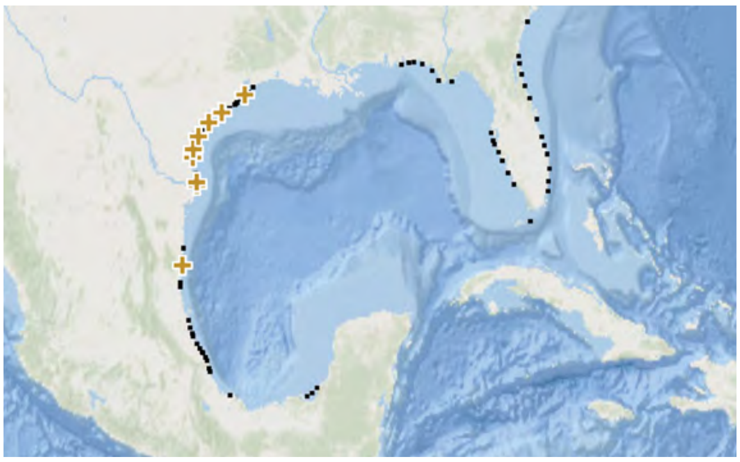
Leatherback turtle management units. Of 889 documented nesting sites, 26 rookeries have been genetically sampled, and nine MUs have been identified. Undersampled regions include parts of Southeast Asia.



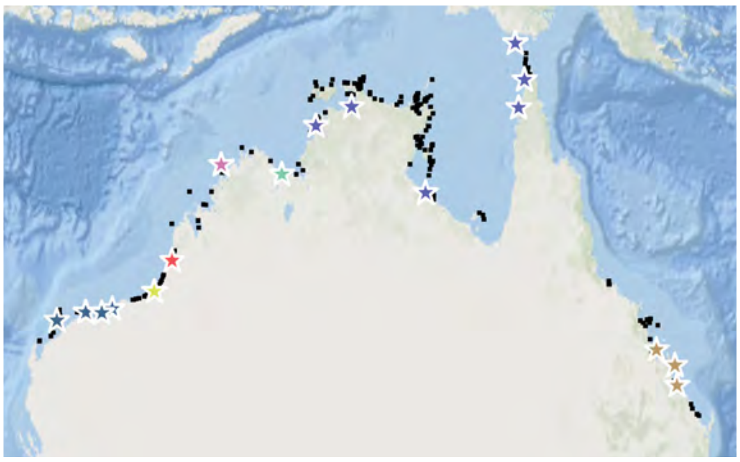
Hawksbill turtle management units. Of 1,650 documented nesting sites, 72 rookeries have been genetically sampled, and 30 MUs have been identified. Undersampled regions include West Africa, the Red Sea, the North Indian Ocean, Southeast Asia, and the Southwest Pacific.



Olive ridley turtle management units. Of 494 documented nesting sites, 33 rookeries have been genetically sampled, and 17 MUs have been identified. Undersampled regions include the northeast coast of South America, West India, Pakistan, and Southeast Asia.



Kemp's ridley turtle management units. Of 67 documented nesting sites, nine rookeries have been genetically sampled, and one MU has been identified. Undersampled regions include the Southern Gulf of Mexico.



Flatback turtle management units. Of 225 documented nesting sites, 17 rookeries have been genetically sampled, and seven MUs have been identified. Undersampled regions include Northeast Arnhem Land, Australia.

Legend

Base maps: Ocean Basemap—Esri, DeLorme, GEBCO, and NaturalVue

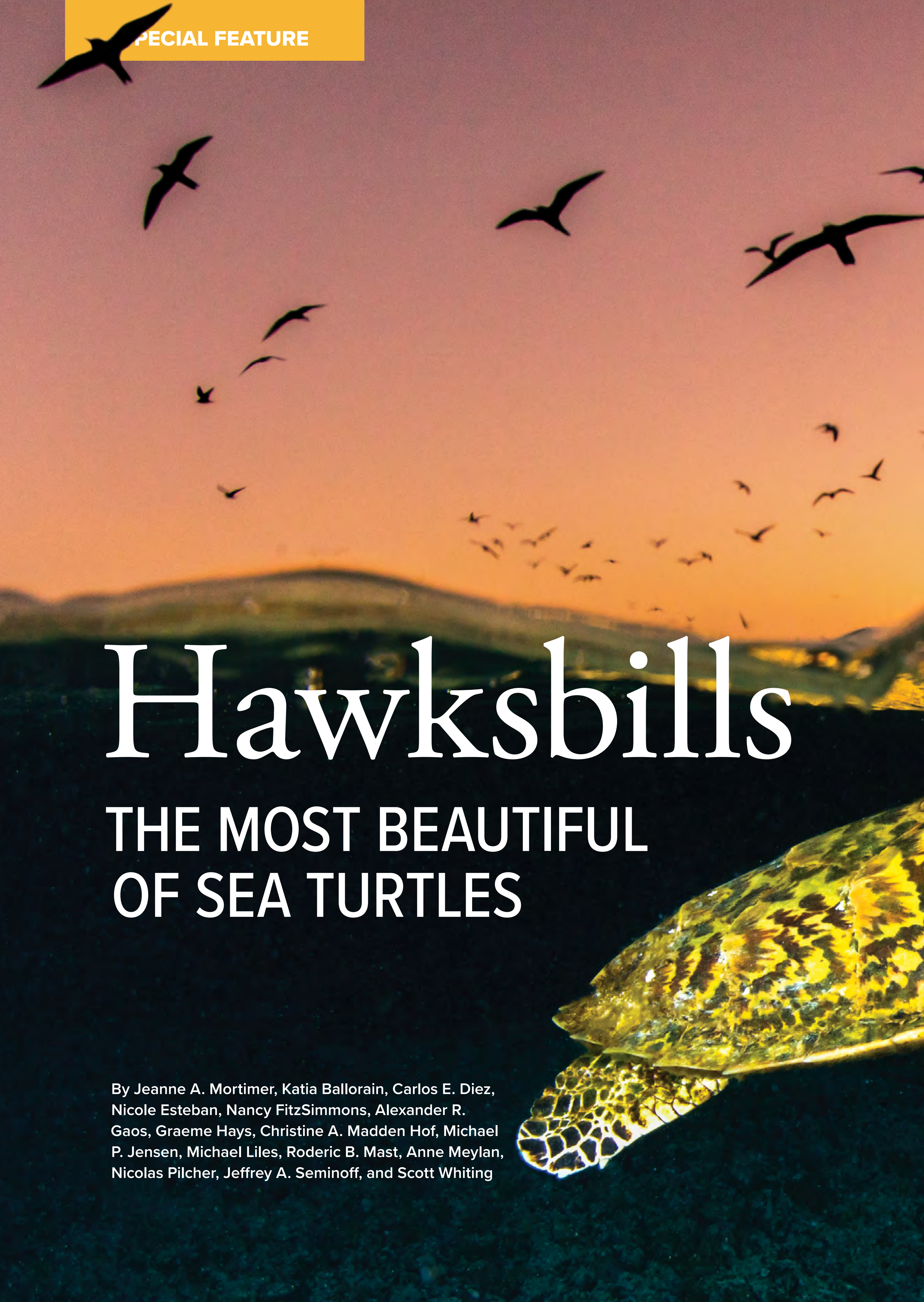
Projection: Eckert IV

Produced in partnership with: Oceanic Society, OBIS-SEAMAP, and the IUCN-MTSG

• unsampled sites

stocks

● *Caretta caretta*
■ *Chelonia mydas*
▲ *Dermochelys coriacea*
⬟ *Eretmochelys imbricata*
✚ *Lepidochelys kempii*
♦ *Lepidochelys olivacea*
★ *Natator depressus*



Hawksbills

THE MOST BEAUTIFUL OF SEA TURTLES

By Jeanne A. Mortimer, Katia Ballorain, Carlos E. Diez, Nicole Esteban, Nancy FitzSimmons, Alexander R. Gaos, Graeme Hays, Christine A. Madden Hof, Michael P. Jensen, Michael Liles, Roderic B. Mast, Anne Meylan, Nicolas Pilcher, Jeffrey A. Seminoff, and Scott Whiting

Remarkable, Tropical, and Hunted for Centuries

Noted for the thick, overlapping, dappled cream-and-brown scutes that cover its carapace and plastron and provide excellent camouflage against a coral reef backdrop, the hawksbill is considered by many to be the most beautiful of all sea turtle species. Its pointed, beak-like head, from which its common name derives, enables it to forage in crevices and feed on prey with leathery or heavily armored outer surfaces. It is the most tropical of sea turtles, nesting on the coasts and islands of some 70 countries whose shores are located primarily between the Tropic of Cancer and the Tropic of Capricorn. The hawksbill demonstrates many surprising biological and ecological traits that make it remarkable among sea turtles.

Hawksbills are pantropical and found in every major ocean basin worldwide. As can be seen on the map (pp. 28–29), the largest population centers for nesting hawksbills include the warm waters of the Gulf of Mexico and the Caribbean Sea, the southwest and northwest Indian Ocean (including the Red Sea and the Persian/Arabian Gulf), and tropical Australasia. Smaller numbers of hawksbills nest in Oceania and the Hawaiian Islands, the eastern Atlantic (West Africa), the western Atlantic (Brazil), and in the recently rediscovered eastern Pacific populations. The IUCN-SSC Marine Turtle Specialist Group recognizes 13 regional management units (RMUs) for hawksbills. Each RMU comprises multiple genetic stocks or management units (MUs) that are mostly defined by significant differences in mitochondrial DNA haplotypes. Each MU may comprise several neighboring rookeries facing similar threats. To date, 30 MUs for hawksbills have been identified globally, and many more are expected to be identified in the near future. Most of the detailed genetic studies undertaken thus far have focused on the western Atlantic and eastern Pacific regions. These have shown genetic differences at unexpectedly fine scales, including differences between rookeries found on opposite sides of the same island. In the Indo-West Pacific, only eight MUs have been defined to date, and the majority of hawksbill populations in the western Pacific have not yet been assessed for their genetic population structure. Significant gaps remain in our understanding of the genetics of hawksbill populations, as evidenced by studies of foraging grounds that have shown variants not previously recorded at rookeries. For more on hawksbill genetics, see "Genetic Tools for Sea Turtle Conservation" on pp. 16–21 of this report.

Decades ago, biologists thought that hawksbills were by nature solitary nesters, but today it is commonly believed that their characteristic low-density nesting is likely an artifact of the long-term overexploitation that has persecuted the species for centuries, mostly for its prized shell (often called tortoiseshell). Tortoiseshell can be fashioned into valuable items ranging from jewelry and trinkets to elaborately carved combs, eyeglass frames, sculptures, and even spurs for fighting roosters. Trade statistics are key to understanding the enormous impact that this commerce has wrought on hawksbills over time. Millions of hawksbills have died in the past century alone, yet the trade can be traced back millennia. Tortoiseshell objects have been found in the graves of the Nubian rulers of predynastic Egypt, the ruins of China's Han Empire, and the middens of pre-Columbian cultures in the Caribbean. Throughout much of human history, hawksbills have paid a lethal price for their beauty.

AT RIGHT: A hawksbill turtle hovers above the reef. Larger hawksbills are seen on the coral reefs outside of the lagoon in Europa National Natural Reserve, Éparses Islands, France, Indian Ocean. © H. Sauvignet; **PREVIOUS SPREAD:** A hawksbill turtle surfaces at sunset on the Great Barrier Reef as a group of Black Noddies flies overhead. © Jordan Robins Photography

Distinctive among Sea Turtles

Among the six species of hard-shelled sea turtles, adult female hawksbills tend to be smaller than green turtles, loggerheads, and flatbacks, but larger than olive or Kemp's ridleys. Throughout most of their range, hawksbills nest primarily at night, as do the larger species of sea turtle, but in much of the western Indian Ocean they more typically nest during the day. What adaptive value diurnal nesting may offer these animals remains a mystery. Unlike other sea turtles, hawksbills tend to dig relatively shallow nests that are often placed under vegetation, possibly to help optimize incubation temperatures and humidity in their shallow nests. In several areas of the eastern Pacific, hawksbills are distinctly associated with mangrove ecosystems, where they even nest on sandy banks hidden amid mangrove roots and shoots.

The diet of hawksbills is peculiar among sea turtles. During their posthatchling pelagic phase, western Atlantic hawksbills are closely associated with floating rafts of the brown algae *Sargassum* and appear to share the omnivorous and opportunistic diet of posthatchling loggerheads, green turtles, and Kemp's ridleys, feeding on *Sargassum*, fish eggs, tunicates, goose barnacles, and more. When older, hawksbills transition to benthic feeding habitats, where they dine predominantly on sponges, and on items that can include corallimorphs (coral-like anemones), zoanthids, tunicates, and algae. At some sites, the hawksbill diet shows variability, particularly where sponges are scarce or absent.

Spongivory is especially rare among other marine creatures given the array of toxic chemical compounds that can be found in sponges, not to mention the gut-piercing glass spicules found in some. Yet hawksbills take these dietary challenges in stride and consume specific sponge species in large quantities. The tendency of hawksbills to consume prey items that other species do not is a strategy that may limit interspecific competition.

Mangrove channels provide habitat for juvenile hawksbill turtles in the lagoon of Europa National Natural Reserve, Éparses Islands, France, Indian Ocean. © H. Sauvignet

Moreover, whether by coincidence or evolutionary design, a diet rich in sponges may be the reason hawksbill meat is sometimes toxic or even fatal to humans who consume it. For this reason, hawksbill meat is frequently off the human menu in some localities in the Indo-Pacific region and elsewhere, where other sea turtle species are preferentially consumed.

Foraging resident hawksbills have a close association with coral reefs and rocky reefs, but they also thrive in a wide variety of other habitats, including seagrass, algal beds, mangrove bays, creeks, and even mud flats. In the eastern Pacific, juvenile and adult hawksbills can spend virtually all of their lives in mangrove-lined estuaries, foraging among aboveground mangrove roots, and even feeding directly on mangrove fruits and seeds.

High density aggregations of juvenile hawksbills have been documented in coastal waters near cities as well. Those "urban hawksbills" inhabit degraded reefs that provide them with food, shelter, and resting sites. In Puerto Rico, the growth rates and weight-to-length relationships of these city-dwelling hawksbills are similar to those of animals that live in more natural habitats, suggesting that the species may be relatively resilient to habitat change. Nevertheless, hawksbills residing in marinas in Seychelles, Hawaii, and some sites in the eastern Pacific often appear emaciated and unhealthy, suggesting limits to their tolerance for habitat degradation.

Though hawksbills inhabit coastal waters in more than 108 countries, their movements are among the least studied of all sea turtle species. In some regions, postnesting hawksbills tend to migrate shorter distances than postnesting green turtles (e.g., the Indian Ocean, Hawaii, and the eastern Pacific, where hawksbill movement corridors are often highly coastal), but this pattern does not hold in the Caribbean or the western Pacific regions (see map on p. 27). Developmental migrations made by immature hawksbills may be even more extensive than the reproductive migrations of adult hawksbills in the same region. Satellite tracking, molecular genetics, and flipper tagging have demonstrated that within each life stage of a hawksbill population, some individuals may engage in particularly extensive migrations. Moreover, larger hawksbills, including postnesting females, seem to venture deeper, farther from shore, and into lesser-known foraging habitats.

Hawksbill hatchlings typically enter a pelagic foraging phase that transitions to benthic foraging at sizes that vary depending on the ocean basin. Those transitions occur at 20, to 25-centimeter carapace length in the Atlantic Ocean and around 30-centimeter length in the Indo-Pacific. Remarkably, in the eastern Pacific some posthatchling hawksbills skip the oceanic stage altogether and remain within the mangrove estuarine habitat that hosts their natal nesting beaches. In such tidally dominated ecosystems, hatchlings grasp floating debris as a dispersal strategy, which may provide energy-saving transport and safety as they cryptically hitchhike with the current.

The Persian/Arabian Gulf experiences dramatic annual fluctuations in sea temperature, ranging from a low of 17°C to a high of 37°C. Although hawksbills appear to be adept at avoiding or tolerating the temperatures in the upper range, many succumb to cold stunning at the lower range. In the United Arab Emirates, hundreds of small hawksbills wash up covered in barnacles and algae each year, and many are subsequently rescued and rehabilitated. Green turtles in the same region are not similarly afflicted, which highlights the tropical nature of hawksbills compared to other sea turtle species.

FEATURE MAPS: HAWKSBILL TURTLES

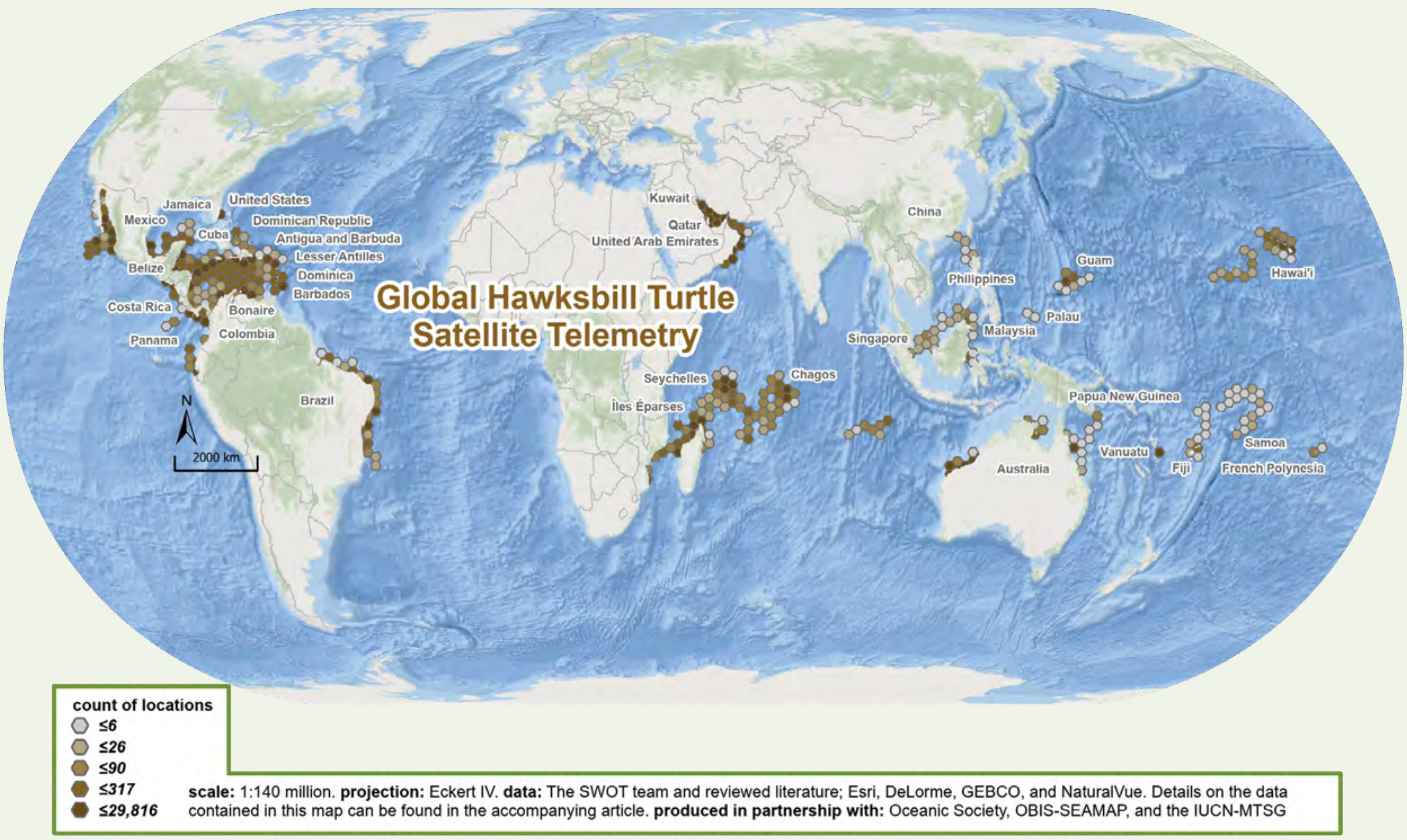
Global Nesting Biogeography

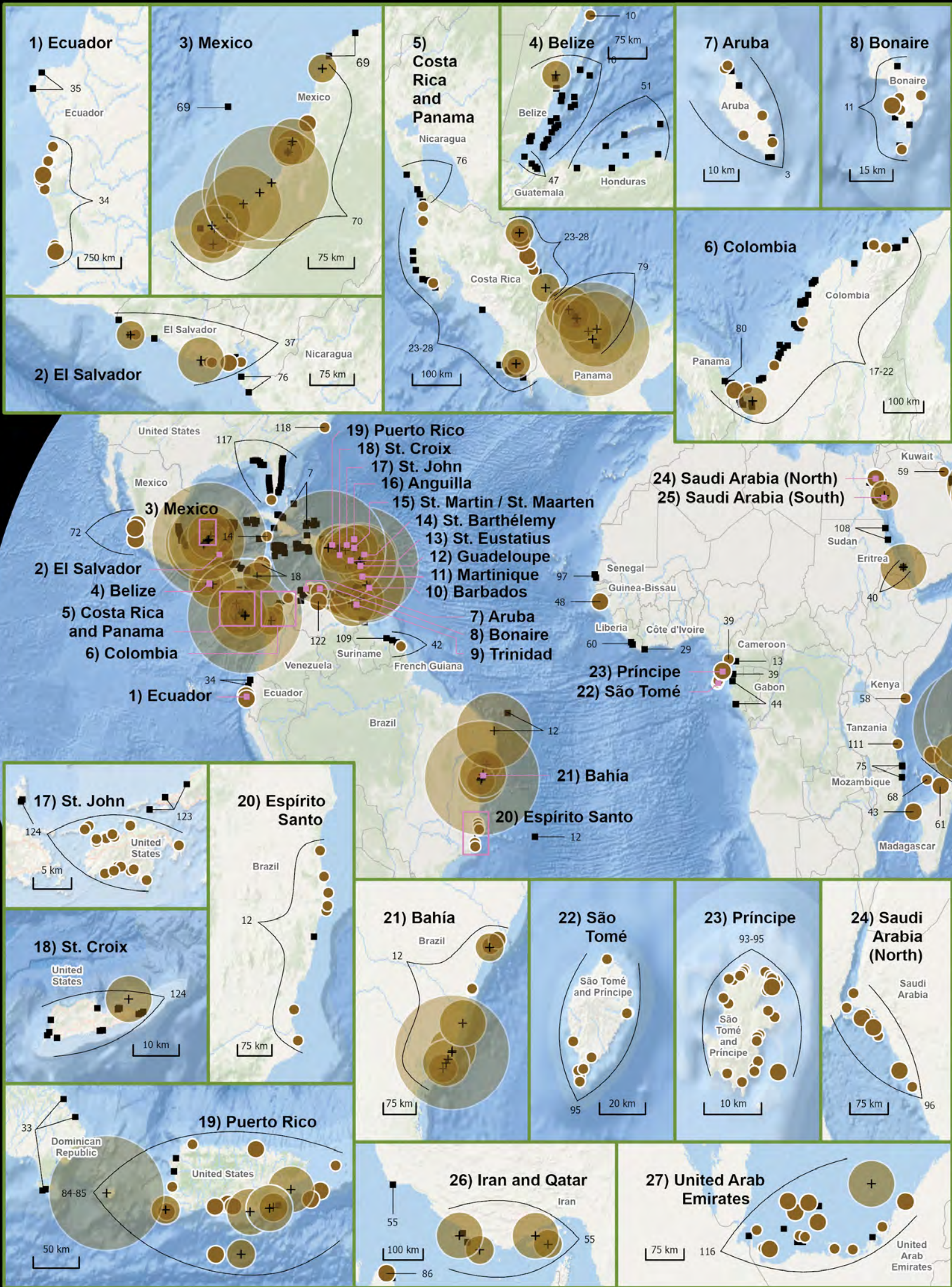
The map on pp. 28–29 displays available nesting data for hawksbill sea turtles. The data include 1,792 nesting sites, which were compiled through a literature review and provided directly to SWOT by data contributors worldwide. For metadata and information about data sources, see the complete data citations on pp. 45–50.

Nesting sites are represented by brown dots scaled according to their relative nesting abundance in the most recent year for which data are available. Black squares represent nesting sites for which data are older than 10 years, data were unquantified, or the nest count for the most recent year was given as zero. For uniformity, all types of nesting counts (such as number of nesting females or number of crawls) were converted to number of clutches, as needed. Conversion factors were as follows: a ratio of 3.6 nests to each nesting female in the eastern Pacific and Indian Oceans, 4.3 nests to each nesting female in the Wider Caribbean and Atlantic Ocean, and 3 nests to each nesting female in Australia, plus a ratio of 0.6 nests for every crawl in all regions.

Global Satellite Telemetry

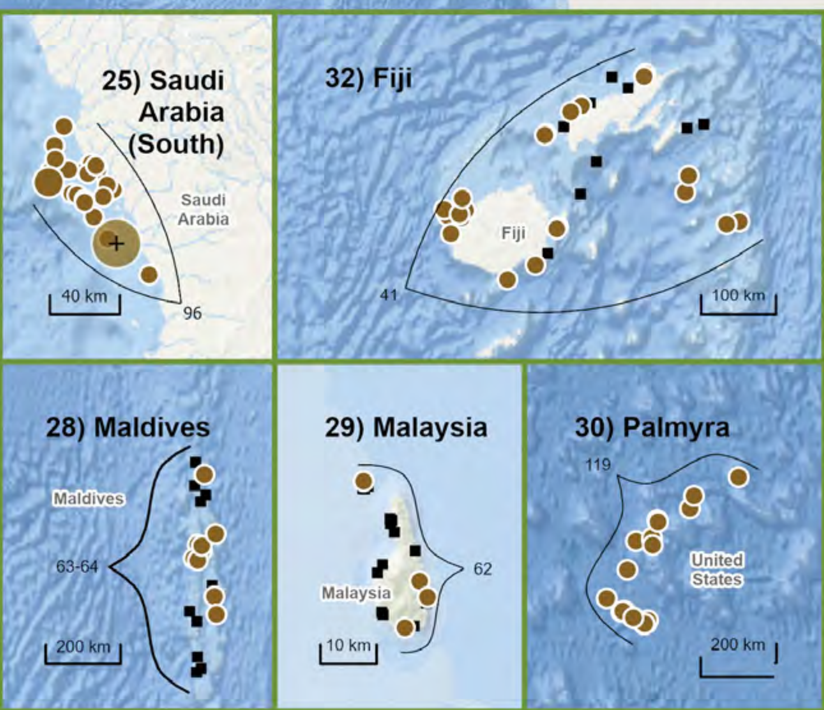
The map below summarizes all available telemetry data from tags deployed on hawksbill sea turtles around the world. The data consist of more than 300,000 locations from 477 individually tracked turtles and were contributed by more than 51 partners (see data citations, pp. 50–52). Telemetry data are represented as polygons that are shaded according to the number of locations they contain. Darker brown represents a higher number of locations, which can indicate that a high number of tracked turtles were present 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. Thus, 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. 50–52.



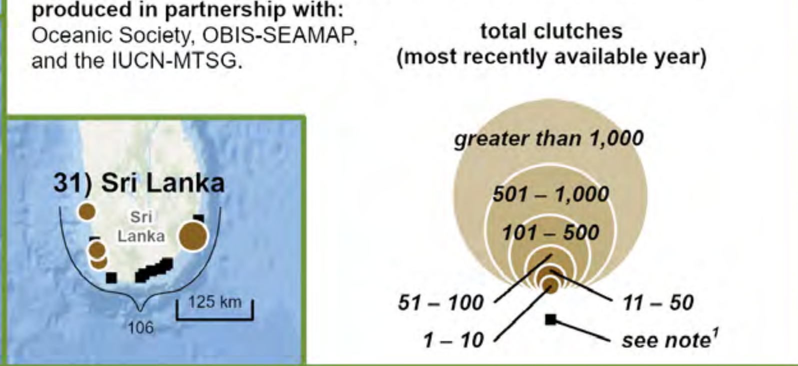


1) Ecuador
35
Ecuador
34
750 km
3) Mexico
69
Mexico
69
70
75 km
5) Costa Rica and Panama
Nicaragua
76
Costa Rica
23-28
79
23-28
Panama
100 km
4) Belize
10
75 km
10
51
Belize
47
Guatemala
Honduras
7) Aruba
Aruba
10 km
3
8) Bonaire
Bonaire
11
15 km
2) El Salvador
El Salvador
37
Nicaragua
76
75 km
6) Colombia
Colombia
80
Panama
17-22
100 km
United States
118
117
7
Mexico
19) Puerto Rico
18) St. Croix
17) St. John
16) Anguilla
15) St. Martin / St. Maarten
14) St. Barthélemy
13) St. Eustatius
12) Guadeloupe
11) Martinique
10) Barbados
7) Aruba
8) Bonaire
9) Trinidad
3) Mexico
72
14
2) El Salvador
4) Belize
18
5) Costa Rica and Panama
6) Colombia
122
109
42
Suriname
Venezuela
French Guiana
34
1) Ecuador
Ecuador
Brazil
12
21) Bahía
20) Espírito Santo
12
24) Saudi Arabia (North)
25) Saudi Arabia (South)
Kuwait
59
108
Sudan
Eritrea
40
97
Senegal
Guinea-Bissau
48
Liberia
Côte d'Ivoire
60
29
39
Cameroon
13
39
Gabon
44
23) Príncipe
22) São Tomé
Kenya
58
Tanzania
111
75
Mozambique
68
43
61
Madagascar
17) St. John
123
124
United States
5 km
20) Espírito Santo
Brazil
12
75 km
18) St. Croix
United States
124
10 km
21) Bahía
Brazil
12
75 km
22) São Tomé
São Tomé and Príncipe
95
20 km
23) Príncipe
93-95
São Tomé and Príncipe
10 km
24) Saudi Arabia (North)
Saudi Arabia
75 km
96
19) Puerto Rico
33
Dominican Republic
United States
84-85
50 km
26) Iran and Qatar
Iran
55
55
100 km
86
27) United Arab Emirates
116
75 km
United Arab Emirates

Nesting Biogeography of Hawksbill Sea Turtles



scale: 1:80,000,000. **projection:** Eckert IV, central meridian 155W.
data: The SWOT team and reviewed literature (see end of report for citations[2]); Ocean Basemap: Esri, DeLorme, GEBCO, NaturalVue; boundary data: Esri Maps and Data for ArcGIS 2022.
notes: 1. Data that are older than 10 years, unquantified, or the count was given as zero (includes sites with confirmed nesting in the past but no nesting in the most recent year for which data are available).
2. The density of data in some regions, particularly the Caribbean, and the limited space on the map precludes creating enough insets so that all nesting sites are individually identifiable. Priority for insets was given to areas that had more recent data. Records for data not visible on the map are marked in the citations with an asterisk but are not labeled.
produced in partnership with:
Oceanic Society, OBIS-SEAMAP, and the IUCN-MTSG.



Conservation Challenges

The following issues present challenges to hawksbill conservation efforts worldwide.

Direct Take and Trade

Hawksbills have been classified globally as critically endangered on the IUCN Red List of Threatened Species since 1996, and a reassessment is currently under way. They were brought to the brink of global extinction in the twentieth century by the unrelenting international tortoiseshell trade. In 1977, the Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES) banned the trade in hawksbill products among its signatory states. But, because some signatory parties had legally registered reservations for hawksbills, CITES had little impact until the 1990s, when all reservations against the ban were dropped. This change led to some wonderful success stories.

In 1994, the government of the Republic of Seychelles reversed a devastating decline in hawksbills by purchasing all worked and unworked tortoiseshell in the country and prohibiting trade in sea turtle products. Then, in 1998, the stockpile of tortoiseshell was publicly burned. Today, you will not find hawksbill shell products for sale anywhere in Seychelles. In March 2022, the government of Cuba also demonstrated its commitment to nonconsumptive, sustainable use of sea turtles for tourism, research, and ecological services by announcing the destruction of its 8.1–metric ton stockpile of hawksbill shell procured in that country prior to 2008, when hawksbill capture became illegal.

The battle to save the hawksbill from human depredation continues despite these and other successes. Illegal international trade and destructive levels of domestic consumption of hawksbill shell continue in many parts of the world. Animals continue to be taken for meat and eggs throughout much of their range, and demand for hawksbill in new and re-emerging black markets in Southeast Asia (including China, Japan, Vietnam, Taiwan, and Hong Kong) is on the rise. This new demand is exacerbated by the growing Chinese presence and purchasing power in the Pacific, combined with illegal, unregulated, and unreported fishing—particularly by the Chinese distant-water fleet. While this demand remains, communities and other small-scale fisheries are becoming increasingly involved and trapped in this vicious trade cycle, whether they are targeting or opportunistically benefitting from it. Also, the marine turtle supply chain has become increasingly fragmented and opaque in some countries, shifting to covert markets that thwart policy responses and enforcement efforts. Using genetics and DNA-based wildlife forensic science, nongovernmental organizations (NGOs), along with local communities, universities, government partners, and international networking efforts, are building a program called ShellBank, a database and platform to help governments, researchers, and conservation managers track the turtle trade from sale to source and to improve the enforcement of bans and identify which populations are most at risk.

Fisheries Bycatch

Some fisheries pose an especially serious threat to hawksbills. Gill nets are particularly problematic, given the hundreds of thousands of small vessels that deploy them in shallow waters throughout the world. Lobster are problematic, as well, since they capture hawksbills opportunistically; so even when hawksbill numbers are low, the pressure on them continues unabated as long as the more lucrative resource (lobsters) remains reliable.

In the Indian Ocean, fish aggregating devices (FADs) associated with tuna purse seiners pose yet another threat. FADs float at the surface and cast a shadow into the water to attract aggregations of tuna but are often constructed of discarded nets and ropes that hang tens of meters below the surface, where they unintentionally entangle marine life—including sea turtles. In the southwestern Indian Ocean, FADs often drift into shallow waters, where they snag onto coral reefs and kill hawksbills. Discarded fishing gear and ghost nets relentlessly plague global waters, especially targeting young pelagic turtles that forage within these artificial habitats. Hawksbills are also killed by blast fishing in many parts of their range, another destructive technique that uses explosives to kill or stun fish and collaterally causes permanent damage to coral reefs and other sensitive habitats.

Negative Impacts on Nesting Habitat

Hawksbills are vulnerable at all stages of their life cycles, but especially at their breeding beaches, where nesting females and their eggs are easy to exploit. Unregulated coastal development can destroy nesting habitat when buildings and artificial lighting are placed too close to the beach, sea walls and other coastal armoring interfere with sand flow and beach access for nesting turtles, and the coastal vegetation under which hawksbills nest is removed. Daytime nesting hawksbills are shy animals that are vulnerable to disturbance from human activities as innocuous as picnics, sunbathing, swimming, and boating, even when the activity involves well-meaning tourists and local residents. Thus, critical stretches of nesting habitat need to be better incorporated into nature reserves that will be maintained in perpetuity and protected from unsupervised human access. Well-managed nature reserves can also produce revenue from ecotourism.

At many sites, both inside and outside formal nature reserves, hawksbill population decline caused by over-exploitation for meat and eggs has been effectively reversed by combining protective legislation with long-term monitoring of nesting beaches (see *SWOT Report*, vol. III, pp. 10–13, and vol. I, p. 8). Beach monitoring programs not only collect population data, but they also serve as a socially responsible approach to conservation when livelihood incentives are tied to conservation outcomes in low-income regions, and as a deterrent to illegal activity. Those programs are particularly effective when implemented by community members because they help create public awareness and support economic well-being. Such programs, however, are often used to provide index site data to represent the long-term status and trends of sea turtle nesting populations for the wider region, and this can be misleading. For example, index beaches that demonstrate increasing trends may not represent the population status of the wider region, in which many more turtle populations and their nesting habitats remain unmonitored and unprotected and may actually be in decline. Regardless of the situation, the expansion of monitoring programs across more nesting sites will allow for an increased understanding of hawksbill population trends and threats.

Genetic Mixing

In the Brazilian state of Bahia, hybridization between hawksbill and loggerhead turtles poses an unusual threat to both species.

Genetic studies there have confirmed that first generation hybrid females produced by the mating of male hawksbills and female loggerheads have successfully produced viable hatchlings, resulting in a population in which turtles now share the mixed DNA of both species. More than 40 percent of the sampled hawksbill nesting population was found to comprise multigenerational hybrids that display loggerhead mitochondrial DNA haplotypes but morphologically appear to be hawksbills. Similar results were also found in a nearby loggerhead rookery, accompanied by evidence of lower survival of hybrid offspring. Considering the vastly different ecological roles of the two species, which were separated more than 20 million years ago, this is a remarkable and troubling phenomenon. Such findings raise conservation concerns about the evolutionary and ecological implications of hybridization and the processes that may be driving it.

Climate Change and Other Human Activity

Though difficult to quantify, climate change poses a threat to nesting beaches through sea level rise and erosion, as well as higher incubation temperatures that may feminize, decrease fitness, or result in hatchling mortality. Rising temperatures have already resulted in the destruction of critical habitats (such as coral reefs) on which hawksbills depend. And, like other marine turtles and marine life in general, hawksbills are threatened during all of their life stages by boat strikes and countless human-generated chemical toxins (see the article on inorganic pollutants on pp. 10–13). Plastic debris in the sea and washed onto the beach is another challenging threat.

A Hopeful Future

On the bright side, many people and organizations are now taking action to learn more about hawksbills and to tackle the problems the animals face at local, national, and international levels around the world.

In the Indo-Pacific, the Memorandum of Understanding on the Conservation and Management of Marine Turtles and their Habitats of the Indian Ocean and South-East Asia (IOSEA MoU) has put in place a framework through which states, territories, governmental entities, and NGOs can work together to conserve marine turtles and their habitats. IOSEA recently published an “Assessment of the Conservation Status of the Hawksbill Turtle in the Indian Ocean and South-East Asia Region” and is currently working to create an action plan for hawksbills in the region. The TImOI project (Tortues Imbriquées de l’Océan Indien, or Hawksbills of the Indian Ocean) is another effort that uses genetics and satellite tracking to look at population connectivity among 13 countries and territories. In the Atlantic/Caribbean region, WIDECAST (the Wider Caribbean Sea Turtle Conservation Network) engages experts from more than 40 nations and territories, and the ICAPO network (Iniciativa Carey del Pacífico Oriental, or Eastern Pacific Hawksbill Initiative) has also made enormous strides over the past decade to amalgamate the efforts of multiple organizations working to engage with local fishers and community members to study and protect hawksbills in that important region (see *SWOT Report*, vol. III, pp. 18–19).

Now in Appendix I of CITES, hawksbills continue to enjoy the protection afforded by a complete ban on legal international trade in hawksbill products by signatory states. Hawksbills are also the focus of a special resolution of the Inter-American Convention for the Protection and Conservation of Sea Turtles (IAC) that promotes national legislation and conservation actions to protect sea turtles in 16 nations in the Americas.

Although problems persist, history has shown that with enough hard work and perseverance, conservation efforts can and will save this most beautiful of sea turtles. •

New Technology Uses Machine Learning to Tackle Tortoiseshell Trade

By Brad Nahill

A new mobile application (app) has been added to the global toolkit to address the illegal trade of products made from hawksbill shell (tortoiseshell). Called SEE Shell, the app uses machine learning to evaluate images of suspected tortoiseshell products and to determine whether they are made of genuine or faux material. Introduced as part of Too Rare to Wear (see *SWOT Report*, vol. XVI, pp. 34–35), which is a campaign led by the nonprofit SEE Turtles, the app enables tourists as well as law enforcement and wildlife officials to quickly identify products made of authentic tortoiseshell.

Despite international laws prohibiting it, the tortoiseshell trade is active in at least 40 countries and remains one of the biggest threats to hawksbills globally. Travelers are the primary consumers of the products in many places; the SEE Shell app will help travelers avoid accidentally purchasing genuine tortoiseshell products. Reports by app users will also help to improve tracking of the illicit trade.

SEE Shell is highly accurate at discerning whether a photo taken by the user shows an item made from real hawksbill shell or other materials, such as resin, horn, bone, seashell, or coconut shell; it can determine content with at least 94 percent accuracy. The application uses deep learning technology that compares user photos with a library of more than 4,000 real and artificial tortoiseshell products. As images are added to the catalog from locations around the world, a clearer understanding of the illegal tortoiseshell trade will emerge, providing information about where trade enforcement and hawksbill conservation are most needed.

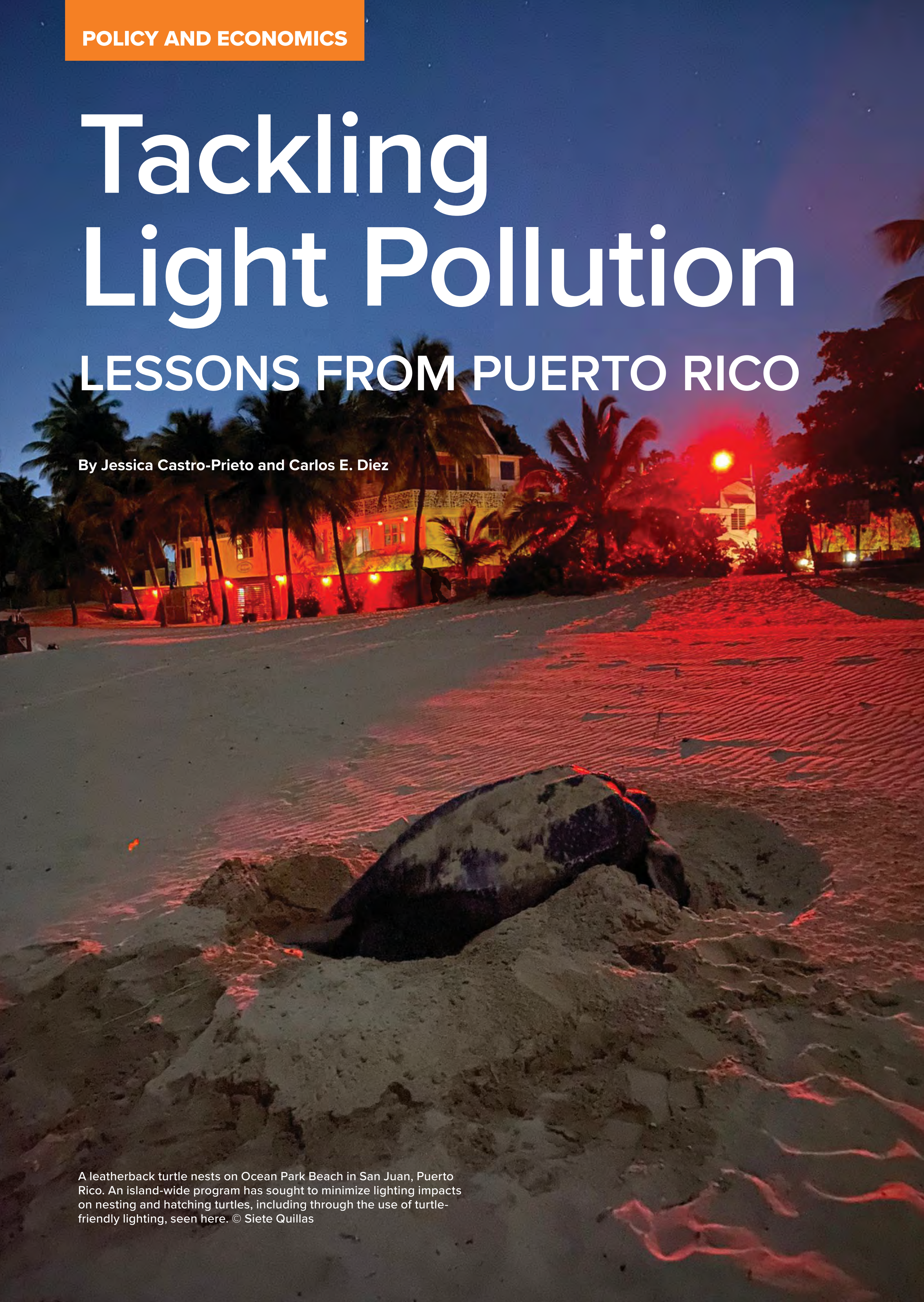
Partner organizations in Indonesia and Latin America have helped to test the app in the field and will train local law enforcement officials in its use to help document the existence of tortoiseshell trade in their regions. Participating organizations include Turtle Foundation (Indonesia), Fundación Tortugas del Mar (Colombia), Latin American Sea Turtles Association (Costa Rica), the Leatherback Project (Panama), Sos Nicaragua, and the World Wildlife Fund (also known as the World Wide Fund for Nature) and its Indo-Pacific affiliates.

POLICY AND ECONOMICS

Tackling Light Pollution

LESSONS FROM PUERTO RICO

By Jessica Castro-Prieto and Carlos E. Diez



A leatherback turtle nests on Ocean Park Beach in San Juan, Puerto Rico. An island-wide program has sought to minimize lighting impacts on nesting and hatching turtles, including through the use of turtle-friendly lighting, seen here. © Siete Quillas

Light pollution—the inappropriate or excessive use of artificial light that can take the form of glare, light trespass, sky glow, or clutter—is a threat to sea turtles globally (to learn why, see FAQs on p. 38), as well as to many other species including humans. Addressing light pollution has become an increasingly important challenge on a rapidly developing planet where true, natural darkness has become a rare commodity.

On the Caribbean island of Puerto Rico, permits for urban and touristic construction in coastal areas have more than doubled in the past five years, and the associated light pollution has become a grave threat to the sea turtles that nest on nearby shores. On beaches near the capital city of San Juan, for instance, nearly all nesting and hatching turtles would be bathed in disorienting artificial light at night were it not for the efforts of community conservation groups to relocate nests and to use light shades and tarps to redirect hatchlings toward the sea. In response to public concerns, legislation was approved in 2008 (Law 218 for the Control and Prevention of Light Pollution) that included specific regulations for properties adjacent to sea turtle nesting beaches. However, enforcement has been lax owing to legal ambiguities and a lack of regulatory personnel.

A Program to Retrofit Lighting

In 2020, a lighting retrofit program funded by the National Fish and Wildlife Foundation was developed as part of the Leatherback Sea Turtle Habitat Restoration Project, which is led by the National Wildlife Refuge Association in collaboration with the Puerto Rico Department of Natural and Environmental Resources (PR-DNER) and several community-based sea turtle conservation groups. The program pursues the following seven-step process:

1. Perform nighttime surveys to identify sources of light pollution, which will include collecting GPS locations and photographs.
2. Conduct daytime property visits to inventory beachfront light fixtures that should be replaced with more turtle-friendly models.
3. Invite property owners to voluntarily comply with lighting changes, which will include receipt of technical advice and of free-of-charge, turtle-friendly lighting.
4. Provide expert-designed lighting retrofit plans for the properties whose owners agree to comply.
5. Have property owners sign a letter of commitment that describes the roles and responsibilities of compliance with the program.
6. Give property owners 45 days to comply with the lighting retrofit plan.
7. Present a certificate from the PR-DNER Light Pollution Office to properties that comply and voluntarily participate in the retrofit program.

If property owners do not agree to take action to mitigate light pollution for which they are responsible or if they refuse to participate in the free assistance offered by the program, their case is referred to the PR-DNER Light Pollution Office for punitive action.

Since the launch of the program, 90 properties in 15 coastal municipalities have participated, including private residences, condominiums, nature reserves, municipal parks, and even commercial properties such as hotels, Airbnbs, and restaurants. As a result, there has been measurably less light pollution on Puerto Rican sea turtle beaches.

Lessons Learned

A number of valuable lessons have been learned from the initial year of the lighting retrofit program that can help others who choose to take on similar efforts. Those lessons include the following:

- Start by working on legislation to regulate light pollution in your region if laws do not already exist. Even though the enforcement of Puerto Rico's law has been weak, it nonetheless provides a legal framework that serves as a strong incentive for participation.
- Conduct education campaigns and prepare to provide technical assistance. This approach is especially important with businesses such as hotels and resorts that are common sources of light pollution near sea turtle beaches in the Caribbean. Offer safe alternatives, and consider developing a program to reward compliance.
- Secure funds to subsidize lighting retrofits, and clearly define priorities and set criteria for who should receive free technical and material support.
- Conduct outreach among property owners that aims to educate them not only about sea turtles, but also about the importance of good lighting practices for improving safety, saving energy, and improving public health (for example, excessive artificial light is linked to anxiety, depression, and poor sleep quality). Outreach campaigns should highlight the benefits of smart lighting practices and demystify the popular belief that more lights promote safety—most crimes reported in Puerto Rico have occurred not at night, but rather from 8:00 to 11:00 a.m.
- Recommend certified turtle-friendly lights (minimum of 560 nanometers), because not all amber or red lights meet turtle-safe standards.
- Listen to and consider peoples' concerns and needs, and find ways to please the people. For example, humans often prefer amber over red lights, a preference that can be easily accommodated.
- Once the retrofit is complete, follow up with property owners periodically to build and maintain long-term relationships. This contact might include phone calls, holiday cards, or check-up visits.

Future Challenges

The big question facing Puerto Rico's lighting retrofit program is whether its work can be sustained for the long term. The program must be reinforced not only by effective enforcement of the law, but also through ongoing efforts in education, awareness campaigns, and local capacity building. Those efforts will require help from various sectors ranging from government professionals to local communities and nonprofit partners. Hopefully, the work done thus far has generated a long-term change in attitudes and behaviors among property owners and program participants. Although the effort and money invested to date has paid off in reduced light pollution at sea turtle beaches, the work must continue to sustain and expand on such successes. •

BURNING ISSUES 7 UPDATE:

Defining Guidelines for Important Marine Turtle Areas

ABOVE: A Kemp's ridley hatchling makes its way to the sea at Padre Island National Seashore, Texas, U.S.A. © Kyle Christensen / @bluelifewild

By the Important Marine Turtle Area (IMTA) Working Group and the IUCN-SSC Marine Turtle Specialist Group

The IUCN-SSC Marine Turtle Specialist Group's (MTSG) Burning Issues (BI) initiative is a collaborative, inclusive, and science-based effort to draw the most accurate and comprehensive picture of global sea turtle status and conservation priorities in order to provide policymakers, managers, funders, and others with guidance to support the most urgent and effective sea turtle conservation actions. The BI initiative enhances and supports the MTSG network, and the resulting outputs are widely used by people working to study and protect sea turtles worldwide.

Ten years after the seminal results from the first six BI workshops were published, a seventh BI process (BI-7) is under way to update past outputs, such as regional management units (RMUs), with new scientific data and expertise. In addition, the MTSG is moving toward setting finer-scale priorities for sea turtle's at-sea habitats by developing Important Marine Turtle Areas (IMTAs).

Why IMTAs?

Among widespread migratory megafauna species, marine turtles are underrepresented in global and regional priority-setting processes. One reason is that currently no global source provides the information needed to identify important areas that need marine turtle protection. Though the MTSG has previously defined RMUs for each species, they cover vast geographies that encompass the entire life cycle of each subpopulation and do not identify important habitats within those ranges. To fill this important gap, the global MTSG membership, a group of more than 300 marine turtle specialists with diverse expertise, has developed criteria and a process for identifying global IMTAs. The IMTA process parallels similar initiatives for seabirds (Important Bird Areas) and marine mammals (Important Marine Mammal Areas), thus ensuring that biodiversity assessment and prioritization processes are comprehensive and comparable across multiple taxa of marine megafauna.

What Are IMTAs?

The goal of identifying IMTAs is to provide a robust, globally consistent framework to support conservation and management of areas that are important for marine turtles at multiple scales. The MTSG defines IMTAs as "discrete areas within existing marine turtle regional management units (RMUs) that are of particular biological significance for the persistence of marine turtles, and/or where the contributions of marine turtles to traditions and cultures of local people are particularly significant." Although the biological and cultural significance of any area where a marine turtle is present might deem it important, IMTAs are intended to reflect the areas of most significant importance for each RMU.

What Criteria and Processes Identify IMTAs?

The proposed IMTA criteria are designed to be inclusive of the many differences that exist across the ranges of all marine turtle species, including human cultures, ecosystems, and data availability. The criteria allow different types of knowledge to be integrated into IMTA assessment efforts, which will be driven by regional and local experts. IMTAs will be identified through a two-step process. First, a candidate area must fall into at least one of two categories: (a) biologically significant or (b) culturally significant. Second, the area will be evaluated against several criteria to demonstrate its disproportionate importance to a given region. The tables that follow, taken from *Important Marine Turtle Areas: Guidelines 1.0 (August 2021)*, provide details on those categories and criteria.

What Next for IMTAs?

The process by which specific IMTAs will be defined is still being refined, but the MTSG anticipates it to be highly participatory and to offer many points of entry for all stakeholders, similar to the way IMTA criteria were developed. Future phases will involve testing and refining the guidelines and criteria with regional partners. See the IMTA guidelines at https://www.iucn-mtsg.org/imtas for more details, and stay tuned for news about updated RMUs and other outputs emerging from the BI-7 process! •

STEP 1: An area must fall into at least one of these two categories:

CATEGORIES	DEFINITION
Biologically significant	Areas that are important for courtship, mating, nesting, and hatching; areas and conditions that provide an important habitat on which a species or population depends for vital processes such as feeding, resting, and ontogenetic development; areas used as migration corridors or other movements, thereby connecting distinct life-cycle areas or the different parts of the year-round range of a nonmigratory population.
Culturally significant	Socio-economic and cultural activities that occur within an area and are compatible with conservation of marine turtles and their habitats so that they do not degrade the integrity of marine turtle habitat and do not entail unsustainable use of marine turtles; activities specifically may include areas associated with marine turtles where the species have a salient role in shaping cultural heritage, as reflected in the fundamental roles in diet, materials, medicine, or social practices, or a combination thereof; areas that contain prehistoric, historic, or contemporary cultural resources related to marine turtles, or a combination thereof; or areas that embody traditional or contemporary beliefs or practices of cultural, religious or spiritual significance, in relation to marine turtles occurring at regional or local scales.

STEP 2: The area identified in Step 1 must meet at least one of the following criteria, as described by supporting information, research data, or other evidence:

CRITERIA	DEFINITION
Relative importance to the population	Areas of particular importance to turtle populations because of age, class of turtles, number of individuals included, or other defining characteristics (e.g., > 50% of total RMU nesting abundance, high density of foraging turtles regularly observed or inferred from tracking data).
Species or populations of particular conservation concern	Areas containing habitat important for the survival and recovery of species or populations at particularly high risk of extinction or under most-severe threats, ideally according to an established conservation status assessment framework (e.g., IUCN Red List Critically Endangered, Endangered, or Vulnerable; MTSG's conservation priorities portfolio; national-scale endangered species lists; documented significant historical depletion).
Aggregations or congregations	Areas with underlying qualities that support important concentrations of a species or population, especially those composed of multiple species or populations, or areas that are important to the persistence of turtle populations or human cultural practices related to marine turtles.
Distinctiveness	Areas that sustain populations with important genetic, plus behaviorally or ecologically distinctive, characteristics, including refugia from environmental change, or areas of distinct or important cultural significance in relation to marine turtles.
Diversity	Areas containing a habitat that supports an important diversity of species, populations, genetic lineages, or human cultural practices (e.g., area regularly supports three or more species, RMUs, or genetic management units).

Moving Beyond Parachute Science in the Sea Turtle Community

By Kartik Shanker, Michelle María Early Capistrán, José Urteaga, Jarina Mohd Jani, and Bryan Wallace

Remember when you first became aware of sea turtles? Beyond the thrill of stalking a strange reptile on a moonlit night was the lure of remote beaches in faraway lands. For some of us, it was the Andaman Islands, Baja California Sur, Playa Grande, Chacocente, Oaxaca, or the Gulf of California. For others, it may have been Aldabra, Seychelles, Gabon, Ascension Island, Sabah, Solomon Islands, Terengganu, Hawaii, or Cyprus. Such places roll off the tongue of any self-respecting sea turtle biologist. The magnificent marine vertebrates that traversed the world's oceans demanded the same of us. We called them voyagers, ambassadors, and flagships. And we thought of ourselves in the same way. It was a badge of honor to follow the turtles to distant lands. And we did so—with determination, passion, and pride.

But did we stop to consider that our "field" was another person's home? That we might be trespassing in some way? That we should take time to listen and learn from the locals before rushing to deploy our scientific research tools in their area? That our quest for knowledge and discovery might be just another form of pillaging, not unlike looting the silver of the natives, as colonizers of all hues had done for centuries? That our professional development and success, defined through Western-centric criteria, owed much to that very pillaging? Or that our research had the power to shape policy and alter peoples' lives, perhaps contrary to their desires? Or that those living in "the field" must live with the effects (foreseen or not, positive or not) of our inquiries—without having a say in those effects after we were long gone?

This phenomenon is referred to colloquially as "parachute science" or "helicopter research," is described in scholarly circles as "neo-colonial" research or science, is humorously called "safari study," and with brutal honesty is named "parasitic research." Broadly, it is when researchers "drop in" to marginalized locations to conduct research, travel back home to analyze data and samples, and then publish results with little or no involvement of local researchers or community members. Although this approach is largely associated with researchers from wealthier countries traveling to low- and middle-income countries, parachute science can happen within countries. Regardless of scale, parachute science occurs when researchers perpetuate power imbalances on historically marginalized people, such as indigenous or Afro-descendant residents, rural dwellers, or communities with lower socioeconomic status.

If this description sounds familiar and made you cringe, you are not alone. It's not a stretch to say that the roots of our discipline—and many of our very careers—are steeped in parachute science. Without justifying it, we must nevertheless acknowledge that scientific progress in natural history, ecology, and evolution were enabled by the knowledge extraction that accompanied other colonial expansionist endeavors. The pioneering expeditions and enormous collections of rocks, plants, and animals that came from the likes of Linnaeus, Cuvier, Darwin, and (Alfred Russel) Wallace enabled the discovery of biogeography and evolution. Throughout the nineteenth century, phyto- and zoogeographers, also geologists, and anthropologists traveled to the far reaches of the world to study nature. We stand on the shoulders of those giants. We may denounce some of them as being racist or ethnocentric and decry their worldviews—an easier task with the distance of time. But the more important question is, Are we able to recognize the remnants of that racism, classism, or cultural bias in ourselves and our current conservation practices? Might we all be parachute scientists to some degree?

Sea turtle biology and conservation are not exempt from this complicated history. Conservation and research programs worldwide have often been designed on the basis of the priorities, values, and sensibilities of organizations and funders in wealthy countries, or from bureaucracies and urban centers,

Parachute science is when researchers "drop in" to marginalized locations to conduct research, travel back home to analyze data and samples, and then publish results with little or no involvement of local researchers or community members. © Brian J. Hutchinson

with little or no involvement from the communities that actually live near and interact with sea turtles day to day. Some efforts may be made to promote participation of local stakeholders, but those attempts all too often fall short of meaningful, culturally appropriate engagement and may be instrumental, condescending, and even manipulative. In many cases the implications of parachute science are not limited to the scientific sphere. Such efforts may result in policies that, well intentioned as they may be, can have disastrous effects on the communities in which they are implemented by failing to adequately incorporate the perspectives and practices of local communities and stakeholders. Such outcomes are detrimental to both people and sea turtles.

Over time, international sea turtle conservation history has been filled with cases that range from reckless parachute science to respectfully integrated science and conservation. Collectively, we have many experiences—good, bad, and ugly—from which to learn or to be inspired. We have the responsibility to learn from these experiences, improve our practices, and foster equitable and mutually beneficial outcomes. But we still have a lot of work to do, much of which begins with listening to and learning from people who live where we work. This approach means (a) respectfully acknowledging each community's distinctive rules, values, and ethics in relation to sea turtles and having the humility not to work as "authoritarian biologists"; (b) creating access to relevant knowledge—scientific or otherwise—toward local capacity building and ensuring that knowledge sharing is a two-way street; and (c) establishing community self-determination as a guiding principle of conservation science and practice.

We welcome the initiative of the SWOT program to create a space in which to have this conversation and look forward to continuing it into the future. A list of further reading on this topic is appended to the online version of this article, which can be viewed at www.seaturtlestatus.org/articles. •

Frequently Asked Questions

A leatherback nests in front of a hotel on Grande Riviere Beach, Trinidad. When not properly managed, artificial lighting can significantly impact nesting and hatching turtles. © Ashleigh Bandimere

Why Are Lights on the Beach Bad for Sea Turtles?

By Blair Witherington

Although lighting the way at night may seem like a harmless necessity, artificial lighting is one of the most profound ways humans alter the natural world. For animals that are active at night, such as nesting and hatching sea turtles, natural light fields provide important information that guides critical behaviors. Artificial lighting pollutes those light fields with dangerous misinformation. For example, artificial lights visible from sea turtle nesting beaches can deter female turtles from nesting and can confuse females and their hatchlings as they orient seaward. The disruption of hatchling movement has lethal consequences to hatchlings both on the beach and in nearshore waters. Artificial lighting has a most severe effect on sea turtles and is a major conservation challenge on human-occupied nesting beaches.

Hatchling turtles emerging from nests at night rely on the natural brightness contrast between seaward and landward directions—such as that presented by celestial light visible over an open seaward horizon and an opposing landward horizon silhouetted by a dune or coastal plants. In experimental light fields, hatchlings move toward the center of the brightest horizon with low light across a broad span. Over millennia, this orientation trait has consistently led hatchlings to the sea. Orienting toward a broadly bright horizon favors seaward movement, even when a celestial light such as the full moon shines above the land. The moon's light may be bright, but it's not as low as the seaward horizon, and its light passes through Earth's atmosphere, lighting up competing directions and making the moon just one part of a brightened light field. Artificial light sources are different. Although proximity makes their light seem bright, the brightness is not sufficient to light other directions. As a result, artificial lighting on land produces a misleading light field with the brightest light overwhelmingly directed toward the land. Misinformed hatchlings that move in that direction often never make it to the sea.

What Can I Do to Help Sea Turtles?

Where do you call home? Is it near a beach? In the heart of a city? In the mountains? Wherever it is, sea turtles and the threats they face are closer than you might think. We live in a globalized, interconnected world in which our lives and lifestyle choices have impacts far beyond our immediate surroundings. As a result, we each have the power to help save sea turtles every day and in a variety of ways.

According to the IUCN-SSC Marine Turtle Specialist Group, the primary threats that endanger sea turtles are fishery impacts, pollution, climate change, coastal development, and direct consumption. Following are ways you can help address each of those threats to sea turtles in your daily life:

- **Fishery Impacts:** Every time you eat seafood, you are supporting the fishery from which it came. Does that fishery harm sea turtles? Is it taking steps to be sustainable? Learn about the sustainability of your seafood choices by asking knowledgeable people, watching documentaries, or doing online research; those efforts will enable you to make more sustainable seafood choices.
- **Pollution:** Plastic and chemical contaminants are two types of pollution that you can readily reduce at home. Take stock of your consumption of single-use plastics and household chemicals and look for environmentally sound alternatives. Explore the extensive online resources that are available for ideas and advice about these topics.
- **Climate Change:** There are many ways to reduce your carbon footprint, including reducing the electricity used in your home, changing the way you get around, and making sustainable food choices. Evaluate your energy use and transportation needs to see if there are ways you can cut back. Consider reducing your consumption of meat—especially beef, which is a major contributor of greenhouse gas emissions.
- **Coastal Development:** When planning your next beach vacation, choose to stay at a hotel or other accommodation that is working to protect the environment. If it is in a sea turtle nesting area, confirm that the establishment has taken steps to ensure the safety of nesting females, nests, and hatchlings. If you live near a sea turtle nesting beach, follow best practices to reduce light pollution and to minimize other disturbances to nesting and hatching turtles. Help others to do the same.
- **Direct Take:** Many people are surprised to learn that hawksbill turtle shells are still widely used to make items sold to tourists, particularly in the Caribbean, Latin America, and Asia. There are no sustainable sources of tortoiseshell; you should never purchase such items. Learn how to recognize items made from tortoiseshell so you can avoid them whenever you travel (see p. 31).

Above all, choose to do the things that make you feel good about helping sea turtles. You will find joy and motivation in knowing that you are not the only one making such choices in your daily life—you are part of a vast global movement of people dedicated to living sustainably. Together, our actions make a meaningful difference. For more ideas, visit https://www.seaturtlestatus.org/how-you-can-help. •

TOP: © Markus Spiske; **BOTTOM:** Beach cleanup. © San Diego Loyal SC

Acting Globally

SWOT SMALL GRANTS 2021

Since 2006, SWOT's small grants have helped field-based partners around the world to achieve their research and conservation goals. To date, 123 grants have been awarded to 102 applicants in more than 53 countries and territories for work addressing three key themes: (a) networking and capacity building, (b) science, and (c) education and outreach. The following are brief overviews of SWOT's 2021 grantees. Visit www.SeaTurtleStatus.org/grants for application instructions and a list of all past SWOT grantees.

TOP ROW: © Aroen Meubanja Community Group; © Abdel-Rahman El Mahdi; **MIDDLE ROW:** © Ocean Connectors; **BOTTOM ROW:** © Shritika S. Prakash; © CNRE (Centre National de Recherches sur l'Environnement)

Abdel-Rahman El Mahdi (Sudan)

Since its designation as a marine protected area in 2004, Dungonab Bay and Mukkawar Island have been recognized as significant sea turtle habitats, but little research has been done. Abdel-Rahman El Mahdi will help to fill the data gaps that relate to nesting and foraging sea turtles and will use the information to recommend conservation and management efforts.

Aroen Meubanja Community Group (Indonesia)

In collaboration with local communities, the Aroen Meubanja Community Group will conduct a comprehensive study about sea turtle ecology, distribution, population demographics, migration patterns, and habitat use in Sumatra. They will use the results to support a management strategy for leatherback conservation.

Centro Mexicano de la Tortuga (Mexico)**

Centro Mexicano de la Tortuga will use its SWOT grant to assist with the management of olive ridley arribada sites and to operate the regional rescue and rehabilitation center, which provides medical care and facilities for injured and sick turtles in the state of Oaxaca.

Colola Proyecto de Tortugas (Mexico)**

The Colola Proyecto de Tortugas will continue its vital nest protection and monitoring work, which has helped to dramatically increase the once-failing population of black (green) sea turtles and to unite the communities of Colola and Maruata, as well as others, around sea turtle conservation in the state of Michoacán.

Comunidad Protectora de Tortugas de Osa (COPROT) (Costa Rica)*

Costa Rica's Osa Peninsula provides nesting habitat for thousands of turtles annually. COPROT will combat the threat of ocean plastic pollution on turtle nesting beaches by expanding a community-based recycling center that aims to clean beaches and upcycle collected plastic debris.

CNRE (Centre National de Recherches sur l'Environnement) (Madagascar)

To combat an increase in the illegal capture and sale of sea turtle products in the Boeny region of Madagascar, CNRE will convene community fishers, fish sellers, and market consumers to facilitate communication between stakeholders and law enforcement.

Fundação Tartaruga Cabo Verde (Cabo Verde)***

Fundação Tartaruga Cabo Verde will introduce children on the island of Boa Vista to the wonders of the ocean and to endangered sea turtles by leading swimming lessons integrated with environmental education.

Mas Kagin Tapani Association (Papua New Guinea)

Papua New Guinea is home to globally important sea turtle nesting beaches. The Mas Kagin Tapani Association will work to conserve leatherbacks nesting near the village of Sarang by increasing awareness among local residents about the value of turtles, the threats they face, and methods to protect them while simultaneously benefiting local stakeholders.

Ocean Connectors (Mexico)

Ocean Connectors works with youth in the underserved Pacific coastal communities of Nayarit, Mexico, to educate them about sea turtles and other migratory marine life, as well as to implement projects that inspire children to engage in waste reduction and litter abatement behaviors.

Shritika S. Prakash of the University of the South Pacific (Fiji)

Ms. Prakash will train fisheries officers, marine biologists, wardens, rangers, conservation officers, village heads, and biology and marine science graduate students in how to conduct sea turtle monitoring and conservation work in remote areas of Fiji, where the nesting ecology of sea turtles is poorly documented.

* Memorial donations made in honor of Marjorie Lee Kemp (1927–2021) allowed SWOT to award an additional grant to this education and outreach project that is led by a woman who is early in her career.

** Donations from the Mast family, Russell Mittermeier (Re:wild), and Gail Evenari (Maiden Voyage Productions) supported these two important initiatives in Mexico.

*** SC Johnson generously donated SCUBAPRO snorkel gear to support this unique program in Cabo Verde.

AZA-SAFE GRANT RECIPIENTS

Since 2019, SWOT has partnered with the Association of Zoos and Aquariums (AZA) and its Sea Turtle SAFE (Saving Animals from Extinction) program to make additional grants available for projects related to two of the top global priorities for conservation of critically endangered sea turtle populations: eastern Pacific leatherbacks and Kemp's ridleys.

TOP ROW: © Campamento Tortuguero Ayotlcalli; © CIFAMAC (Centro de Investigación de Fauna Marina y Avistamiento de Cetáceos); **MIDDLE ROW:** © Palmarito Sea Turtle Rescue and the Mazunte Project; **BOTTOM ROW:** © The Gulf Center for Sea Turtle Research at Texas A&M University–Galveston; © Paso Pacífico

The Leatherback Project (Ecuador)

The Leatherback Project will survey fishers at various ports in Ecuador to understand their relationships and beliefs around the ocean, marine wildlife, and conservation. The goals are to (a) improve the livelihoods of artisanal fishers, (b) increase marine wildlife populations (including leatherbacks), and (c) foster healthy relationships between fishers and governmental agencies.

Campamento Tortuguero Ayotlcalli (Mexico)

Campamento Tortuguero Ayotlcalli will lead beach surveys, protect and tag animals, and organize community education and outreach activities adjacent to leatherback nesting beaches in Guerrero, Mexico.

CIFAMAC (Centro de Investigación de Fauna Marina y Avistamiento de Cetáceos) (Chile)

CIFAMAC will conduct boat and drone surveys of Mejillones Bay, a newly discovered turtle foraging area on Chile's Atacama coast, and will generate valuable information about the distribution, behavior, habitat use, and demographics of leatherbacks.

Gladys Porter Zoo and Rancho San José (Mexico)

Gladys Porter Zoo and Rancho San José will expand tagging operations on two major Kemp's ridley nesting beaches in Mexico—La Pesca and Tepehuajes—using state-of-the-art tags and tagging protocols to generate data needed to evaluate the survival status and recovery of Kemp's ridleys.

The Gulf Center for Sea Turtle Research at Texas A&M University–Galveston (U.S.A.)

Texas Gulf waters are an important habitat for hawksbills, leatherbacks, loggerheads, greens, and Kemp's ridleys, all of which are vulnerable to cold-stunning during winter months. The Gulf Center for Sea Turtle Research will bring sea turtle awareness to the public and build a network of volunteers in Galveston, Texas, to quickly locate and respond to nesting, stranded, sick, injured, and deceased sea turtles.

Palmarito Sea Turtle Rescue—The Mazunte Project (Mexico)

Along the coast of Oaxaca, Mexico, domestic and stray dogs pose a threat to sea turtle nests and hatchlings, including leatherbacks. The Mazunte Project will conduct mobile dog spay and neuter operations, plus education events designed to decrease canine predation of sea turtle eggs and hatchlings.

Paso Pacífico (Nicaragua)

The Pacific beaches of southwestern Nicaragua provide vital nesting and foraging habitat for sea turtles, yet the turtles are often killed by fishing gear. Moreover, turtle eggs are illegally harvested. Paso Pacífico will train 100 Junior Rangers from eight low-income coastal communities and will empower them to encourage a change in behaviors around egg harvest. The program's goal is to improve the survival of leatherbacks.

Sea Turtle, Inc. (U.S.A.)

The Rio Grande Valley is one of the most underserved regions in southern Texas, U.S.A., with more than a third of its families living in poverty. Most schools lack the resources to bring nature education programs to their students. Sea Turtle, Inc., will conduct outreach and education programs among students in Cameron and Willacy Counties to educate and engage children about the importance of protecting the Kemp's ridley sea turtles that nest in that region.

Turtles Fly Too (U.S.A.)

Turtles Fly Too will continue to coordinate response teams and provide emergency air transport for endangered marine life, including Kemp's ridleys. This effort includes recruiting and training pilots, who contribute their aircraft, time, and expertise to move cold-stunned animals to rehabilitation facilities.

Living Legends of Sea Turtle Conservation

Today's sea turtle conservationists stand on the shoulders of the giants who came before them, going back centuries to the first women and men who ever observed, described, and marveled at these incredible marine reptiles. Each successive generation has advanced our cause, and along that continuum of humans past and present are influential people of all ages, from all over the world, working in many arenas on countless topics and tasks. And within that spectrum, there are some who walk among us today whose work spans decades and whose influence and impact has been outsized by any number of metrics. In this new feature, *SWOT Report* begins a tradition to spotlight some of these living legends.

LEFT: Shown here in April 2022 accepting a Lifetime Achievement Award bestowed posthumously upon her husband (and legend in his own right), Dr. Alan Bolten, Karen (left) was joined by a dozen students, including Dr. Blair Witherington (right), and Hannah Vander Zanden (photographer). **RIGHT:** B.C. at the sea turtle beaches of Odisha, India, where he and his team tagged and tracked thousands of turtles.

Karen A. Bjorndal

Karen Bjorndal received her PhD in 1979 under the direction of Archie Carr. She is director of the Archie Carr Center for Sea Turtle Research and is a distinguished professor in the Department of Biology at the University of Florida. Her research focuses on nutritional ecology and demography of sea turtles, with an emphasis on the roles of sea turtles in marine ecosystems and how these ecosystems have changed in response to major shifts in abundance of sea turtle populations. She has authored more than 260 scientific papers. She served as chair of the Marine Turtle Specialist Group of the International Union for the Conservation of Nature for 12 years and is active in international sea turtle conservation. Karen has been blessed to have her husband, Alan Bolten, as her partner in sea turtle research around the world, Archie Carr as her mentor, her graduate students as continual sources of inspiration, and a network of wonderful international collaborators.

B.C. Choudhury

B.C. Choudhury started his sea turtle career in 1975 with the Odisha (India) Forest and Wildlife Department, then with the states of Tamil Nadu and Andhra Pradesh, and ultimately with the Wildlife Institute of India (WII). He was associated with the turtle walk and egg collection program in Madras that became the Students Sea Turtle Network, which is still active, and he has overseen dozens of master's and PhD dissertations on Indian sea turtles. In 1994, his team discovered the Rushikulya olive ridley rookery, and with his teams he has tagged more than 35,000 turtles and satellite tracked dozens more. He led the Indian National Sea Turtle Program, which surveyed the entire Indian coastline in the 2000s, and he edited a book on marine turtles of the Indian subcontinent. B.C. was instrumental in mentoring a generation of leading sea turtle biologists and conservationists, and he continues to work on an array of policy, environmental impact assessment, and conservation issues relating to sea turtles in and around India.

Visit www.seaturtlestatus.org/legends for longer interviews with Karen and B.C.

SWOT Data Citations

We are grateful to all who generously contributed their sea turtle data for inclusion in the maps featured throughout this volume. Data sources are cited throughout the following pages. For information about how the feature maps of hawksbill biogeography were created, please see the sidebar on p. 27.

GUIDELINES OF DATA USE AND CITATION

The nesting and satellite telemetry data that follow correspond to the maps of hawksbill biogeography on pp. 27–29. Nesting data records are numbered to correspond with their respective points on the map. To use data for research or publication, you must obtain permission from the data providers.

Hawksbill Nesting Data Citations

To save space, beach names and clutch counts have been omitted from the following citations, but additional metadata may be found online at http://seamap.env.duke.edu/swot or by viewing the original data source (if published). In addition, we have used the abbreviation "Spatial Database for the Wider Caribbean" to refer to Dow, W. E., and K. L. Eckert. 2007. *Sea Turtle Nesting Habitat: A Spatial Database for the Wider Caribbean Region*. WIDECAST Technical Report No. 6, Wider Caribbean Sea Turtle Conservation Network (WIDECAST) and The Nature Conservancy, Beaufort, NC. Due to space limitations, not all data records are labeled on the map; those that are not are marked with an asterisk (*).

ANGUILLA

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SWOT Contacts: Stuart Wynne, James Gumbs, Farah Mukhida, and Janeczka Richardson

ANTIGUA AND BARBUDA

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SWOT Contacts: Peri Mason, Cheryl Appleton, James Richardson, and Tricia Lovell

ARUBA

DATA RECORD: 3

Data Sources: **(A)** Van der Wal, E., and R. Van der Wal. 2010. TurtugAruba (Aruban Foundation for Sea Turtle Protection and Conservation). Personal communication. In *SWOT Report—State of the World's Sea Turtles*, vol. VI (2011). **(B)** Van der Wal, E., and R. Van der Wal. 2014. TurtugAruba (Aruban Foundation for Sea Turtle Protection and Conservation). SWOT Database Online 2015. **(C)** Van der Wal, R. 2021. Aruba. In M. A. Nalovic, S. A. Ceriani, M. M. P. B. Fuentes, J. B. Pfaller, N.E. Wildermann, A. Uribe-Martínez, and E. Cuevas (eds.), *Sea Turtles in the North Atlantic and Wider Caribbean Region: MTSG Annual Regional Report 2021.* IUCN-SSC Marine Turtle Specialist Group. **(D)** Spatial Database for the Wider Caribbean.
SWOT Contacts: Richard Van der Wal and Edith Van der Wal

AUSTRALIA

DATA RECORD: 4

Data Sources: **(A)** Bell, I. P., J. J. Meager, T. Eguchi, et al. 2020. Twenty-eight years of decline: Nesting population demographics and trajectory of the north-east Queensland endangered hawksbill turtle (*Eretmochelys imbricata*). Biological Conservation, 241, 108376. **(B)** Broderick, D., C. Moritz, J. D. Miller, et al. 1994. Genetic studies of the hawksbill turtle (*Eretmochelys imbricata*): Evidence for multiple stocks in Australian waters. Pacific Conservation Biology 1: 123–131. **(C)** Limpus, C. J., and J. D. Miller. 2000. *Final Report for Australian Hawksbill Turtle Population Dynamics Project.* Queensland Parks and Wildlife Service and the Japan Bekko Association, Queensland, Australia.
SWOT Contacts: Colin Limpus, Ian Bell, and Kirstin Dobbs

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Data Source: Hattingh, K., N. Hajnoczky, and M. Tan. 2015. *Gnaraloo Turtle Conservation Program, Gnaraloo Bay Rookery and Gnaraloo Cape Farquhar Rookery: GTCP Monitoring Procedure 2014/15.* Unpublished report, Gnaraloo Station Trust, Western Australia, www.gnaraloo.com.au.
SWOT Contact: Karen Hattingh

DATA RECORD: 6

Data Source: Pendoley, K., L. Howitt, M. Speirs, and A. Viternbergs. 2008. Hawksbill nesting in Western Australia. In *SWOT Report—State of the World's Sea Turtles*, vol. III (2008).
SWOT Contact: Kellie Pendoley

BAHAMAS

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Data Sources: **(A)** Bolten, A. 2008. Hawksbill nesting in Bahamas. Personal communication. In *SWOT Report—State of the World's Sea Turtles*, vol. III (2008). **(B)** Mortimer, J. A., and M. Donnelly. 2008. *Eretmochelys imbricata.* In *2008 IUCN Red List of Threatened Species.* IUCN-SSC Marine Turtle Specialist Group. **(C)** Spatial Database for the Wider Caribbean.
SWOT Contacts: Karen Bjorndal, Alan Bolten, and Eleanor Phillips

BANGLADESH

DATA RECORD: 8

Data Source: Rashid, S. M. A., and M. Z. Islam. 2006. Status and conservation of marine turtles in Bangladesh. In K. Shanker and B. C. Choudhury (eds.), *Marine Turtles of the Indian Subcontinent*, pp. 200–216. Hyderabad, India: Universities Press.
SWOT Contact: M. Zahirul Islam

BARBADOS

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SWOT Contacts: Julia Horrocks and Carla Daniel

BELIZE

DATA RECORD: 10

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SWOT Contacts: Isaias Majil, Janet Gibson, University of Belize, Toledo Institute for Development and Environment, South Water Caye Marine Reserve, Sapodilla Cayes Marine Reserve, Glovers Reef Marine Reserve, Gales Point Wildlife Sanctuary Management Team, Friends of Nature, Belize Audubon Society, and Bacalar Chico Marine Reserve

BONAIRE

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Data Sources: **(A)** Nava, M. 2006. *Sea Turtle Conservation Bonaire: Progress Report 2006.* Unpublished report. **(B)** Sea Turtle Conservation Bonaire. 2007. Progress report. Personal communication. SWOT Database Online 2010. **(C)** Sea Turtle Conservation Bonaire. 2010. Progress report. Personal communication. SWOT Database Online 2011. **(D)** Sea Turtle Conservation Bonaire. 2011. Progress report. Personal communication. SWOT Database Online 2012. **(E)** Sea Turtle Conservation Bonaire. 2014. Progress report. Personal communication. SWOT Database Online 2014. **(F)** Sea Turtle Conservation Bonaire. Personal communication. In *SWOT Report—State of the World's Sea Turtles*, vol. XVII (2022); **(G)** Spatial Database for the Wider Caribbean.
SWOT Contact: Kaj Tamar Schut

BRAZIL

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Data Sources: **(A)** Fundação Projeto TAMAR. 2022. Unpublished data from SITAMAR (Information System of Fundação Projeto Tamar). Personal communication. In *SWOT Report—State of the World's Sea Turtles*, vol. XVII (2022). **(B)** Mendilaharsu, M. L., M. Â. Marcovaldi, B. Giffoni, L. Medeiros, et. al. 2021. Brazil. In M. Â. Marcovaldi, J. Thomé, and A. Fallabrino (eds.), *Sea Turtles in the Southwest Atlantic Region: MTSG Annual Regional Report 2021.* IUCN-SSC Marine Turtle Specialist Group. **(C)** Santos, A. S., A. P. Almeida, A. B. Santos, et al. 2011. *Plano de Ação Nacional para a Conservação das Tartarugas Marinhas.* Série Espécies Ameaçadas No. 25. Instituto Chico Mendes de Conservação da Biodiversidade, Brasília.
SWOT Contacts: Alexsandro Santos, Maria Ângela Marcovaldi, Eduardo Lima, Frederico Tognin, and Paulo Lara

CAMEROON

DATA RECORD: 13

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SWOT Contacts: Alain Gibudi and Jules Ngunguim

CAYMAN ISLANDS

DATA RECORD: 14

Data Source: Cayman Islands Department of Environment. 2022. Unpublished data. Personal communication. In *SWOT Report—State of the World's Sea Turtles*, vol. XVII (2022).
SWOT Contact: Janice Blumenthal

CHAGOS ARCHIPELAGO

DATA RECORD: 15

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COLOMBIA

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SWOT Contacts: Anderson Jhovany Rosado Gómez, Carolina Monterrosa, Carlos Pinzón, and Juan Manuel Rodríguez-Baron

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SWOT Contacts: Claudia Ceballos, Zunilda Baldonado, and Elizabeth Taylor

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SWOT Contact: Juan Manuel Rodríguez-Baron

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Data Sources: **(A)** Angarita Jiménez, L. E., R. Franke Ante, and Parques Nacionales Naturales de Colombia, Dirección Territorial Caribe. 2015. Personal communication. In *SWOT Report—State of the World's Sea Turtles*, vol. XI (2016). **(B)** Patiño-Martínez, J., and L. Quiñones. 2008. Hawksbill nesting in Colombia. Personal communication. In *SWOT Report—State of the World's Sea Turtles*, vol. III (2008). **(C)** Restrepo-Garzón, N., R. A. Álvarez-Rodríguez, C. Ramírez-Gallego, et al. 2021. Conservation of the hawksbill turtle (*Eretmochelys imbricata*) in Rincón del Mar, Colombia. *Boletín de Investigaciones Marinas y Costeras* 50 (2): 53–72.
SWOT Contacts: Luz Elvira Angarita Jiménez, Rebeca Franke Ante, Liliana Quiñones, and Juan Patiño Martínez

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COSTA RICA

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SWOT Contact: Didiher Chacón-Chaverri

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Data Sources: **(A)** Venegas-Li, R., R. Valentín-Gamazo, and A. García. 2014. Hawksbill turtle nesting at Pacuare Reserve, Limón, Costa Rica. SWOT Database Online 2015. **(B)** Harrison, E. 2014. Personal communication. SWOT Database Online 2015. **(C)** Castro-Morales, C., and F. Campos-Rodríguez. 2006. *Final Report: Research and Protection of the Leatherback, Green and Hawksbill Turtles of the Parismina River Mouth.* Asociación Salvemos Las Tortugas de Parismina. Unpublished report.
SWOT Contacts: Claudio Quesada, Emma Harrison, Marco Ramírez-Vargas, and Vicky Taylor

DATA RECORD: 25

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SWOT Contact: Luis Gabriel Fonseca López

DATA RECORD: 26

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DATA RECORD: 27

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SWOT Contacts: Juan Carlos Cruz and Tortugas Preciosas de Osa

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SWOT Contact: Juan Patiño-Martínez

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PAPUA NEW GUINEA

DATA RECORD: 82

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SWOT Contact: Barry Krueger

PHILIPPINES

DATA RECORD: 83

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DATA RECORD: 87*

Data Sources: (A) Spatial Database for the Wider Caribbean. **(B)** Pemberton, E., and Nevis Department of Fisheries. 2008. Hawksbill nesting in Nevis. In *SWOT Report—State of the World's Sea Turtles*, vol. III (2008). **(C)** St. Kitts Sea Turtle Monitoring Network and Ross University School of Veterinary Medicine. 2008. Hawksbill nesting in St. Kitts. In *SWOT Report—State of the World's Sea Turtles*, vol. III (2008). **(D)** Stewart, K., and St. Kitts Sea Turtle Monitoring Network. 2006. Leatherback nesting in St. Kitts. In *SWOT Report—State of the World's Sea Turtles*, vol. I (2006).
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DATA RECORD: 91

Data Sources: (A) Spatial Database for the Wider Caribbean. **(B)** Morris, K. 1984. The national report for the country of St. Vincent. In P. Bacon, F. Berry, K. Bjorndal, H. Hirth, L. Ogren, and M. Weberet (eds.), *Proceedings of the Western Atlantic Sea Turtle Symposium*, Vol. 3, pp. 381–385. Miami, FL: University of Miami Press. **(C)** Scott, N., and J. A. Horrocks. 1993. Sea turtle recovery plan for St. Vincent and the Grenadines. CEP Technical Report No. 27, Caribbean Environment Programme, United Nations Environment Programme.
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DATA RECORD: 92*

Data Sources: (A) Momoemausu, M., J. Ward, M. Iakopo, et al. 2006. *Report on the Hawksbill Turtle Nesting Survey 2005–2006.* Division of Environment and Conservation, Ministry of Natural Resources and Environment, Samoa. **(B)** Ward, J., and I. Asotasi. 2008. *An Assessment of the Current Status of the Hawksbill Turtles (*Eretmochelys imbricata*) on the Aleipata islands, 2007–2008.* Division of Environment and Conservation, Ministry of Natural Resources and Environment, Samoa.
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DATA RECORD: 93

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DATA RECORD: 100

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DATA RECORD: 101

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DATA RECORD: 102

Data Sources: (A) Nature Protection Trust of Seychelles. 2009. *2008–2009 Silhouette Conservation Project: Quarterly Report.* Unpublished report. **(B)** Nature Protection Trust of Seychelles. 2010. *2009–2010 Silhouette Conservation Project: Quarterly Report.* Unpublished report. **(C)** Vanherck, L. 2008. Hawksbill nesting on North Island, Seychelles. Personal communication. In *SWOT Report—State of the World's Sea Turtles*, vol. III (2008).
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DATA RECORD: 103

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SINT MAARTEN

DATA RECORD: 104

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SOLOMON ISLANDS

DATA RECORD: 105

Data Source: Siota, C., and P. Ramohia. 2007. *Peak Hawksbill Nesting Activities in the Arnavon Community Marine Conservation Area: A Report for The Nature Conservancy.* Solomon Islands Field Office, Honiara.
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DATA RECORD: 106

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DATA RECORD: 107

Data Sources: (A) Agence Territoriale de l'Environnement de Saint Barthélémy. *Rapport de Suivi des Pontes de Tortues Imbriquées* (Eretmochelys imbricata)*, 2012–2021 de Saint Barthélémy.* **(B)** Eckert, K. L., and A. E. Eckert. 2019. *An Atlas of Sea Turtle Nesting Habitat for the Wider Caribbean Region.* Rev. ed. WIDECAST Technical Report No. 19, Godfrey, IL.
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SUDAN

DATA RECORD: 108

Data Source: El Mahdi, A.-R. The marine turtle in the Republic of Sudan: Their biology and conservation. In *SWOT Report—State of the World's Sea Turtles*, vol. XVII (2022).
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DATA RECORD: 109

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TAIWAN, REPUBLIC OF CHINA

DATA RECORD: 110

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DATA RECORD: 111

Data Sources: (A) Joynson Hicks, C., and L. West. 2017. Sea turtle nesting in Tanzania. Personal communication. In *SWOT Report—State of the World's Sea Turtles*, vol. XII (2017). **(B)** Muir, C. 2008. Hawksbill nesting in Tanzania. Personal communication. In *SWOT Report—State of the World's Sea Turtles*, vol. III (2008).
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DATA RECORD: 112

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TRINIDAD AND TOBAGO

DATA RECORD: 113

Data Sources: (A) Spatial Database for the Wider Caribbean. **(B)** Fournillier, K., and K. L. Eckert. 1998. *Draft WIDECAST Sea Turtle Recovery Action Plan for Trinidad and Tobago.* United Nations Caribbean Environment Programme, Kingston, Jamaica. **(C)** Livingstone, S. R. 2006. *Sea Turtle Ecology and Conservation on the North Coast of Trinidad.* PhD dissertation, University of Glasgow, Scotland.
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DATA RECORD: 114

Data Source: Walker, G. 2013. *An Update on Sea Turtle Nesting in the Northeast of Tobago.* Unpublished report.
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TURKS AND CAICOS ISLANDS

DATA RECORD: 115*

Data Sources: (A) Spatial Database for the Wider Caribbean. **(B)** Siota, C., and P. Ramohia. 2007. *Peak Hawksbill Nesting Activities in the Arnavon Community Marine Conservation Area: A Report for The Nature Conservancy.* Solomon Islands Field Office, Honiara.
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UNITED ARAB EMIRATES

DATA RECORD: 116

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UNITED STATES

DATA RECORD: 117

Data Source: Florida Fish and Wildlife Conservation Commission, Fish and Wildlife Research Institute. 2015. *Statewide Atlas of Sea Turtle Nesting Occurrence and Density.* http://myfwc.com/research/wildlife/sea-turtles/nesting/nesting-atlas/
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DATA RECORD: 118

Data Source: Finn, S., W. P. Thompson, B. M. Shamblin, and C. J. Nairn. 2016. Northernmost records of hawksbill sea turtle nests and possible trans-Atlantic colonization event. *Marine Turtle Newsletter* 151: 27–30.
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DATA RECORD: 119

Data Sources: (A) Parker, D., G. H. Balazs, M. King, W. Seitz, et al. 2015. *Map Guide to Hawaiian Marine Turtle Nesting and Basking.* www.GeorgeHBalazs.com. **(B)** Parker, D. M., G. H. Balazs, C. S. King, et al. 2009. Short-range movements of hawksbill turtles (*Eretmochelys imbricata*) from nesting to foraging areas within the Hawaiian Islands. *Pacific Science* 63 (3): 371–382.
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VANUATU

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VENEZUELA

DATA RECORD: 121

Data Sources: (A) Spatial Database for the Wider Caribbean. **(B)** Espinoza, R., P. Vernet, L. Moran, et al. 2013. Primer reporte de la actividad de anidación de tortugas marinas en la costa nor-occidental del Golfo de Venezuela. *Boletín del Centro Investigaciones Biológicas* 47 (1): 86–95. **(C)** Guada, H. 2008. Hawksbill nesting in Venezuela. Personal communication. In *SWOT Report—State of the World's Sea Turtles*, vol. III (2008). **(D)** Guada, H. J., and G. Solé. 2000. *WIDECAST Plan de Acción para la Recuperación de las Tortugas Marinas de Venezuela.* Informe Técnico del PAC No. 39. United Nations Environment Programme, Caribbean Environment Programme, Kingston, Jamaica. **(E)** Guada, H. J. 2000. *Areas de Anidación e Impactos Hacia las Tortugas Marinas en la Península de Paria y Lineamientos de Protección.* M. thesis, Universidad Simón Bolívar, Sartenejas. **(F)** Rodríguez-Baron, J. M.. 2015. Personal communication. In *SWOT Report—State of the World's Sea Turtles*, vol. XI (2016). **(G)** Quijada, A., and C. Balladares. 2004. Conservación de las tortugas marinas en el Golfo de Paria. In R. Babarro, A. Sanz, and B. Mora (eds.), *Tortugas Marinas en Venezuela: Acciones para Su Conservación*, pp. 47–54. Oficina Nacional de Diversidad Biológica and Fondo Editorial Fundambiente Caracas.
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VIETNAM AND SPRATLY ISLANDS

DATA RECORD: 122*

Data Source: Hamann, M., C. The Cuong, N. Duy Hong, et al. 2006. Distribution and abundance of marine turtles in the Socialist Republic of Viet Nam. *Biodiversity and Conservation* 15: 3703–3720.

VIRGIN ISLANDS, BRITISH

DATA RECORD: 123

Data Sources: (A) Spatial Database for the Wider Caribbean. **(B)** Eckert, K. L., J. A. Overing, and B. B. Lettsome. 1992. *Sea Turtle Recovery Action Plan for the British Virgin Islands.* CEP Technical Report No. 15, Caribbean Environment Programme, Kingston, Jamaica.
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VIRGIN ISLANDS, UNITED STATES

DATA RECORD: 124

Data Sources: (A) Buck Island Sea Turtle Research Program, National Park Service. 2016. Hawksbill nesting at Buck Island Reef National Monument, St. Croix, U.S. Virgin Islands. SWOT Database Online 2017. **(B)** Spatial Database for the Wider Caribbean. **(C)** Mackay, A. L. 2005. *Sea Turtle Monitoring Program the East End Beaches of St. Croix, U.S. Virgin Islands, 2005.* West Indies Marine Animal Research and Conservation Service, St. Croix. **(D)** Virgin Islands National Park (VINP) Sea Turtle Program. Personal communication. In *SWOT Report—State of the World's Sea Turtles*, vol. XVII (2022).
SWOT Contacts: Clayton Pollock, Steve Garner, Rafe Boulon, U.S. Virgin Islands Division of Fish and Wildlife, Adren Anderson, Willow Melamet, and VINP Sea Turtle Program

Hawksbill Telemetry Data Citations

The following data records refer to satellite telemetry datasets from tags that were deployed on hawksbill turtles worldwide. These records were combined to create the map on p. 27. The data are organized by country of deployment. For information regarding data processing and filtering, see the note on the map on p. 27. These data were generously contributed to SWOT by the people and partners listed subsequently. Records that have a SWOT ID can be viewed in detail in the SWOT online database and mapping application at http://seamap.env.duke.edu/swot, which contains additional information about the projects and their methodologies.

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

AUSTRALIA

DATA RECORD 1 | SWOT ID: 8043

Project Title: Post Rehabilitation Success of Marine Turtles
Metadata: 1 juvenile, rehabilitated and released *E. imbricata*
Data Sources: (A) Gilbert, J. 2021. Post rehabilitation success of marine turtles. Data downloaded from OBIS-SEAMAP (http://seamap.env.duke.edu/dataset/644) on March 15, 2022, and originated from STAT (http://www.seaturtle.org/tracking/index.shtml?project_id=501). **(B)** STAT. **(C)** SWOT Online Database. **(D)** OBIS-SEAMAP.
SWOT Contact: James Cook University, Cairns

DATA RECORD 2

Project Title: Hawksbills Tracked in Northern Australia
Metadata: 2 adult female *E. imbricata* and 1 adult *E. imbricata* of undetermined sex
Data Sources: (A) Hoenner, X., S. D. Whiting, M. A. Hindell, and C. R. McMahon. 2012. Enhancing the use of Argos satellite data for home range and long distance migration studies of marine animals. *PLoS One* 7 (7): e40713. **(B)** Hoenner, X., S. D. Whiting, M. Hamann, and C. J. Limpus. 2015. High-resolution movements of critically endangered hawksbill turtles help elucidate conservation requirements in northern Australia. *Marine and Freshwater Research* 67 (8): 1263–1278.
SWOT Contact: Scott Whiting and Xavier Hoenner

BARBADOS

DATA RECORD 3

Project Title: Post-nesting Hawksbills Tracked from Barbados
Metadata: 7 postnesting female *E. imbricata*
Data Source: Horrocks, J. A., and D. C. B. Browne. Unpublished hawksbill turtle tracks from Barbados (2004–2018). Personal communication. In *SWOT Report—State of the World's Sea Turtles*, vol. XVII (2022).
SWOT Contact: Julia Horrocks

BELIZE

DATA RECORD 4 | SWOT ID: 18281

Project Title: Hope: Hawksbill Hope and Marymount University
Metadata: 28 adult *E. imbricata*
Data Sources: (A) Rimkus, T. 2022. Hope: Hawksbill Hope and Marymount University. Data downloaded from OBIS-SEAMAP (http://seamap.env.duke.edu/dataset/769) on

March 15, 2022, and originated from STAT (http://www.seaturtle.org/tracking/index.shtml?project_id=655). **(B)** STAT. **(C)** SWOT Online Database. **(D)** OBIS-SEAMAP.
SWOT Contact: Todd Rimkus

BONAIRE

DATA RECORD 5 | SWOT ID: 4808

Project Title: Sea Turtle Tracking in Bonaire, 2003–2011
Metadata: Postnesting female *E. imbricata*
Data Sources: (A) Nava, M. 2013. Sea turtle tracking in Bonaire, 2003–2011. Data downloaded from OBIS-SEAMAP (http://seamap.env.duke.edu/dataset/753) on March 15, 2022. **(B)** STAT. **(C)** SWOT Online Database. **(D)** OBIS-SEAMAP.
SWOT Contact: Mabel Nava

DATA RECORD 6 | SWOT ID: 7784

Project Title: Satellite Tracking of Three Species of Sea Turtles on Bonaire
Metadata: 11 adult *E. imbricata*
Data Sources: (A) Nava, M. 2021. Satellite tracking of three species of sea turtles on Bonaire. Data downloaded from OBIS-SEAMAP (http://seamap.env.duke.edu/dataset/879) on March 15, 2022, and originated from STAT (http://www.seaturtle.org/tracking/index.shtml?project_id=798). **(B)** STAT. **(C)** SWOT Online Database. **(D)** OBIS-SEAMAP.
SWOT Contact: Sea Turtle Conservation Bonaire

BRAZIL

DATA RECORD 7 | SWOT ID: 16079

Project Title: Study of the Biology of Sea Turtles in Brazil through Satellite Telemetry
Metadata: 15 adult *E. imbricata*
Data Sources: (A) Projeto TAMAR. 2021. Study of the Biology of Sea Turtles in Brazil through Satellite Telemetry. Data downloaded from OBIS-SEAMAP (http://seamap.env.duke.edu/dataset/984) on March 15, 2022, and originated STAT (http://www.seaturtle.org/tracking/index.shtml?project_id=63). **(B)** STAT. **(C)** SWOT Online Database. **(D)** OBIS-SEAMAP.
SWOT Contact: Projeto TAMAR

CHAGOS

DATA RECORD 8

Project Title: Travel Routes to Remote Ocean Targets Reveal the Map Sense Resolution for a Marine Migrant
Metadata: 22 postnesting female *E. imbricata*
Data Source: Hays, G. C., N. Atchison-Balmond, G. Cerritelli, J.-O. Laloë, P. Luschi, J. A. Mortimer, A. Rattray, and N. Esteban. 2022. Travel routes to remote ocean targets reveal the map sense resolution for a marine migrant. *Journal of the Royal Society Interface* 19 (190): 2021.0859. https://doi.org/10.1098/rsif.2021.0859
SWOT Contacts: Graeme Hays, Nadine Atchison-Balmond, Giulia Cerritelli, Jacques-Olivier Laloë, Paolo Luschi, Jeanne A. Mortimer, Alex Rattray, and Nicole Esteban

DATA RECORD 9

Project Title: Hawksbill/Green Turtles, Chagos Archipelago, Western Indian Ocean
Metadata: 21 juvenile *E. imbricata*
Data Sources: (A) Hays, G. C., J. A. Mortimer, A. Rattray, T. Shimada, and N. Esteban. 2021. High accuracy tracking reveals how small conservation areas can protect marine megafauna. *Ecological Applications* 31 (7): e02418. https://doi.org/10.1002/eap.2418. **(B)** Hays, G. C., J. A. Mortimer, A. Rattray, T. Shimada, and N. Esteban. 2021. Data from High accuracy tracking reveals how small conservation areas can protect marine megafauna. Movebank Data Repository. https://doi.org/10.5441/001/1.r72ph75f.
SWOT Contacts: Graeme Hays, Nicole Esteban, Jeanne Mortimer, and Alex Rattray

CHINA

DATA RECORD 10

Project Title: Hawksbills Tracked in China
Metadata: 1 *E. imbricata*
Data Sources: Parker, D. 2013. Hawksbills tracked in China. Personal communication. In *SWOT Report—State of the World's Sea Turtles*, vol. XVII (2022).
SWOT Contact: Denise Parker

COLOMBIA

DATA RECORD 11

Project Title: Hawksbill Tracked From Gorgona, Colombia
Metadata: 1 female and 1 male *E. imbricata*
Data Source: Amorocho, D. 2013. Hawksbill tracked from Gorgona, Colombia. Personal communication. In *SWOT Report—State of the World's Sea Turtles*, vol. XVII (2022).
SWOT Contact: Diego Amorocho

DATA RECORD 12 | SWOT ID: 1724

Project Title: Caribbean Colombian Sea Turtle Satellite Tracking
Metadata: 1 adult, 1 subadult, and 3 juvenile *E. imbricata*
Data Sources: (A) Sea Turtles and Marine Mammal Conservation Program (ProCTMM). 2021. Caribbean Colombian sea turtle satellite tracking. Data downloaded from OBIS-SEAMAP (http://seamap.env.duke.edu/dataset/1292) on March 15, 2022, and originated from STAT (http://www.seaturtle.org/tracking/index.shtml?project_id=471). **(B)** STAT. **(C)** SWOT Online Database. **(D)** OBIS-SEAMAP.
SWOT Contact: ProCTMM

DATA RECORD 13 | SWOT ID: 4351

Project Title: World Wide Fund for Nature (WWF) Sea Turtle Satellite Tracking in Latin America and the Caribbean
Metadata: *E. imbricata*
Data Sources: (A) Amorocho, D. 2021. WWF sea turtle satellite tracking in Latin America and the Caribbean. Data downloaded from OBIS-SEAMAP (http://seamap.env.duke.edu/dataset/1306) on March 15, 2022, and originated from STAT (http://www.seaturtle.org/tracking/index.shtml?project_id=791). **(B)** STAT. **(C)** SWOT Online Database. **(D)** OBIS-SEAMAP.
SWOT Contact: Research Center for Environmental Management and Development (CIMAD)

COSTA RICA

DATA RECORD 14

Project Title: Hawksbills Tracked in Costa Rica
Metadata: 2 *E. imbricata*
Data Sources: Tortuguero National Park and World Wide Fund for Nature. 2022. Hawksbills tracked in Tortuguero National Park, Costa Rica. Personal communication. In *SWOT Report—State of the World's Sea Turtles*, vol. XVII (2022).
SWOT Contact: Tortuguero National Park, WWF, and Denise Parker

DATA RECORD 15 | SWOT ID: 91

Project Title: Cocos Island Monitoring and Research (C-MAR) Project
Metadata: 1 juvenile *E. imbricata*
Data Sources: (A) Arauz, R. 2021. C-MAR project. Data downloaded from OBIS-SEAMAP (http://seamap.env.duke.edu/dataset/1086) on March 15, 2022, and originated from STAT (http://www.seaturtle.org/tracking/index.shtml?project_id=953). **(B)** STAT. **(C)** SWOT Online Database. **(D)** OBIS-SEAMAP.
SWOT Contact: Pretoma

CUBA

DATA RECORD 16

Project Title: Hawksbill Turtles from the Cuban Shelf
Metadata: 13 *E. imbricata*
Data Source: Moncada, F. G., L. A. Hawkes, M. R. Fish, B. J. Godley, et al. 2012. Patterns of dispersal of hawksbill turtles from the Cuban shelf inform scale of conservation and management. *Biological Conservation* 148 (1): 191–199.
SWOT Contact: Félix Guillermo Moncada Gavilán

DOMINICA

DATA RECORD 17 | SWOT ID: 5708

Project Title: Sea Turtles of Dominica
Metadata: 2 juvenile *E. imbricata*
Data Sources: (A) Levenson, J. 2021. Sea Turtles of Dominica. Data downloaded from OBIS-SEAMAP (http://seamap.env.duke.edu/dataset/890) on March 15, 2022, and originated from STAT (http://www.seaturtle.org/tracking/index.shtml?project_id=773). **(B)** STAT. **(C)** SWOT Online Database. **(D)** OBIS-SEAMAP.
SWOT Contact: Jacob Levenson

DOMINICAN REPUBLIC

DATA RECORD 18 | SWOT ID: 6684

Project Title: Dominican Republic 2008: Hawksbill Turtles
Metadata: 4 adult *E. imbricata*
Data Sources: (A) Hawkes, L. A., J. Tomás, O. Revuelta, Y. M. León, J. M. Blumenthal, A. C. Broderick, M. Fish, J. A. Raga, M. J. Witt, and B.J. Godley. 2012. Migratory patterns in hawksbill turtles described by satellite tracking. *Marine Ecology Progress Series* 461: 223–232. **(B)** Revuelta, O., L. Hawkes, Y. M. León, B. J. Godley, J. A. Raga, and J. Tomás. 2015. Evaluating the importance of Marine Protected Areas for the conservation of hawksbill turtles (*E. imbricata*) nesting in the Dominican Republic. *Endangered Species Research* 27: 169–180. **(C)** Tomás, J. 2021. Dominican Republic 2008: hawksbill turtles. Data downloaded from OBIS-SEAMAP (http://seamap.env.duke.edu/dataset/1905) on March 15, 2022, and originated from STAT (http://www.seaturtle.org/tracking/index.shtml?project_id=301). **(B)** STAT. **(C)** SWOT Online Database. **(D)** OBIS-SEAMAP.
SWOT Contact: Marine Turtle Research Group

ÎLES ÉPARSES

DATA RECORD 19

Project Title: Movements of Postnesting Hawksbill Turtle Satellite-Tracked from Juan de Nova, Éparses Islands, under the Southwest Indian Ocean Fisheries Project (SWIOFP) and Run Sea Science Project
Metadata: 1 adult female *E. imbricata*
Data Source: Ballorain, K., A. Barat, C. Jean, M. Nivière, and C. Gobeaut. 2022. *TImOI: Tortues Imbriquées de l'Océan Indien—Comprendre la Connectivité des Populations; Résultats préliminaires, Mai 2022.* Technical report of the INTERREG V Indian Ocean project. Centre d'Étude et de Découverte des Tortues Marines (CEDTM), Kelonia.
SWOT Contacts: Manon Nivière, Jeanne Mortimer, Claire Jean, Katia Ballorain, and CEDTM Institut de Recherche pour le Développement

FIJI

DATA RECORD 20

Project Title: Hawksbills Tracked in Fiji
Metadata: 2 *E. imbricata*
Data Source: *SWOT Report—State of the World's Sea Turtles*, vol. XVII (2022).
SWOT Contacts: World Wide Fund for Nature, National Trust of Fiji, Lui Bell, Secretariat of the Pacific Regional Environment Programme, University of the South Pacific, Aisake Batibasaga, DFMFF, Mamanuca Environment Society, National Oceanic and Atmospheric Administration, Denise Parker, and George H. Balazs

FRENCH POLYNESIA

DATA RECORD 21

Project Title: Hawksbills Tracked in French Polynesia
Metadata: 1 *E. imbricata*
Data Sources: Gaspar, C., D. Parker, and G. H. Balazs. 2012. Hawksbills tracked in French Polynesia. Personal communication. In *SWOT Report—State of the World's Sea Turtles*, vol. XVII (2022).
SWOT Contacts: Te Mana o Te Moana, Cecil Gaspar, Department of Environment, National Oceanic and Atmospheric Administration, Denise Parker, and George H. Balazs

GUAM

DATA RECORD 22

Project Title: Hawksbills in Guam
Data Sources: Gaos, A., M. Martin, and J. Seminoff. Hawksbills in Guam. Personal communication. In *SWOT Report—State of the World's Sea Turtles*, vol. XVII (2022).
SWOT Contacts: Alexander Gaos, Summer Martin, Jeffrey Seminoff, and National Oceanic and Atmospheric Administration Pacific Islands Fisheries Science Center and Southwest Fisheries Science Center

JAMAICA AND ANTIGUA

DATA RECORD 23

Project Title: Hawksbills Tracked from Antigua and Jamaica
Metadata: 8 *E. imbricata*
Data Source: Maurer, A. S., C. Dawson, R. Bjorkland, A. Donaldson, S. P. Stapleton, J. I. Richardson, D. M. Parker, G. H. Balazs, and B. A. Schroeder. 2022. Satellite telemetry elucidates migratory pathways and new foraging areas for hawksbill sea turtles, *E. imbricata*, in the Caribbean. *Caribbean Journal of Science* (accepted for publication).
SWOT Contact: Andrew Maurer

KUWAIT

DATA RECORD 24

Project Title: Tracking Hawksbills in Kuwait
Metadata: 4 adult female *E. imbricata*
Data Source: Rees, A. F., N. Papathanasopoulou, and B. J. Godley. 2019. Tracking hawksbills in Kuwait: Contributions to regional behavioral insights. *Chelonian Conservation and Biology* 18 (1): 86–90.
SWOT Contact: ALan Rees

LESSER ANTILLES

DATA RECORD 25

Project Title: Green and Hawksbill Turtles in the Lesser Antilles Demonstrate Behavioural Plasticity in Inter-nesting Behaviour and Post-nesting Migration
Metadata: 2 postnesting female *E. imbricata*
Data Source: Esteban, N., R. van Dam, E. Harrison, A. Herrera, and J. Berkel. 2015. Green and hawksbill turtles in the Lesser Antilles demonstrate behavioural plasticity in inter-nesting behaviour and post-nesting migration. *Marine Biology* 162 (6): 1153–1163. https://doi.org/10.1007/s00227-015-2656-2.
SWOT Contacts: Robert van Dam, Emma Harrison, and Arturo Herrero

MEXICO

DATA RECORD 27 | SWOT ID: 794

Project Title: Migratory Patterns of Yucatán Peninsula Hawksbills
Metadata: 6 postnesting adult female *E. imbricata*
Data Sources: (A) Cuevas, E. 2021. Migratory patterns of Yucatán Peninsula hawksbills. Data downloaded from OBIS-SEAMAP (http://seamap.env.duke.edu/dataset/364) on March 15, 2022, and originated from STAT (http://www.seaturtle.org/tracking/index.shtml?project_id=154). **(B)** STAT. **(C)** SWOT Online Database. **(D)** OBIS-SEAMAP.
SWOT Contact: Eduardo Cuevas

DATA RECORD 28 | SWOT ID: 707

Project Title: Movimiento Migratorio de la Tortuga Carey, Islas del Parque Nacional Sistem Arrecifal Veracruzano (PNSAV)
Metadata: 3 postnesting female *E. imbricata*
Data Sources: (A) Miron, R. 2021. Movimiento migratorio de la tortuga carey. Islas del PNSAV, Veracruz, Mexico. Data downloaded from OBIS-SEAMAP (http://seamap.env.duke.edu/dataset/1197) on March 15, 2022, and originated from STAT (http://www.seaturtle.org/tracking/index.shtml?project_id=1023). **(B)** STAT. **(C)** SWOT Online Database. **(D)** OBIS-SEAMAP.
SWOT Contact: Acuario de Veracruz A.C.

DATA RECORD 29 | SWOT ID: 38505

Project Title: Tortugas Carey en el Pacífico Mexicano.
Metadata: 14 adult, 2 juvenile, and 2 subadult *E. imbricata*
Data Sources: (A) Hart, C. 2022. Tortugas carey en el Pacífico mexicano. Data downloaded from OBIS-SEAMAP (http://seamap.env.duke.edu/dataset/1002) on March 15, 2022, and originated from STAT (http://www.seaturtle.org/tracking/index

.shtml?project_id=916). **(B)** STAT. **(C)** SWOT Online Database. **(D)** OBIS-SEAMAP.
SWOT Contact: Red Tortuguera A.C.

PALAU

DATA RECORD 30

Project Title: Hawksbills Tracked in Palau
Metadata: 1 *E. imbricata*
Data Source: Secretariat of the Pacific Regional Environment Programme (SPREP) and World Wide Fund for Nature (WWF). 2022. Hawksbills tracked in Palau. Personal communication. In *SWOT Report—State of the World's Sea Turtles*, vol. XVII (2022).
SWOT Contacts: SPREP, WWF, and Denise Parker

PANAMA

DATA RECORD 31

Project Title: Hawksbill Tracked from Panama
Metadata: 1 female *E. imbricata*
Data Source: Amorocho, D. 2013. Hawksbill tracked from Panama. Personal communication. In *SWOT Report—State of the World's Sea Turtles*, vol. XVII (2022).
SWOT Contact: Diego Amorocho

PAPUA NEW GUINEA

DATA RECORD 32

Project Title: Satellite Tracking of Hard-Shelled Sea Turtles of Papua New Guinea
Metadata: 3 *E. imbricata*
Data Source: Gearhart, G. 2018. Data from Satellite tracking of hard-shelled sea turtles of Papua New Guinea. Movebank Data Repository.
SWOT Contact: Geoffrey Gearheart

PHILIPPINES

DATA RECORD 33

Project Title: Hawksbills Tracked In the Philippines
Metadata: 2 *E. imbricata*
Data Sources: Philippine Turtle Island Park and D. Parker. 2002. Hawksbills tracked in the Philippines. Personal communication. In *SWOT Report—State of the World's Sea Turtles*, vol. XVII (2022).
SWOT Contacts: Philippine Turtle Island Park and Denise Parker

PUERTO RICO

DATA RECORD 34 | SWOT ID: 2835

Project Title: Understanding the Effects of Climate Change on Caribbean Hawksbill Turtles: Satellite Tracking Hawksbill Migrations
Metadata: 6 adult *E. imbricata*
Data Sources: **(A)** Drews, L. 2021. Understanding the effects of climate change on Caribbean hawksbill turtles: Satellite tracking hawksbill migrations. Data downloaded from OBIS-SEAMAP (http://seamap.env.duke.edu/dataset/469) on March 15, 2022, and originated from STAT (http://www.seaturtle.org/tracking/index.shtml?project_id=291). **(B)** STAT. **(C)** SWOT Online Database. **(D)** OBIS-SEAMAP.
SWOT Contact: WWF

QATAR

DATA RECORD 35 | SWOT ID: 10502

Project Title: Reproductive Biology of Marine Turtles Under Extreme Climatic Conditions
Metadata: 1 adult and 4 juvenile *E. imbricata*
Data Sources: **(A)** Pilcher, N. 2021. Reproductive Biology of Marine Turtles under Extreme Climatic Conditions. Data downloaded from OBIS-SEAMAP (http://seamap.env.duke.edu/dataset/1134) on March 15, 2022, and originated from STAT (http://www.seaturtle.org/tracking/index.shtml?project_id=978). **(B)** STAT. **(C)** SWOT Online Database. **(D)** OBIS-SEAMAP.
SWOT Contact: Marine Research Foundation

SABAH

DATA RECORD 36

Project Title: Hawksbills Tracked in Sabah
Metadata: 3 *E. imbricata*
Data Sources: Pilcher, N. J., J. Bali, J. Buis, et al. 2019. A review of sea turtle satellite tracking in Malaysia. *Indian Ocean Turtle Newsletter* 29: 11–22.
SWOT Contact: Denise Parker

SAMOA

DATA RECORD 37

Project Title: Hawksbills Tracked in Samoa
Metadata: 1 *E. imbricata*
Data Sources: Bell, L., D. Parker, and G. H. Balazs. 2010. Hawksbills tracked in Samoa. Personal communication. In *SWOT Report—State of the World's Sea Turtles*, vol. XVII (2022).
SWOT Contact: Lui Bell, Secretariat of the Pacific Regional Environment Programme, Ministry of Natural Resources, National Oceanic and Atmospheric Administration, Denise Parker, and George H. Balazs

SEYCHELLES

DATA RECORD 38

Project Title: Movements of Post-nesting Hawksbill Turtle Satellite-Tracked from Mahe, Seychelles, under the Marine Conservation Society Seychelles (MCSS) Mahe Seychelles Hawksbill Project
Metadata: 2 adult female *E. imbricata*
Data Sources: **(A)** Seychelles turtles with MCSS (http://seychelles-turtles.blogspot.com/). **(B)** *TImOI: Tortues Imbriquées de l'Océan Indien—Comprendre la Connectivité des Populations; Résultats préliminaires, Mai 2022.* Technical report of the INTERREG V Indian Ocean project. Centre d'Étude et de Découverte des Tortues Marines (CEDTM), Kelonia
SWOT Contacts: Manon Nivière, Jeanne Mortimer, Claire Jean, Katia Ballorain, MCSS, and CEDTM

DATA RECORD 39

Project Title: Post-nesting Migrations of Hawksbill Turtles in the Granitic Seychelles
Metadata: 5 postnesting female *E. imbricata*
Data Source: Mortimer, J. A,. and G. H. Balazs. 2000. Post-nesting migrations of hawksbill turtles in the granitic Seychelles and implications for conservation. In H. Kalb and T. Wibbels (eds.), *Proceedings of the 19th Annual Symposium on Sea Turtle Biology and Conservation*, pp. 22–26. NOAA Technical Memorandum NMFS-SEFSC-443, 291, National Oceanic and Atmospheric Administration, Washington, D.C.
SWOT Contact: Jeanne Mortimer

SINGAPORE

DATA RECORD 40

Project Title: Hawksbills Tracked in Singapore
Metadata: 8 *E. imbricata*
Data Sources: Pending
SWOT Contact: Denise Parker

UNITED ARAB EMIRATES

DATA RECORD 41 | SWOT ID: 10568

Project Title: Gulf Turtle Tracking Project 2010
Metadata: 20 adult *E. imbricata*
Data Sources: **(A)** Antonopoulou, M. 2021. Gulf Turtle Tracking Project 2010. Data downloaded from OBIS-SEAMAP (http://seamap.env.duke.edu/dataset/1255) on March 15, 2022, and originated from STAT (http://www.seaturtle.org/tracking/index.shtml?project_id=658). **(B)** STAT. **(C)** SWOT Online Database. **(D)** OBIS-SEAMAP.
SWOT Contact: Emirates Wildlife Society–WWF

DATA RECORD 42 | SWOT ID: 23710

Project Title: Gulf Turtle Tracking Project 2011
Metadata: 24 adult *E. imbricata*
Data Sources: **(A)** Antonopoulou, M. 2021. Gulf Turtle Tracking Project 2011. Data downloaded from OBIS-SEAMAP (http://seamap.env.duke.edu/dataset/1257) on March 15, 2022, and originated from STAT (http://www.seaturtle.org/tracking/index.shtml?project_id=737). **(B)** STAT. **(C)** SWOT Online Database. **(D)** OBIS-SEAMAP.
SWOT Contact: Emirates Wildlife Society–WWF

DATA RECORD 43 | SWOT ID: 35709

Project Title: Marine Turtle Conservation Project, 2012–2013
Metadata: 36 adult *E. imbricata*
Data Sources: **(A)** Antonopoulou, M. 2021. Marine Turtle Conservation Project, 2012–2013. Data downloaded from OBIS-SEAMAP (http://seamap.env.duke.edu/dataset/1282) on March 15, 2022, and originated from STAT (http://www.seaturtle.org/tracking/index.shtml?project_id=494). **(B)** STAT. **(C)** SWOT Online Database. **(D)** OBIS-SEAMAP.
SWOT Contact: Emirates Wildlife Society–WWF

U.S.A.

DATA RECORD 44

Project Title: Home Range and Movement Patterns of Subadult Hawksbill Sea Turtles in Southeast Florida
Metadata: 6 subadult *E. imbricata*
Data Source: Wood, L. D., B. Brunnick, and S. L. Milton. 2017. Home range and movement patterns of subadult hawksbill sea turtles in Southeast Florida. *Journal of Herpetology* 51 (1): 58–67. https://doi.org/10.1670/15-133.
SWOT Contact: Larry Wood

DATA RECORD 45

Project Title: Hawksbills Tracked in Hawaii
Metadata: 11 *E. imbricata*
Data Sources: **(A)** Parker, D. M., G. H. Balazs, C. S. King, L. Katahira, and W. Gilmartin. 2009. Short-range movements of hawksbill turtles (*E. imbricata*) from nesting to foraging areas within the Hawaiian Islands. *Pacific Science* 63 (3): 371–382. https://doi.org/10.2984/049.063.0306. **(B)** Parker, D. M., C. King, M. Rice, and G. Balazs. 2014. First use of a GPS satellite tag to track a post-nesting hawksbill (*E. imbricata*) in the Hawaiian Islands with an indication of possible mortality. *Marine Turtle Newsletter* 142: 10–13.
SWOT Contact: Denise Parker

DATA RECORD 46

Project Title: Hawksbills in Hawaii
Data Source: Gaos, A., M. Martin, and J. Seminoff. Hawksbills in Hawaii. Personal communication. In *SWOT Report—State of the World's Sea Turtles*, vol. XVII (2022).
SWOT Contact: Alexander Gaos, Summer Martin, Jeffrey Seminoff, and National Oceanic and Atmospheric Administration Pacific Islands Fisheries Science Center and Southwest Fisheries Science Center

VANUATU

DATA RECORD 47

Project Title: Hawksbills Tracked in Vanuatu
Metadata: 1 *E. imbricata*
Data Sources: Parker, D., and G. H. Balazs. 2008. Hawksbills tracked in Vanuatu. Personal communication. In *SWOT Report—State of the World's Sea Turtles*, vol. XVII (2022).
SWOT Contacts: Secretariat of the Pacific Regional Environment Programme, World Wide Fund for Nature, Wan Smolbog Theatre, National Oceanic and Atmospheric Administration, Denise Parker, and George H. Balazs

MULTINATIONAL

DATA RECORD 48

Project Title: Movements of Post-nesting Hawksbill Turtle Satellite-Tracked from the South Western Indian Ocean under INTERREG V Indian Ocean TImOI Project and STORM-IO Project
Metadata: 10 adult female *E. imbricata* from Seychelles, 5 from Madagascar, and 1 from Comoros
Data Sources: Ballorain, K., A. Barat, C. Jean, M. Nivière, and C. Gobeaut. 2022. *TImOI: Tortues Imbriquées de l'Océan Indien—Comprendre la Connectivité des Populations; Résultats préliminaires, Mai 2022.* Technical report of the INTERREG V Indian Ocean project. Centre d'Étude et de Découverte des Tortues Marines (CEDTM), Kelonia.
SWOT Contacts: Manon Nivière, Jeanne Mortimer, Claire Jean, Katia Ballorain, CEDTM, Marine Conservation Society Seychelles, Island Biodiversity and Conservation Center at Seychelles University, Seychelles Parks and Gardens Authority, Wildlife Conservation Society, Institut Halieutique et des Sciences Marines de l'Université de Toliara, Madagascar National Parks, Time+Tide Foundation, Laboratoire de l'Atmosphère et des Cyclones de l'Université de La Réunion, and Parc National de Mohéli

DATA RECORD 49 | SWOT ID: 15878

Project Title: Iniciativa Carey del Pacífico Oriental (ICAPO) Eastern Pacific Hawksbill Initiative
Metadata: 30 adult, 7 subadult, 6 juvenile *E. imbricata*
Data Sources: **(A)** Seminoff, J. 2021. ICAPO Eastern Pacific Hawksbill Initiative. Data downloaded from OBIS-SEAMAP (http://seamap.env.duke.edu/dataset/1336) on March 15, 2022, and originated from STAT (http://www.seaturtle.org/tracking/index.shtml?project_id=295). **(B)** STAT. **(C)** SWOT Online Database. **(D)** OBIS-SEAMAP.
SWOT Contact: U.S. National Oceanic and Atmospheric Administration Southwest Fisheries Science Center

DATA RECORD 50

Project Title: Movements and Distribution of Hawksbill Turtles in the Eastern Indian Ocean
Metadata: 42 postnesting female *E. imbricata* tagged in Australia and Timor-Leste
Data Source: Fossette, S., L. C. Ferreira, S. D. Whiting, J. King, et al. Movements and distribution of hawksbill turtles in the eastern Indian Ocean. *Global Ecology and Conservation* 29: e01713.
SWOT Contacts: Sabrina Fossette, Tony Tucker, Scott Whiting, Michele Thums, Luciana Ferreira, and Kellie Pendoley

DATA RECORD 51

Project Title: Hawksbills Tracked in the East Pacific
Metadata:
Data Source: Gaos, A., M. Martin, and J. Seminoff. Hawksbills Tracked in the East Pacific. Personal communication. In *SWOT Report—State of the World's Sea Turtles*, vol. XVII (2022).
SWOT Contacts: Sabrina Fossette, Tony Tucker, Scott Whiting, Michele Thums, Luciana Ferreira, and Kellie Pendoley

Global Management Units for Sea Turtles Data Citations

The following data sources were used to create the maps of "Global Management Units for Sea Turtles" on pp. 20–21.

LEATHERBACKS

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Cabo Verde Loggerhead Nesting Citations

Loggerhead nesting data for the map on p. 9 were generously shared via personal communication by the following data providers:

Albert Taxonera Amoros, Associação Projeto Biodiversidade, **Sal Island**

María E. Medina Suarez, Cabo Verde Natura 2000, **Boa Vista**

Caro Oujo, BIOS.CV, **Boa Vista**

Airton Jesus, Fundação Tartaruga / Turtle Foundation, **Boa Vista**

João Henrique Gomes da Cruz, Associação Varandinha, **Boa Vista**

Jairson Veiga, Maio Biodiversity Foundation, **Maio Island**

Ana Varela-da-Veiga, Associação Lantuna, **Santiago**

João Pina Lomba, Associação Ambiental Caretta Caretta, **Santiago**

Piter Bento, Fauna e Flora de São Francisco, **Santiago**

Sandra Correia, Instituto do Mar, **São Vicente**

Alberto Queiruga, Biosfera I, **São Vicente and Santa Luzia**

Herculano Dinis, Associação Projecto Vitó, **Fogo Island** and **Rombo Islets**

Silvana Roque, TerriMar Ambiente e Desenvolvimento Sustentável, **Santo Antão**

Amandio Lima, Associação Comunitária de Cruzinha, **Santo Antão**

Nilson Ramos Brás, Associção de Biólogos e Investigadores de Cabo Verde, **São Nicolau**

Zofia Radwan, Direção Nacional do Ambiente, **Cabo Verde**

Sea Turtle Toxicology Sampling Overview Data Citations

The dataset for the toxins map on pp. 12–13 was created using the data from Cortés-Gómez, Romero, and Girondot (2017). In addition, data from the following publications were added to the original dataset for this map.

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In Memoriam

Since the publication of *SWOT Report*, vol. XVI, in June 2021, the sea turtle conservation world has lost many beloved members of our community, including those memorialized herein and others, like Thomas Lovejoy and Edward O. Wilson. Both Dr. Lovejoy and Dr. Wilson were icons of biodiversity conservation, as well as lovers of sea turtles and supporters of SWOT. The renowned E. O. Wilson is quoted in SWOT's first volume (2006): "As we begin to understand the state of the world's sea turtles, new priorities arise, global strategies form, and fresh hope swells for the survival of these incredible creatures." Special thanks go to Dimitris Dimopoulos, Karen Eckert and the WIDECAST Network, Alex Gaos, Janet Hochella, Yakup Kaska, Kate Mansfield, Dimitris Margaritoulis, Aliki Panagopoulou, Jim Stevenson, and Blair Witherington for the content that follows.

Jessica Berkel (1969–2021)

Jess was the long-standing Sea Turtle Program coordinator for Sint Eustatius and head of the Oranjestad-STENAPA (St. Eustatius National Parks) Marine Park. She was loved and respected by her colleagues—especially within the Dutch Caribbean conservation community and broader WIDECAST network—and deeply devoted to biodiversity conservation. She was unafraid, irreverent, independent, and incredibly talented. She loved her global sea turtle family, and she leveraged their collective spirit to get things done that otherwise might have been impossible. Jess was famous for her strong opinions and her bluntness in public discussions—for instance, about the constitutional status of the island with respect to COVID-19 vaccinations. But above all she will be remembered for her steadfast dedication to nature preservation and to her beloved marine park.

Kostas Bouyouris (1965–2021)

Kostas helped to build the Greek nonprofit ARCHELON into a force for sea turtle conservation. After working in Zakynthos, he set up a project on Crete in 1989. He left to pursue agronomy but was always there to help the turtles. For example, he found the perfect olive grove in Crete, which became ARCHELON's home, and he helped replace an unsightly seawall at the heart of the island's loggerhead beach with natural rocks and dune vegetation. His vision and principles also guided the Management Plan for the Protection of Sea Turtles in Crete, an effort that bore his ideas, passion, commitment, and love. A "turtler" at heart, Kostas later became a pioneer in sustainable nutrition and agriculture, local nature conservation, and more. But mostly, it was hard not to love Kostas simply as a human being. Whether working hard in the field, singing karaoke, or doing a dowsing, Kostas' smile always shone brightly.

Mario Boza (1942–2021)

One of the fathers of Costa Rica's renowned National Parks System, Mario's life was spent protecting his country's rich flora and fauna—especially sea turtles. He played a pivotal role in the creation of the Las Baulas National Marine Park and fought hard to protect critically endangered eastern Pacific leatherbacks for decades. He helped to organize the Western Atlantic Turtle Symposium in 1983 and the 2004 International Sea Turtle Symposium in San Jose, both game-changing gatherings for global sea turtle conservation. And he also cofounded The Leatherback Trust. Widely recognized and honored as a conservation pioneer, he was a mentor and friend to countless students and others who shared his love for nature globally and especially in his beloved Costa Rica.

Shandell Brunson (1976–2022)

Shandell pursued her lifelong passion to be a sea turtle scientist with the National Oceanic and Atmospheric Administration (NOAA) Fisheries in Honolulu, beginning as a volunteer while she was still an undergraduate at the University of Hawaii. In the ensuing 20 years, she advanced to become the sea turtle stranding coordinator for Hawaii and the Pacific Islands Region, a position in which she was recognized as NOAA Fisheries' Employee of the Year. She was also working on her master's degree in zoology. Besides her love of the ocean, the beach, and turtles, Shandell loved to ride her motorcycle and to travel, sit around the campfire, and enjoy the beauty of her native Idaho. She will be remembered for her warm spirit, kind demeanor, and shining smile.

Llewellyn “Doc” Ehrhart (1942–2022)

Doc built a globally respected sea turtle research program at the University of Central Florida over three decades, and it would be difficult to find any sea turtle on Earth that was not touched in one way or another by him, either personally or indirectly through his many legacies. In all things, he was a traditionalist yet a groundbreaker; a naturalist and a conservationist; a field biologist who enjoyed getting dirty but cleaned up well; a teller of one particularly bad joke that only he thought was hilarious; and a much-loved husband, father, teacher, mentor, and friend. Doc’s passion and enthusiasm for sea turtles earned him incomparable respect and admiration. He will forever be remembered by those he inspired to follow in his footsteps.

John Fuller (1947–2021)

A prominent (often *pro bono*) lawyer, John’s life revolved around tireless environmental advocacy for Antigua and Barbuda and the Caribbean. Both in and out of the courtroom, he was unafraid to do what was right for a just cause. Friends recall him standing alongside his neighbors to stop his town’s historical public library from being bulldozed, a badge of honor he wore with pride. He also helped establish the longest-running hawksbill program in the world at Jumby Bay, led the development of WIDECAST’s Sea Turtle Recovery Action Plan, and was a pivotal voice for biodiversity in his country. His sharp wit, altruism, and kindness, combined with his irreproachable professional and personal conduct, made John a man of great character.

June Haimoff (1922–2022)

An English-born eclectic artist (painter, opera singer, ballet dancer) and environmentalist, “Captain” June first stepped foot in Dalyan, Turkey, in 1975. It was love at first sight, and she ultimately became a Turkish citizen. She and other prominent conservationists of her day, including Britain’s HRH Prince Philip, launched a successful campaign in the 1980s to halt an ecologically damaging construction project and preserve Iztuzu Beach, one of the most important loggerhead beaches in the Mediterranean and now the Köyceğiz-Dalyan Special Environmental Protection Area. And this was just the start of Captain June’s storied career, which was dedicated to protecting Mediterranean sea turtle nesting beaches from development and degradation. Her passion and success earned her the title “Mother of *Caretta carettas*.”

Bertrand Bennette Lettsome (1962–2021)

As the first chief conservation and fisheries officer for the British Virgin Islands, Bert (also known as “Washasha X”) ushered in and led many efforts to protect sea turtles, including the development of the nation’s first Sea Turtle Recovery Action Plan, created in partnership with WIDECAST. He fought passionately for the well-being of nature and the people in the Caribbean, and he was a pioneer in understanding the economic consequences of impaired ecosystems. He was hailed as a leader who brought vision, growth, and direction to his work. He raised the awareness of the public, and especially of his fellow policymakers, about the importance of conserving mangroves, sea grass, beaches, coral reefs, and turtles. Bert is the reason that much of the British Virgin Islands’ natural beauty is intact today.

Fernando Manzano (1957–2021)

Best known as “Papá Tortuga,” Fernando was inspired from childhood, by seeing Jacques Cousteau on TV, to help the Kemp’s ridleys nesting in his home town of Tecolutla, Veracruz, Mexico. In the early 1970s, the species appeared doomed to extinction from years of human impact at its main nesting beach near Rancho Nuevo, Tamaulipas, and Fernando was disturbed by the common practice of eating sea turtle meat and eggs in his own town. He soon involved his entire community and established the nonprofit Vida Milenaria AC. After years of dedication, that important rookery’s annual nest count has grown from 5 in 1974 to more than 800 nests per year today. Fernando earned the respect and admiration of his neighbors and the global sea turtle conservation movement. Tourists and the children of Tecolutla especially adored Papá Tortuga and loved to join him on the beach for hatchling releases.

Authors and Affiliations

F. ALBERTO ABREU-GROBOIS, Instituto de Ciencias del Mar y Limnología, Universidad Nacional Autónoma de México, Mexico

KATIA BALLORAIN, Centre d'Étude et de Découverte des Tortues Marines (CEDTM), Île de la Réunion, France

NILSON RAMOS BRÁS, Associação de Biólogos e Investigadores de Cabo Verde, São Vicente, Cabo Verde

MICHELLE MARÍA EARLY CAPISTRÁN, Centro de Investigación Científica y de Educación Superior de Ensenada (CICESE), Ensenada, Mexico

JESSICA CASTRO-PRIETO, National Wildlife Refuge Association, Puerto Rico

AUDREY CHEVALIER, WWF France–World Wide Fund for Nature, French Guiana

DAMIEN CHEVALLIER, CNRS BOREA Research Unit–Laboratoire de Biologie des Organismes et des Écosystèmes Aquatiques, Martinique, France

SANDRA CORREIA, Instituto do Mar, São Vicente, Cabo Verde

ADRIANA CORTÉS-GÓMEZ, Conservation des Populations et des Communautés group, París-Saclay University, France, and SEE Turtles, Oregon, U.S.A.

CARLOS E. DÍEZ, Department of Natural and Environmental Resources, Puerto Rico

PETER H. DUTTON, Southwest Fisheries Science Center, National Oceanic and Atmospheric Administration–National Marine Fisheries Service (NOAA-NMFS), California, U.S.A.

KAREN ECKERT, Wider Caribbean Sea Turtle Conservation Network, Illinois, U.S.A.

NICOLE ESTEBAN, Bioscience, Swansea University, Wales, United Kingdom

CHRISTOPHE EIZAGUIRRE, Queen Mary University of London, United Kingdom

KIRSTEN FAIRWEATHER, Associação Projeto Biodiversidade, Sal Island, Cabo Verde

NANCY N. FITZSIMMONS, Australian Rivers Institute, School of Environment and Science, Griffith University, Australia

ALEXANDER R. GAOS, Pacific Islands Fisheries Science Center, NOAA-NMFS, Hawaii, U.S.A.

MARC GIRONDOT, Conservation des Populations et des Communautés group, París-Saclay University, France

JOÃO HENRIQUE GOMES DA CRUZ, Associação Varandinha, Boa Vista, Cabo Verde

ALBERTINO GONZALVES, Associação Ponta d'Pom, São Vicente, Cabo Verde

KATHARINE HART, Wider Caribbean Sea Turtle Conservation Network, Turks and Caicos Islands

GRAEME C. HAYS, Deakin University, Victoria, Australia

CHRISTINE A. MADDEN HOF, World Wide Fund for Nature; Coral Triangle Programme, Indonesia; and University of the Sunshine Coast, Queensland, Australia

MICHAEL P. JENSEN, Department of Chemistry and Bioscience, Aalborg University, Denmark, and Australian Rivers Institute School of Environment and Science, Griffith University, Australia

AIRTON JESUS, Fundação Tartaruga, Boa Vista, Cabo Verde

LAURENT KELLE, WWF France–World Wide Fund for Nature, French Guiana

ERIN L. LaCASELLA, Southwest Fisheries Science Center, NOAA-NMFS, California, U.S.A.

MATHILDE LASFARGUE, L'Office Français de la Biodiversité (OFB), French Guiana

MICHAEL LILES, Asociación ProCosta, El Salvador

AMANDIO LIMA, Associação Comunitária de Cruzinha, Santo Antão, Cabo Verde

JOÃO PINA LOMBA, Associação Ambiental Caretta Caretta, Santiago, Cabo Verde

CARLA LOPES, Projecto Vitó, Fogo, Cabo Verde

ADOLFO MARCO, Estación Biológica de Doñana, Consejo Superior de Investigaciones Científicas (CSIC), Spain

RODERIC B. MAST, Oceanic Society, California, U.S.A.

ANNE MEYLAN, Florida Fish and Wildlife Conservation Commission, Fish and Wildlife Research Institute, Florida, U.S.A.

CAMILA MIGUEL, Projeto Chelonia mydas, Instituto Marcos Daniel, Brazil

JARINA MOHD JANI, Faculty of Science and Marine Environment, Universiti Malaysia Terengganu, Malaysia

JEANNE A. MORTIMER, Turtle Action Group Seychelles, Mahé, Seychelles, and Department of Biology, University of Florida, Florida, U.S.A.

BRAD NAHILL, SEE Turtles, Oregon, U.S.A.

MICHEL A. NALOVIC, French Guiana Regional Fisheries Committee, Port of Larivot, French Guiana

CARO OUJO, BIOS.CV, Boa Vista, Cabo Verde

JUAN PATIÑO, Fundação Maio Biodiversidade, Maio Island, Cabo Verde

NICOLAS PILCHER, Marine Research Foundation, Sabah, Malaysia

ALBERTO QUEIRUGA, Biosfera I, São Vicente, Cabo Verde

ZOFIA RADWAN, Direção Nacional do Ambiente, Santiago, Cabo Verde

PATRICIA RENDALL, Nautilica, São Vicente, Cabo Verde

VALDIR RODRIGUES, Associação Terra, São Vicente, Cabo Verde

SILVANA ROQUE, TerriMar Ambiente e Desenvolvimento Sustentável, Santo Antão, Cabo Verde

JEFFREY A. SEMINOFF, Southwest Fisheries Science Center, NOAA-NMFS, California, U.S.A.

BRIAN M. SHAMBLIN, Warnell School of Forestry and Natural Resources, University of Georgia, Georgia, U.S.A.

KARTIK SHANKER, Indian Institute of Science and Dakshin Foundation, Bangalore, India

KELLY R. STEWART, Southwest Fisheries Science Center, NOAA-NMFS, California, U.S.A., and The Ocean Foundation, Washington, D.C., U.S.A.

MARÍA E. MEDINA SUÁREZ, Cabo Verde Natura 2000, Boa Vista, Cabo Verde

ALBERT TAXONERA AMOROS, Associação Projeto Biodiversidade, Sal Island, Cabo Verde

BENOIT DE THOISY, Association Kwata, Cayenne, French Guiana

MANJULA TIWARI, Ocean Ecology Network, and research affiliate of NOAA–NMFS, California, U.S.A.

JOSÉ URTEAGA, Emmett Interdisciplinary Program in Environment and Resources, Stanford University, and Wild Earth Allies, Nicaragua

ANA VARELA-DA-VEIGA, Lantuna, Santiago, Cabo Verde

BRYAN WALLACE, Ecolibrium, Inc, Colorado, U.S.A.

SCOTT WHITING, Department of Biodiversity, Conservation and Attractions, Western Australia, Australia

BLAIR WITHERINGTON, Inwater Research Group, Florida, U.S.A.

RONALD WONGSOPAWIRO, RNA–Reserve Naturel de l'Amana, Awala, French Guiana

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The State of the World's Sea Turtles

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Oceanic Society
P.O. Box 844
Ross, CA 94957
U.S.A.

www.SeaTurtleStatus.org