SWOT report

Volume XIX

The State of the World's Sea Turtles

SPECIAL FEATURE

SEA TURTLES OF Southeast Asia

A loggerhead turtle swims in Coral Bay, Ningaloo Reef, Western Australia. © Emilie Ledwidge/Ocean Image Bank; **FRONT COVER:** A green turtle captured in the sunburst off of Sipadan Island, Sabah, Malaysia. © Jason Isley/Scubazoo

Editor's Note

Miracles Worth Celebrating

The first draft of this note lacked my usual optimism. I was in quarantine, separated from family, and mired in gloomy news, which has become omnipresent. I was impatient with the seemingly tectonic pace of ocean protection; saddened by wars in Ukraine, Gaza, and elsewhere; troubled by the daily signs of and slow responses to a steadily warming planet; and stricken by the barely noticed moment when humanity exceeded the 8 billion mark, representing an additional 5 billion people on the planet since my birth.

But the clouds lifted as I began to review the contents of this, our 19th volume of the *State of the World's Sea Turtles (SWOT) Report*. Volunteers from a dozen countries have contributed data, ideas, photos, writing, and mapping and editorial skills to create the special feature on Southeast Asian sea turtles (pp. 22–37), with stories reflecting mostly good news and quality science, technology, and collaboration that could not have happened even a few short years ago. Articles rolled in also with good news about Mexico's black turtles (pp. 16–17); rebounding hawksbills in the U.S. Virgin Islands (pp. 38–39); community-led conservation in the Maldives (pp. 20–21); innovations to tackle plastic pollution (pp. 40–41); and promising results from collaborations in the eastern Pacific (pp. 12–13), Indonesia (pp. 14–15), and the Asia-Pacific region (pp. 18–19). And although we still have much to learn about climate impacts on turtles and their habitats, the science has advanced enormously in recent decades (pp. 6–9). Even answers to simple questions about sea turtles' diving and breath-holding abilities (pp. 46–47) and their lost years (pp. 12–13) remind us of how we are continually discovering important details about sea turtles' lives that improve our ability to conserve them.

Perhaps most importantly, our community is now seriously exploring the role of human social identity, basic needs, value systems, and norms in our conservation planning. We are breaking old paradigms, measuring success more wisely, and embracing the idea that the only cure to make the oceans healthy lies in understanding and changing human behavior (pp. 42–43). We have realized that people are at the core of both the problems and the solutions for nature, at all scales.

Though it is undeniable that there are some bad things happening on Earth, most things used to be worse. Slow change in the direction of saving nature is a whole lot better than no change, and the advances made by our community in the face of many challenges are miracles worth celebrating.

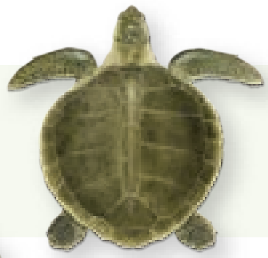
Please join me in stepping away from the endless bad news as you turn the pages of this report, which is filled with the positive results of our community's hard work and dedication. We have a lot to be grateful for. I am uplifted by the camaraderie, enthusiasm, and volunteer spirit of our community, and I am certain that if we keep doing what we've been doing, things will continue to get better for the sea and her turtles.

Roderic B. Mast
Chief Editor

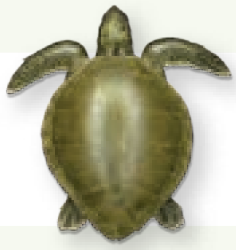
AT LEFT: A green turtle rests among the corals in Ningaloo Reef, Australia. © Jake Wilton Photography

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.

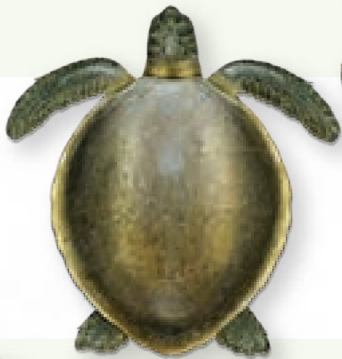


Kemp's ridley
Lepidochelys kempii
CR



Olive ridley
Lepidochelys olivacea
VU

Hawksbill
Eretmochelys imbricata
CR



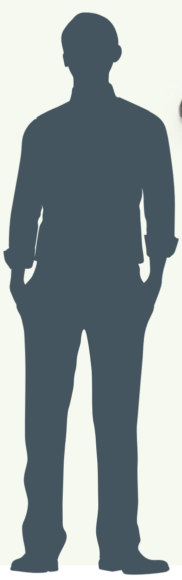
Flatback
Natator depressus
DD

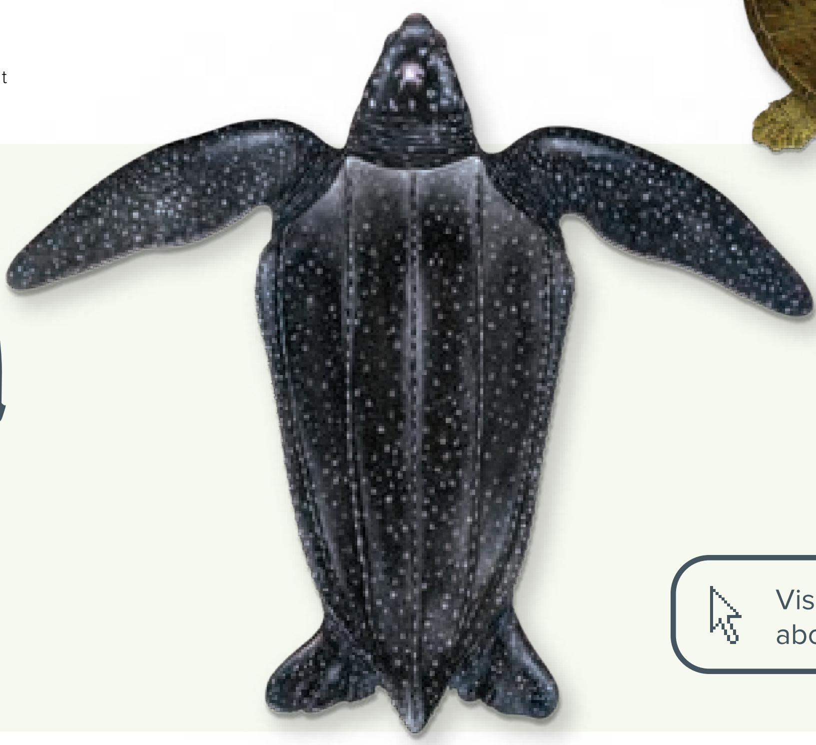
Loggerhead
Caretta caretta
VU

Green
Chelonia mydas
EN

IUCN RED LIST STATUS:

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





Leatherback
Dermochelys coriacea
VU

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

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SWOT
The State of the World's Sea Turtles

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Find Mr. Leatherback!
Can you spot Mr. Leatherback's distinctive silhouette? It's hidden 9 times in this issue of *SWOT Report*.

ILLUSTRATIONS: © Dawn Witherington
THIS PAGE: © Willyam

Turning Up the Heat on Sea Turtles

By Samantha G. Kuschke, Justin R. Perrault, and Jeanette Wyneken

Climatic changes are occurring on a global scale and at a rapid pace, leading to elevated ocean and beach temperatures, prolonged heat waves, droughts, severe storms, and other abnormal weather events. Individually, each of those changes can negatively affect sea turtles, but when they occur together, the scope of the problem can be broad and pervasive. Sea turtles rely on healthy oceans, coastal waters, estuaries, and sandy beaches for their survival. Hence, there is an urgent need to characterize the full suite of climate change influences on sea turtles so that we can design adaptation strategies and mitigations.

Time to Prepare, Conservationists!

There remains an overall lack of knowledge about the effects of shifting climate on different sea turtle species and life-stage classes, and we have even less information about those impacts at population scales. Yet these types of knowledge will be essential for defining management options. Classically important quantifiable measures for sea turtles (called *vital rates*) such as hatchling production and death rates, hatchling health, age to maturity, sex ratios, and population age structure are all affected by climate; however, baseline measures for those vital rates are sorely lacking.

Meanwhile, climatic effects on food chains and how the changes may affect the growth and survival of juvenile sea turtles also are understudied. Slowing growth rates of sea turtles have been linked to ecological shifts, including losses of basic or intermediate links in food chains that affect nutrient availability, ratios of dissolved gases, and more. Such disruptions can have population-scale responses in some cases. Furthermore, severe storm events can cause large-scale movements of undersea sediments that disturb submerged vegetation or silt coral reefs, thereby reducing available food items for both juvenile and adult turtles.

AT RIGHT: A juvenile green turtle off Cape Tribulation in Australia's Great Barrier Reef, which has experienced severe coral bleaching due to climate change. © Jackson Groves/journeyera.com

Visible Impacts

The planet already is experiencing irrefutable changes in sea levels and storm severity that have direct impacts on the reproductive success of turtles. Prolonged seawater inundation of nests and nest overwash events have been shown to greatly reduce reproductive output. In addition, extreme onshore wind events, which also are on the upswing globally, can lead to excessive sand erosion or accretion, sometimes exposing or deeply burying eggs—scenarios that can lead to nest failure. Loss of entire beaches to rising seas is an increasing reality, and in some locations, efforts to nourish beaches replace sand where it was eroded. At other sites, full armoring of beaches can protect upland structures but results in the loss of suitable nesting habitats for turtles. Some armored beaches actually present vertical walls to break waves and prevent wave runup; not only are such obstacles impassable by inbound nesting turtles, but also they prevent the natural renewal of suspended sand required for healthy nesting beaches.

Less Visible Impacts

Sea turtle embryos, hatchlings, and posthatchlings are facing increased amounts of physiological stress as a result of increasing beach temperatures. The warming of nesting beaches is a major issue directly related to sea turtle reproductive success and feminizing effects on sea turtle hatchling sex ratios. However, data to support those observations remain scant (see sidebar at right), and rising beach temperatures have even more profound effects on nests and eggs, which need further study and attention. Fundamentally, eggs are enclosed, stationary life support systems for developing embryos. As the embryos grow, their eggs breathe, in a way, exchanging respiratory gases with the external environment. Eggs also take in and release water vapor. Up to a point, the temperature of the nest is positively related to the rate of development, and a range of temperatures (within extremes often termed the *thermal minimum* and *thermal maximum*) can support normal hatchling development. Some researchers report that eggs incubated closer to the thermal minimum rarely hatch. Yet, with global temperatures increasing, there are now very few nesting beaches where that occurs. Sea turtle species differ somewhat in their thermal maxima, with olive ridleys tolerating warmer temperatures than leatherbacks, loggerheads, and green turtles tolerate.

A suite of consequences can occur when nests reach or exceed the maximum temperature limit, and typically, reproductive success declines when incubation temperatures exceed the maximum for prolonged periods. When loggerhead eggs are exposed to an average temperature of 33.5 degrees Celsius (92.3 degrees Fahrenheit), the incubation period becomes less predictable, and the embryos may perish or respond by using less energy for growth. Leatherback and loggerhead nests from southern Florida also show significant declines in hatching and emergence success at average incubation temperatures of 32 degrees and 33 degrees Celsius (89.6 degrees and 91.5 degrees Fahrenheit), respectively.

Proteins perform essential roles as the building blocks for muscles, viscera, enzymes, and hormones, and they aid in the transport of molecules around the body. Embryonic death can occur when temperatures reach the threshold that prevents normal protein synthesis. When the thermal maximum is reached, turtle embryos experience hyperthermia and can suffer developmental abnormalities, including orofacial defects (cleft palate), eye abnormalities, or diverse gastrointestinal defects, or they may die if thermal stress is too high. However, far more research is required to understand the timing of thermal maxima impacts from a variety of perspectives.

Kemp's ridley turtles nest just outside a hatchery in Rancho Nuevo, Mexico. Rising beach temperatures are affecting sea turtle eggs, embryos, and hatchlings in many ways. © Tui de Roy/Princeton University Press

Although egg health is challenging to measure, understanding hatchling health is more straightforward. Research on Florida's beaches shows that leatherback, loggerhead, and green turtle hatchlings that come from warmer nests show signs of dehydration and inflammation, and alterations in other blood analytes suggest additional physiological stress. Increased incubation temperatures also appear to have long-term effects on hatchlings, causing physiological stress well into the first month of life and possibly beyond.

Aside from the eggs, respiratory gases, and moisture in a turtle nest, an array of microbes also thrive in turtle nests and on hatchling skin under different thermal and hydric ranges. The nest environment is home to diverse communities of bacteria, fungi, and archaea that can also be found on and within healthy animals and likely play important roles in development, disease resistance, and response to outside stressors. When maintained in a healthy balance, these microbes are benign or even beneficial, but overgrowth of opportunistic pathogens can lead to skin infections, yolk sac infections, or systemic disease. Initial data suggest there are changes to the microbial communities present on the skin of hatchlings that emerge from hotter nests. Moreover, hatchlings from nests that have been overwashed show significantly higher white blood cell counts than those that are not overwashed, indicating that excess moisture alters the nest microbial community and hatchling physiological responses. It also appears that increasing nest temperatures cause a decrease in the microbial diversity on the skin of leatherback hatchlings, which is generally thought to have a negative impact on hatchling health.

Our data, and those from other populations and locations, suggest that higher beach temperatures may indeed drive decreased hatching, emergence, and survival rates in sea turtles.

Sounding the Alarm

The impact of climate change on sea turtles is a complex interaction of environmental events that together affect a wide range of species and life stages, and the examples given here could be just the tip of a much larger iceberg. From the moment sea turtle eggs are laid on the beach until the offspring return as sexually mature females or breeding males, turtles are physiologically combating the negative effects of climate change, and all species of sea turtles are now struggling to adapt at pace with these changes to their ocean and terrestrial habitats. Though we currently have some baseline knowledge, a more comprehensive understanding of the impacts of climate change on sea turtles is essential to our efforts to assure their survival. •

Be Careful with Your Predictions about Sea Turtle Sex Ratios

By Marc Girondot

© I Wayan Wiradnyana/BSTS

Ever since the discovery of temperature-sensitive sex determination (TSD), research has been hindered by scientists' inability to estimate hatchling sex ratios using nonlethal methods, because the sacrifice of embryos is inconceivable in species that we wish to protect. But numerous methods have been attempted. Typically, average incubation temperature is measured in nests, then compared to a profile obtained from a nest at constant temperature; sometimes that comparison is conducted over just one-third of the incubation period. Other methods use the duration of incubation as an integrating proxy. Scientists sometimes validate those methods by sacrificing a small number of embryos, but often no validation is done.

Although it is tempting to presume that average temperatures or incubation duration can be used as sex ratio proxies, it has been shown clearly that this is not the case; average nest temperature is not a reliable indicator for hatchling sex ratio; neither is the incubation period. Indeed, after 50 years of work on the subject, we still do not have a simple method for estimating sex ratios from a series of nest temperatures.

The most precise method to estimate sex ratios is to (1) obtain a TSD pattern from incubation at constant temperatures, (2) model embryo growth to define the precise thermosensitive period of sex determination using embryonic stages (not incubation duration), and (3) apply the constant temperature equivalent with the TSD pattern using a weighting scheme to correct for the fact that some temperatures have a greater capacity than others to sexualize the gonad. Such a model is difficult to apply; moreover, it should be calibrated for each specific nesting site to ensure accuracy. This approach is not simple field-based science by any means.

Recent promising results could do much to advance TSD research. It is possible using a blood test called ELISA (enzyme-linked immunosorbent assay)—or DNA methylation—to nonlethally determine the sex of hatchling turtles. The practicality of such techniques, however, remains to be determined. Meanwhile, it is important to continue to gather accurate data about nest temperatures globally only when those data will contribute to research goals that adhere to the strictest standards of analysis—as well as to monitor hatchling sex ratios whenever possible while minimizing the loss of animals. It is good to remember that marine turtles have numerous ways to control their own nest temperature by shifting phenology. Management is not always the best solution, and shading in hatcheries or cooling nests by watering will never be a practical solution to manage the tens of millions of nests laid annually. Sea turtles have survived global temperature peaks and valleys for millennia, and it is likely they will continue to do so.

The Rise and Fall

of Green Turtles and Seagrasses in Bermuda

By Richard Herren, Daniel Evans, Gaëlle Roth, Jennifer Gray, David Godfrey, Anne Meylan, and Peter Meylan

Bermuda is an ideal place to study immature green turtles and their foraging habitats. The island chain sits isolated a little more than 1,000 kilometers (620 miles) off the U.S. East Coast. There is no competition from nesting adults, because they were extirpated there by the late 1700s, and there are very few large oceanic predators. Seagrass beds on shallow offshore flats and nearshore bays are protected from open ocean swells by large reefs. The warm, clear water at the edges of the Gulf Stream and Sargasso Sea invites many subtropical species to this relatively northern location. And for a young oceanic green turtle in search of developmental habitat, Bermuda must seem an oasis of opportunity. However, this perceived green turtle paradise is no longer what it used to be.

Through its half-century-long capture-mark-recapture program, the Bermuda Turtle Project (BTP) has documented some troubling changes for the archipelago's green turtles. Protections put in place in foraging grounds like Bermuda and in nesting beaches throughout the wider Caribbean have significantly increased the size of the Bermuda green turtle aggregation in recent decades. However, although green turtle densities increased in Bermuda from 1992 to 2018, larger turtles became much less common, body condition decreased, and site fidelity declined. Then, in 2020, the green turtle aggregation in Bermuda suddenly crashed, and today it is estimated to be about one-fourth of what it was just a few years ago. So what happened? It may be a simple case of green turtles eating themselves out of house and home, but research by the BTP over the past five decades suggests that the explanation is much more complicated.

Seagrasses are in trouble worldwide because of everything from higher land-based nutrient inputs to increased levels of boat propeller damage, and in Bermuda, seagrasses have been in decline since at least the late 1990s. By 2010, the decline had accelerated, and seagrasses (primarily turtlegrass, *Thalassia testudinum*, preferred by green turtles) had all but disappeared from offshore flats and had become sparse in nearshore bays. Today, the remaining pastures exist in sheltered inshore bays and are largely composed of manatee and shoal grasses (*Syringodium filiforme* and *Halodule wrightii*, respectively).

A green turtle swims above seagrass, its primary food, with a remora in tow. © Serge Melesan

After millions of years of coexistence between green turtles and seagrasses, it is reasonable to expect that there are natural mechanisms in place that create balance between the grazers (turtles) and their primary food source (seagrasses). Indeed, the BTP's data suggest that the green turtles in Bermuda were responding to the seagrass decline long before it was detected by biologists. Nevertheless, some researchers have sought to explain the loss of seagrass as entirely caused by green turtle overgrazing. That simple top-down (predator-driven) explanation seems unlikely, because it ignores both the existence of natural mechanisms to balance predator and prey and the high likelihood of other impacts on Bermuda's seagrasses. In Australia, where seagrasses have also declined in areas with abundant green turtle populations, seagrass researchers have suggested that "synergistic stressors" from multiple threats are a more likely culprit for the declines. But what additional stressors might be at play in Bermuda?

Bermuda's marine environment is subject to multiple human impacts. The roughly 54 square kilometers of land (21 square miles) are home to one of the highest human population densities on earth (1,200 people per square kilometer). An estimated 44,000 vehicles travel the narrow roads adjacent to the ocean, and another 7,600 boats are anchored in small bays or narrow passages. Bermuda does not have a centralized sewerage system. Homes and businesses rely instead on a mixture of septic tanks built into the porous limestone rock, deep-sealed boreholes for larger discharges, and offshore sewage pipes. Domestic and commercial garbage has been incinerated since 1996, and the ash is incorporated into cement-infused blocks that have been used as a shoreline stabilization material. Consequently, Bermuda has high concentrations of anthropogenic contaminants and nutrient loads in its water.

Resolution of this crisis for Bermuda's green turtles will require a more comprehensive approach to understanding—and eventually reestablishing—Bermuda's marine ecosystems. We need to move past the green turtle overgrazing hypothesis as the primary reason for the collapse of the island's seagrass beds and closely examine the many other impacts that may be tipping the ecological balance. We recommend developing a multidisciplinary framework to identify all seagrass impacts, funding projects to study them, and then pursuing solutions to mitigate and minimize them. These problems are happening in other parts of the world as well, and what Bermuda's government officials, scientists, and conservation leaders do next could serve as a model to help other nations to manage their seagrass and coral reef habitats and, indeed, to manage the fate of all marine species. •

Lost Years Project
Yields Surprises about Eastern Pacific Hawksbills

By Felipe Vallejo and Cristina Miranda

All sea turtles hatch on a beach somewhere in the world and “run” as quickly as they can to the ocean before a predator can eat them. Then, they are lost. Lost, that is, to the researchers trying to study their lives, who generally will not see them again until they return as juveniles and subadults to their foraging areas several years later. That gap of time is called the *lost years* and has proven to be a challenging life stage to study. New technologies, in particular smaller acoustic and satellite tags, are making it easier for researchers to chip away at this mysterious sea turtle life stage. And as we’ve begun to uncover the lost years of hawksbills in the eastern Pacific, we’ve found surprises at every step of the way.

From Conversation to Collaboration

In 2016, at the 36th Annual Sea Turtle Symposium, in Lima, Peru, the two of us learned about the existence of new acoustic transmitters that were so tiny they could be attached to newly hatched sea turtles. The small transmitters allow researchers to follow the turtles during their first movements in the ocean. We also began a dialogue with the nonprofit organization Upwell, which had been using the transmitters to study baby leatherback turtles. That dialogue evolved into a multiyear, multicountry project to decipher the lost years of the critically endangered eastern Pacific hawksbill turtle, a project that has begun to bear fruit.

Hawksbills are one of the most endangered sea turtle species globally. The eastern Pacific population, in particular, was thought to be extinct until just over a decade ago. Around 2007, researchers throughout the eastern Pacific began to discover previously unknown hawksbill nesting activity in several places, particularly Ecuador, where we work; El Salvador; and Nicaragua. Our shared interest in this poorly known population led to the first regional meeting of what later became ICAPO, the Eastern Pacific Hawksbill Initiative, which managed to unite more than 70 people and organizations with one unique objective: to bring the hawksbill back from the brink of extinction in the eastern Pacific region.

At that time, our organization, Equilibrio Azul, was doing what most sea turtle conservation organizations start off doing: nesting beach research and conservation. That is where organizations typically begin because it is both easier and cheaper to work on land, when nesting females come out of the water to nest, than it is to study and protect turtles at sea. But after more than a decade of nesting beach research and protection, we decided to embark on a new and more complicated challenge: our Lost Years Project.

Following Baby Turtles, Rain or Shine

After attaching acoustic transmitters made by Vemco/Innovasea that weigh less than 2 grams to the carapaces of hatchlings using tiny Velcro patches (a method developed by Upwell), we rowed our inflatable boat following 52 hawksbill hatchlings right after they left the beach. During two nesting seasons, we spent 12-hour days under the blazing hot sun and tropical rain, following along behind these beautiful babies. Our goal was to map their first swims and understand how they disperse from La Playita (inside Machalilla National Park, Manabí, Ecuador), our most important index nesting beach, where hawksbills lay an average of 30 nests per year.

At the same time, we placed drifters in the ocean to track the local ocean currents and compare their movements with those of the hatchlings. The individual turtle tracks that we were able to record through that work lasted from two to eight hours, and they represented movements ranging from only a few meters to as much as 2 kilometers (1.2 miles) from the original release site. As we tracked more individuals, we came face to

To learn where newly hatched hawksbill turtles travel, researchers in Ecuador fitted hatchlings with acoustic transmitters and followed them to record their movements. © Equilibrio Azul; **AT LEFT:** The availability of smaller satellite tags enabled new research on neonate hawksbill turtles in Ecuador, yielding surprises about the turtles' lost years. © Equilibrio Azul

face with our first surprise: The hatchlings were actively swimming with a defined and similar bearing, not simply being carried by the currents as we had expected.

Another coincidence, or just a stroke of plain luck, took place soon after. About 10 months earlier, while excavating two nests at La Playita, we had a few hatchlings in the nest that were too weak to get to the ocean. Because this population of hawksbills is so endangered, we took them to the local marine life rehabilitation center to grow and gain strength. While still rowing behind the final hatchlings from our first phase, we learned that those turtles were still at the rehabilitation center, yet to be released. Though they were now neonates and larger than the hatchlings we were studying, we assumed that they were still too small to equip with satellite transmitters. But as it turned out, newly developed satellite tags by Wildlife Computers could indeed be fitted to those young hawksbills. And unlike the acoustic transmitters we were using, the satellite transmitters would not require us to follow along in a boat to receive their transmissions, meaning that we could track the young turtles for much longer and farther than we were previously able.

Tiny Satellite Tags Unlock New Knowledge

We have now attached a total of six small satellite transmitters to neonate hawksbills (less than a year old), and the surprises keep coming. Judging from what we had already learned from tracking adult female hawksbills, we assumed that this population did not travel far, staying close to their breeding grounds even when not reproducing. But these turtles have shown us that just when you think you may know the whole picture, nature can still surprise you.

As soon as the satellite-tagged neonates were released (from the furthest location that the hatchlings took us), they gathered a bearing and began swimming north following the coast of South America. One of them, Julián, visited the waters of four countries—Ecuador, Colombia, Panama, and Costa Rica—traveling more than 2,000 kilometers (1,240 miles) and debunking our belief that these animals don't travel far. Moreover, previous genetic analysis had determined that the Ecuadorian hawksbill population does not mix with the populations up north, so the movements of these animals into waters shared with other populations has opened new questions for us to explore.

Collaborations Expand beyond Ecuador

As we began to share news about the preliminary results of our Lost Years Project, we were contacted by a team at ProCosta and ICAPO in El Salvador that was interested in undertaking similar research. So we traveled to El Salvador to beautiful Bahía de Jiquilisco—the place that likely receives the most hawksbill nests annually in the eastern Pacific. There we helped launch a similar project that is studying the dispersal and migrations of neonate hawksbills in that part of Central America, where a different ecosystem—mangrove estuaries—has begun to yield even more surprises.

Studies of the hawksbill's lost years are still ongoing in both Ecuador and El Salvador and have involved participation or sponsorship by Equilibrio Azul, Upwell, ICAPO, ProCosta, NOAA (the National Oceanic and Atmospheric Administration), Wild Earth Allies, the National Fish and Wildlife Foundation, Machalilla National Park, and the Ministry of Environment of Ecuador. We are preparing to publish our findings soon and look forward to sharing more complete results. In the meantime, one thing is certain: Eastern Pacific hawksbills will continue to surprise us every step of the way. •

New Network Tackles Turtle Strandings in Bali, Indonesia

By Pande Ketut Cahya Krisnanta Arioka and Rodney Westerlaken

A dead sea turtle on Kuta Beach, Bali, Indonesia, that was killed by a boat propeller. A new network in Bali aims to collect, centralize, and share data on dead stranded turtles. © Wolfgang

Strandings of sea turtles have been an enduring concern in Bali, Indonesia, where three species regularly occur offshore: green, hawksbill, and olive ridley. Although strandings of live turtles are addressed by a well-established rescue and recovery network consisting of government and nongovernment representatives, the same cannot be said for strandings of dead turtles, which often go unrecorded. However, such strandings can provide valuable insights into the threats that sea turtles face.

Recognizing the importance of this issue, Yayasan Bali Bersih established a network in January 2021 to facilitate collecting and reporting data about stranded dead turtles. The network was established in collaboration with daily beach-cleaning authorities (traditionally responsible for burying stranded turtles), local communities, and prominent social media platforms. Additionally, the network's marine team proactively monitors social media hashtags to identify instances of turtle strandings. This initiative aims to centralize data that will identify stranding hotspots, educate the general public, and improve policies for recording such strandings throughout Bali.

The network has already begun to yield intriguing data. In 2021, 38 dead turtles were reported, mostly on South Bali beaches (see map). That number dropped to just 7 in 2022, and only 10 strandings were reported through October 2023. The stranded turtles have been primarily greens (24) and olive ridleys (20), plus a few hawksbills (6). Six other animals were too decayed to be identified. The year-by-year drop in numbers could be a positive sign, but it is too soon to tell. With a longer-term dataset, such fluctuations could help pinpoint causes of mortality or verify the success of conservation measures.

Unfortunately, necropsies could only be performed on a few carcasses because of their poor condition, meaning that the causes of death remain largely unknown. The occurrence of stranded turtles appears to increase during the extreme weather associated with the rainy season. During that time of year there is also an influx of marine debris, including wood and plastic waste, and in some cases, plastic waste has been found in the mouths or digestive systems of turtles during necropsies and may be a cause of mortality.

As a strategy to improve the effectiveness of the stranding network's efforts to document, reduce, and respond, the following actions have been suggested:

- Expand Bali's stranding reporting network by partnering with local communities, governmental organizations, and nongovernmental organizations for better awareness and faster reporting.
- In stranding hotspots, create rapid response teams composed of trained individuals with necessary resources for rescuing live turtles and recovering deceased ones.
- Perform comprehensive necropsies on examinable turtles using standardized data collection for species, size, location, and stranding causes.
- Collaborate with research institutions to improve understanding of ecological factors contributing to strandings, and conduct scientific research on sea turtle health and behavior.
- Implement educational programs and outreach in stranding hotspots to encourage community involvement in rescue efforts and promote responsibility and empathy. Strengthen efforts to reduce marine pollution in Bali's waters, including community cleanup initiatives and stricter waste disposal regulations.

By implementing those measures, we can foster a more sustainable coexistence between humans and these magnificent marine creatures in Bali. At the same time, we can also contribute to the broader scientific understanding of sea turtle threats and provide a call to action for conservation efforts in the region. For more details, please visit www.westerlakenfoundation.org/publications and www.westerlakenfoundation.org/turtle-stranding-database. ●

Map showing locations (red dots) and species of stranded turtles recorded in Bali, Indonesia, from 2021 to 2023. White borders indicate regency boundaries. Source: Yayasan Bali Bersih

Extinction Avoided—Now What?

By Carlos Delgado-Trejo and Cutzi Bedolla-Ochoa

Studies of the eastern Pacific green, or black, turtle (*Chelonia mydas*, known locally as *tortuga negra*) that began in the 1960s estimated that there were some 25,000 nesting females in the Mexican state of Michoacán. Those studies used nest counts along some 80 kilometers (50 miles) of coastline and several important nesting beaches such as La Llorona, Motín del Oro, Xicuaza, Maruata, Maruata Viejo, Paso de Noria, Cachán de Echeverría, Arenas Blancas, and Chocola. The early studies suggested that turtle numbers were in decline because of the near-industrial-scale overconsumption of eggs and adults that supported burgeoning local and regional markets. Thus, a broad-based conservation program was recommended to save the black turtle from extinction. That effort has now been under way for decades and is led by Mexican authorities with support from a number of international backers.

According to the most basic of metrics (the numbers of nesting females), Michoacán's black turtle conservation program is an undeniable success (see *SWOT Report*, vol. XIII, pp. 44–45). In the most recent breeding season, fully 86,000 black turtle nests were recorded at Colola Beach between August 2021 and April 2022, representing roughly 28,000 nesting females. That number is nearly the estimate for 1965's total population for all of Michoacán, but *at a single beach*! And if one considers the entire state, this number increases to at least 104,000 nests (or approximately 35,000 females).

Moreover, now that long-term studies have shown an average remigration interval of three years, we can estimate the total number of Michoacán black turtle females at around 105,000, a near quadrupling of the estimated abundance since 1965. Indeed, the recovery of the black turtle throughout the Mexican Pacific is noteworthy, and significant increases in nesting have also occurred in the neighboring states of Guerrero, Jalisco, Nayarit, and Oaxaca (at Palmarito Beach).

As has been reported for Florida and Hawaii (USA), Galápagos (Ecuador), and other sites around the world where sea turtle populations appear to be recovering, Mexico's black turtle rebound is the result of steady and continuous conservation efforts by national and international organizations, indigenous communities, academics, students, and volunteers, who have collaborated synergistically on this arduous task for more than 50 years.

How Many Turtles Are Enough?

Although numbers of turtles are an obvious and often-used metric, they are but one of many approaches that must considered when one contemplates long-term sustainability. For the many people and projects worldwide that are dedicated to biodiversity conservation and that have seen successes of this nature, especially with sea turtles, a question resounds: What is the next step? Since the 1960s, we conservationists have rallied to prevent the extinction of the black turtle, and now—in some places at least—we appear to have achieved and surpassed that worthy goal. Barring some unforeseen cataclysm, and if we continue what we have been doing, trends indicate that extinction has been avoided and that turtle numbers should continue to rise.

But how many turtles are enough? For instance, the increase in black turtle abundance is undeniable and evident to the people who live in coastal Michoacán, many of whom recall hunting, selling, or consuming turtles for food in their youth, and many of whom are still faced with the challenges of poverty and hunger—problems that sea turtle harvesting could potentially alleviate.

Understandably, some people are thinking that it may be time to change the laws, to question the authorities who protect turtles, and to return to the old paradigm of utilization. But even if harvesting could be demonstrated to be scientifically sustainable (there are presently no data to support this concept), it would still be very hard—and potentially very damaging—to turn a decades-old "protection" mindset back into a "use" mindset. Furthermore, were the use of sea turtles to become commonplace once again, how would we avoid repeating the scenario that brought these animals to the brink of extinction 50 years ago?

Nonextractive Use

For the moment, we are not prepared to give an answer about returning to a paradigm of consumptive use of sea turtles, nor would such a return even be legal without significant changes to Mexican policy that are highly unlikely and certainly slow. It does not make sense to cease protection or to slow recovery efforts

that have been underway for decades. But what we can and should do is to support efforts to generate local income, jobs, interest, and conservation attention through nonextractive uses of sea turtles.

Well-managed ecotourism is one such alternative that can generate local jobs and revenue while simultaneously creating an incentive to protect turtles by turning them into a "goose that lays golden eggs" and hence likewise creating an incentive to protect them at all costs. In the case of the black turtle in Michoacán, tourism can help local livelihoods and is gradually becoming a necessary alternative source of financing for conservation activities.

Such alternative funding sources are needed because international support is drying up as the urgency of black turtle extinction has diminished and may be arguably absent in the foreseeable future. Other innovative financial schemes are worth considering, such as "payment for ecosystem services" initiatives, which would produce higher income by using living turtles rather than harvested turtles and would ensure that revenues revert to local communities that are on the front lines of such turtle protection.

ABOVE: An eastern Pacific green (or black) turtle returns to sea after nesting at Colola Beach, Michoacán, Mexico. The innumerable tracks that mark the sand are evidence of this population's impressive recovery. © Carlos Delgado-Trejo

Ways to Design Conservation at a Generational Scale

During the restoration process of sea turtle populations, the design of self-sustaining, generation-scale strategies must become more commonplace. It is important to plan for the long term and to avoid the traditional boom and bust of conservation investment; investment is usually high when extinction is high or threats are acute, and planning disappears when the urgency diminishes. Just because populations have recovered does not mean that all threats have been ruled out. Effective beach protection ensures that some threats have been removed or significantly reduced, thereby allowing population growth through recruitment of hatchlings and protection of adults in nesting and feeding areas. But other threats continue, and new ones can always emerge or old ones reemerge.

Social changes can at some point favor biodiversity conservation but can later work against it, especially if the perception of abundance encourages exploitation—as has happened in the past. In addition, when the analyses of abundance and recovery of a species such as the black turtle is used to design ongoing management strategies, it is equally important to undertake an in-depth socioeconomic analysis of the human environment in which the animal is immersed. Humans must not be left out of conservation planning for the long term. •

Addressing Hawksbill Turtle Trade
IN THE ASIA-PACIFIC REGION

By Heidrun Frisch-Nwakanma and Christine Madden

Critically endangered hawksbill turtles, famed and exploited for their beautiful carapaces, have experienced severe declines over the past century. Although protected in many countries by bans on international trade in the species and its products, hawksbill turtles continue to be taken for their meat, eggs, and carapaces for commercial purposes, subsistence, or cultural practices.

The hawksbill's dire conservation status in Southeast Asia and the western Pacific requires concerted action, which the World Wide Fund for Nature (WWF) and University of the Sunshine Coast have sought to facilitate in partnership with the Convention on the Conservation of Migratory Species of Wild Animals (CMS) and the Indian Ocean–South-East Asian Marine Turtle Memorandum of Understanding (IOSEA Marine Turtle MoU).

Shedding Light on Hawksbill Status

Two assessments of hawksbill status were published in 2022 and 2023, one covering the Indian Ocean and Southeast Asia region and the other describing the situation in the western Pacific Ocean region.

Those publications highlight some success stories, and indeed a small number of hawksbill rookeries are showing a positive trajectory. However, many rookeries still have low nesting numbers, with populations that are decreasing or heading toward extirpation. The assessments also underscore the numerous known threats to the species, such as consumptive use, predators, climate change, coastal development, fisheries, and entanglement in discarded fishing gear, each summarized for the genetically distinct populations (genetic stocks or management units).

As with most migratory species, conservation of hawksbills is challenging because of their cross-border distribution and long-lived nature. Conservation is further complicated by gaps in scientific knowledge—including about their genetic stock structure, the distribution of foraging grounds, and hatchling sex ratios—which are recommended as areas for future research.

Understanding Use and Trade

The aforementioned assessments—along with other recent publications, including reports about the status and trend of marine turtle use and trade published by TRAFFIC in November 2022 and May 2023—all confirm that the Asia-Pacific region is the epicenter of exploitation and trade in marine turtles. Those documents report that from 2015 to 2019, more than 1,800 live and 1,200 dead turtles, 1,900 shell pieces and items of jewelry, thousands of kilograms of meat, and tens of thousands of eggs were intercepted and seized by authorities in Indonesia, Malaysia, and Vietnam alone. And from 2003 to 2021, in the Sulu-Celebes Seas, marine turtles were the only species in the top five for every metric of marine species seizures, whether as individuals, by volume, as parts, or by number of incidents. And those numbers represent just the tip of the iceberg.

Besides getting a grip on the numbers of turtles taken, we also need to understand the drivers and motivations of sea turtle use and trade among local fishers and community members. WWF is currently rolling out the Turtle Use Project across the Asia-Pacific region, with the aim of scaling it up globally. The program will provide insights into the levels of take by small-scale fisheries and community-level harvests, helping researchers to determine areas that may require nature-based solutions or sustainable development projects to reduce use. One such area may be the Solomon Islands, where an estimated 11,200 marine turtles are harvested by small-scale fisheries annually, with a quarter of those being hawksbills. These recent numbers are at least six times greater than those from previous studies.

Connecting the Dots with ShellBank

One of the greatest challenges to tackling unsustainable take and trade of sea turtles is understanding which populations are being targeted and at what stage of their lives. A recently launched resource called ShellBank helps connect the dots by matching the DNA of a seized turtle part or product—such as turtle meat, eggs, or tortoiseshell trinkets—with a reference database of genetic data collected from nesting, foraging, bycaught, and stranded turtles. By capturing the unique DNA signatures of each nesting and foraging population, ShellBank allows comparisons to DNA extracted from seized items, thereby making it possible to identify poaching hotspots and turtle populations most at risk.

By matching DNA from seized turtle parts or products, like these items made of hawksbill shell, with a reference database, ShellBank aims to identify poaching hotspots. © Hal Brindley/travel4wildlife.com. **LEFT** Hawksbill turtles have been exploited for their beautiful shells for centuries, leaving them critically endangered. © Mat Williams/@Rokit

Addressing Trade through Policy Actions

With the goal "to address unsustainable use and trade of hawksbill turtles in the South-East Asia and Western Pacific Ocean region and build resilience in the populations," several Southeast Asian countries agreed on a Single Species Action Plan (SSAP) in June 2022. Cambodia, Myanmar, the Philippines, and Vietnam have already adopted the SSAP, and more countries will likely follow suit when the SSAP is considered for adoption at upcoming meetings of CMS and the IOSEA Marine Turtle MoU. The SSAP outlines 23 actions at both the domestic and international levels and provides a framework to assist governments in implementing their commitments to relevant policy forums—including CMS and the MoU, CITES (the Convention on International Trade in Endangered Species of Wild Fauna and Flora), and regional initiatives and fisheries bodies—in a cohesive way to ensure effective conservation of hawksbill turtles.

The SSAP has three key objectives, which take into account the complex links between community and commercial use:

1. Review and, where necessary, improve legislation, policy, compliance, and enforcement of hawksbill turtle take, use, and trade by 2025.
2. Increase action and improve accountability to further monitor and report on hawksbill take, use, and trade nationally, and cooperate regionally to exchange data, share intelligence, and strengthen collaborations.
3. Further research that evaluates the level of impact that trade and fishery activities have on hawksbill populations and deliver on-the-ground implementation projects by 2027.

Although critical gaps remain in our knowledge of hawksbill turtle trade, we must act now, before it is too late. Areas for further research have been identified, and action plans are in place. Now we need to mobilize the resources and political will to safeguard and recover hawksbills in this region for generations to come. •

Returning to Home Shores and Traditions in the Maldives

By Enas Mohamed Riyaz (Tonti), Isha Afeef, and Ibrahim Inaan

There is a long-standing and deeply entwined relationship between the people and sea turtles of the Maldives. The archipelago is home to five species of sea turtles, the most common of which are greens and hawksbills. Their images can be found emblazoned on the Maldives' currency, stamps, and historical artifacts, and turtles are present in cultural songs and folk tales. The historical relationship between Maldivians and turtles is also one of consumption—initially through egg harvest and then through subsistence hunting for meat—and eventually that grew into commercial trade with the advent of tourism in the 1970s.

The hunting of sea turtles and harvest of their eggs continues to this day despite that it is now illegal, and sea turtle habitats are also threatened by ongoing development in a land-scarce country. As pressures on sea turtles in the Maldives increase, a historical model of conservation has also begun to reemerge—one that relies on local-scale stewardship.

The Story of Gaadhoo

The most significant green turtle nesting site in the Maldives is a 500-meter (1,640-foot) strip of beach known as *velaa heylhi* on the island of Gaadhoo. During the 1900s, the beach hosted as many as 1,400 nests annually, and island community members acted as custodians of the beach. Using indigenous knowledge of sea turtle reproduction and habitats, the island office systematically managed the turtle nesting beach by selectively harvesting eggs to generate revenue for community development. Everyone in the community participated in, and benefited from, that unique system of managing and sustainably harvesting sea turtle eggs, and community members actively defended nesting turtles from hunters. Unfortunately, that symbiotic system was not to last.

A former resident of Gaadhoo, Maldives, in the Gaadhoo mangroves. A return to traditional conservation approaches is helping study and protect Gaadhoo's turtle population. © Andy Ball

The ban on sea turtle egg harvesting imposed by the central government in 2006 unintentionally disempowered the community, which, without access to the eggs, could no longer manage the beach using its traditional methods. Yet without a tangible system in place for the government to enforce the ban, the illegal take of nesting turtles and eggs increased uncontrollably. Sadly, by the time the residents of the island were relocated to a nearby island in 2016, nesting had reportedly declined by 40 percent or more. Gaadhoo remains the only known island in the Maldives to have protected a nesting beach long before state-implemented conservation policies required it.

National Protection of Sea Turtles in Maldives

Despite the 2016 designation of sea turtles as protected species in Maldives, changing people's attitudes and behaviors around conservation remains a challenge. Because of the geographically dispersed nature of this island nation, implementing legislation at the local level has proven to be difficult and is hindered by a top-down approach that fails to incorporate community-based conservation models. Additionally, the sea turtle conservation work being done at the community level by councils or locally based NGOs (nongovernmental organizations) is often underrepresented because of financial restrictions or lack of access.

An aerial view of Gaadhoo and its seagrass meadows. © Leanna Crowley

Apart from the government-backed law enforcement and protection of sea turtle habitats, the types of sea turtle conservation projects in the Maldives that receive the majority of recognition are those based in the country's numerous tourist resorts. Isolated from local communities, these efforts largely engage with tourists through activities focused on seeing sea turtle hatching events or on up-close rescue and rehabilitation of adult turtles. That isolation has created a negative bias against sea turtle conservation among local communities, because those efforts are widely viewed as a profitable colonialist venture catering to Western conservation principles and benefiting only the tourism industry.

Returning to Traditional Conservation Practices

The importance of community-based conservation models is now recognized at the policy level by the Maldives Ministry of Environment. Hence, the Environmental Protection Agency of Maldives and the Olive Ridley Project have been collaborating to launch a community-based sea turtle conservation project in Laamu Atoll, where Gaadhoo is. Since January 2022, the team has been working with the local government, atoll-based NGOs, and other key stakeholders, including a local sea turtle "ranger" hired from the atoll, to monitor Gaadhoo's nesting beach. The community—including former residents of Gaadhoo—has shown incredible willingness to take ownership of the project. Efforts are currently under way with atoll-based NGOs to provide capacity-building and financial opportunities for the work. The preliminary findings are hopeful, with a clear indication that poaching activities have decreased, likely because of the consistent monitoring of the nesting beach by the ranger, who works alongside agricultural workers who also reside on the atoll.

Indigenous methods are also being incorporated into the management plan for the nesting beach, which was designated as a National Protected Area in 2021. There are plans to replicate this model of empowering local communities in conservation science and management in other nesting beaches in the country. After many years lost at sea, we are finally remigrating back to local shores and traditional techniques for conservation stewardship. •

SEA TURTLES OF Southeast Asia

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A REGION OF REMARKABLE DIVERSITY

Southeast Asia is a cradle of evolution, home to globally outstanding levels of biodiversity. Terrestrially, there are three biodiversity hotspots within Southeast Asia—the Philippines, Indo-Burma, and Sundaland—as well as a portion of the major wilderness area of New Guinea and three megadiversity countries (Indonesia, Malaysia, and the Philippines). From a marine perspective, Southeast Asia's underwater realm is the undisputed global epicenter of biological diversity. The Coral Triangle—a zone roughly demarcated by the triangle formed between Indonesia, Melanesia, and the Philippines—encompasses a large swath of Southeast Asian waters that are home to unfathomable numbers of species, including 75 percent of the world's coral species.

From a human standpoint, Southeast Asia's cultural diversity is equally rich, represented by a kaleidoscope of ethnicities, languages, and traditions that have flourished since the arrival of humans more than 70,000 years ago. Today the region is home to more than 675 million people from 10 nations. And though the region grapples with challenges like high population densities, wealth disparities, and climate change impacts, the countries of Southeast Asia strive to maintain a delicate balance between tradition, culture, human activities, and the natural environment both on land and at sea.

A TENUOUS STRONGHOLD FOR SEA TURTLES

Six of the planet's seven sea turtle species are found along the coasts and in the adjacent waters of the countries of Brunei, Cambodia, Indonesia, Malaysia, Myanmar, the Philippines, Singapore, Thailand, Timor-Leste, and Vietnam (see maps, pp. 30–31). Five sea turtle regional management units (RMUs, or subpopulations) lie almost fully within the region, including one RMU each for the green turtle, hawksbill, and olive ridley, and two RMUs for the leatherback. In addition, parts of the ranges of four more RMUs (two for the green turtle, two for the hawksbill) occur in the region.

Green turtles are the most prevalent Southeast Asian species, followed by hawksbills, olive ridleys, and leatherbacks (see maps, pp. 30–31). Loggerheads also are reported sporadically in Malaysia, Myanmar, Thailand, Timor-Leste, and Vietnam, though the species no longer nests in the region. Even the flatback, an Australian endemic, occasionally wanders into Southeast Asian waters.

The region's sea turtles have confronted an array of threats over the years, which have left many rookeries in a depleted state and others extinct, or nearly so. In contrast, some populations are stable or rising thanks to effective conservation measures. Conservationists must continue to work hard to slow and reverse the impacts of egg harvest, direct take, pollution, habitat alteration, and climate change, and to confront the severe and immediate dangers posed by fishery bycatch.

A hawksbill swims over Tubbataha Reef in the Philippines. Hawksbills are still prevalent in Southeast Asia, though many populations have declined significantly. © David Fleetham/Alamy Stock Photo; PREVIOUS SPREAD: Green turtles at a cleaning station near Sipadan Island, Sabah, Malaysia. Southeast Asia is home to the world's most diverse coral reef ecosystems and six of the planet's seven sea turtle species. © Jason Isley/Scubazoo

Countries of the Region

From a sea turtle's perspective, Southeast Asia is a maze of tens of thousands of islands, large and small, spread across millions of square miles of sea and bounded by the immense Indian Ocean to the south and west and the vast Pacific to the east. What these reptiles cannot see are the human-made borders of more than a dozen countries and the delineations of numerous seas wherein cultural, economic, and legal differences shape their fate. Instead, they are guided by their senses and a deeply embedded cellular awareness of which beaches possess the proper conditions for nesting, and where to find food and shelter among the region's innumerable coral reefs, seagrass pastures, and mangrove forests and the open ocean expanses between them.

From a sea turtle's perspective, Southeast Asia is a maze of tens of thousands of islands, large and small, spread across millions of square miles of sea and bounded by the immense Indian Ocean to the south and west and the vast Pacific to the east.

BRUNEI DARUSSALAM

Brunei has a short 161-kilometer (100-mile) coastline in north Borneo that is the site of the only substantial rookery of olive ridley turtles on the island, with a nesting season that coincides with the northeast monsoon (November–June). Although the adjacent Malaysian states of Sarawak and Sabah are dominated by greens and hawksbills and receive only infrequent olive ridleys, Brunei exhibits the reverse, with mostly olive ridleys and only a small number of nesting greens and hawksbills. There was little in the way of sea turtle conservation and management in Brunei until the early 1990s, when the Departments of Fisheries and Museums began artificially incubating eggs to improve hatchling production and reverse dwindling turtle numbers. The first two years of the program yielded just 107 eggs and 67 hatchlings, but by 2002–2003 those numbers had increased to 4,215 eggs incubated (3,986 olive ridley, 229 hawksbill) yielding 3,562 hatchlings released into the wild and others held for head-starting prior to liberation. The current government strategy, led by a National Sea Turtle Management and Conservation Committee, aims to increase the numbers of hatchlings and pursue public outreach, especially to schoolchildren.

CAMBODIA

Cambodia's relatively short 443-kilometer (275-mile) coast and adjacent seas support a rich abundance of marine life that once included olive ridley, hawksbill, loggerhead, green, and leatherback turtles, though only green and hawksbill turtles have been seen in the past decade. Juveniles are reported foraging in nearshore seagrass pastures and are frequently caught by fishers both incidentally and as direct take. These young animals show high site fidelity in these habitats, then move to other locations as adults, making Cambodian waters an important developmental habitat for Gulf of Thailand turtles. Some nesting is also known to occur on the country's islands.

Evidence suggests that sea turtles are in decline in Cambodia due to bycatch, direct take, habitat degradation, and coastal development. The widespread use of trawling and push nets is of particular concern, because such nets are deployed in seagrass foraging habitats. Recent surveys conducted by Fauna & Flora International (FFI) estimated that in more than 800 bycatch incidents, some 491 animals were released, 199 were sold, and 92 were consumed by fishers. Meanwhile, egg harvesting now appears to be minimal in Cambodia.

Numerous government agencies, nongovernmental organizations (NGOs), and communities manage Cambodia's sea turtle conservation efforts, focusing on different themes and locations. At the national level, a key milestone was the development of the Action Plan for the Protection of Sea Turtles in Cambodia (2016–2026) by the Fisheries Administration with the support of FFI. A national database for sea turtle sightings and information on nesting and bycatch has also been developed and is being used to inform national policies.

At the remote islands of Koh Tang, Poulo Wai, and Koh Pring, southwest of Preah Sihanouk Province, nesting is monitored by FFI and the Royal Cambodian Navy, and every four years bycatch assessments are conducted at key landing sites to measure the size and nature of the turtle trade. Those surveys found that fishers were not aware of national regulations, so a broad outreach and information campaign was launched.

Historical records suggest that nesting once spanned Cambodia's coasts and islands, yet records in recent decades are few. The rediscovery of turtle nesting on Cambodian beaches in 2021 after a decade-long search resulted from a lucky find by FFI staff members who spotted hatchlings on the remote island of Poulo Wai. That sighting led to surveys that found additional signs of turtle nesting in 2022 and 2023, when volunteers on Koh Pring witnessed five possible and four confirmed clutches. Subsequent excavations showed a high hatch rate.

The coastal provinces of Kampot and Kep harbor coral reefs and the largest seagrass meadows in the Gulf of Thailand. Those systems provide foraging and resting habitat for green and hawksbill turtles, especially juveniles. In that region, rates of bycatch, intentional capture, and meat consumption are among the highest in Cambodia. The Kampot–Kep region also faces acute pressures from coastal development and illegal fishing practices, including bottom trawling.

On Cambodia's southwest coast, the Fisheries Administration collaborates with Wild Earth Allies, Marine Conservation

Cambodia, and others to use a spatial management approach that assigns territorial rights to communities, and establishes and manages marine protected areas. A network of 10 communities now protects sea turtles and their habitats, monitors fisheries, and implements bycatch responses. This work has improved reporting and increased the safe release of incidentally captured sea turtles.

INDONESIA

A vast country of some 18,000 islands, Indonesia has a coastline of 99,083 kilometers (61,567 miles), among the largest on Earth; Indonesia faces both the Pacific and Indian Oceans, as well as numerous local and regional seas. Its waters are home to six species of sea turtles, and its beaches host nesting grounds for four of them (leatherback, hawksbill, green turtle, and olive ridley). Turtle nesting is widespread, though many islands are uninhabited and unmonitored, so it is difficult to obtain a full picture of sea turtle abundance in the country. Many rookeries were assessed in the 1970s and 1980s but have not been monitored since, or updates are not available. Plus, new rookeries are still being found thanks to the rapid growth of local nonprofits, community groups, dive shops, and other institutions that generate citizen science.

All sea turtle species are legally protected in Indonesia, though illegal consumption of eggs, meat, and turtle shell still occurs in many areas. Bali was once famous for its massive turtle market, but harvest is now banned there and the open market shut down in the early 2000s (see sidebar). Historically, Indonesia was also the largest commercial exporter of tortoiseshell, with an estimated 2.5 million hawksbills exported between the mid-1800s and 1990s. Though illegal since 1978, trade in sea turtles remains prevalent in the country and even online (see pp. 18–19). Traditional hunting of leatherbacks for food still occurs in the Kei Islands as well (discussed later). Fishery bycatch and bomb fishing also cause widespread impacts on Indonesia's turtles, and researchers even report the use of sea turtle viscera as bait in shark fisheries.

The Bird's Head Peninsula of the Indonesian province of West Papua is where approximately 75 percent of all western Pacific leatherback nesting occurs, at two main beaches: Jeen Yessa (formerly Jamursba Medi; 18 kilometers, or 11 miles) and Jeen Syuab (formerly Wermon; 6 kilometers, about 4 miles). These beaches also host nesting olive ridleys, greens, and hawksbills. The Indonesian Ministry of Marine Affairs and Fisheries created the Jeen Womom Coastal Park to protect these two nesting sites. The area once hosted 3,000–13,000 leatherback, 5,000–6,500 hawksbill, and 4,000–5,000 green turtle nests annually, but large-scale egg collection from the 1970s to 1990s, as well as fisheries bycatch, caused the populations to decline. Leatherback nesting has dropped by nearly 6 percent per year since the 1980s, and the statuses of other turtle species are still being

Bedawang Nala and the Bali Turtle Market

By Ketut Sarjana Putra

The Indonesian island of Bali has been a thriving tourist destination for half a century or more, attracting international visitors to enjoy its beautiful beaches and forests and to appreciate its rich cultural diversity. Over time Bali has increasingly become a hopping-off point for scuba divers, surfers, and ecotourists who are interested in experiencing Indonesia's vast wealth of species and ecosystems. The fact that the island was also the epicenter of green turtle harvest—and the site of what was arguably the world's largest unconcealed green turtle market from the 1960s to the early 2000s—was a sad and stark juxtaposition. The Bali green turtle market had long been justified as both a key part of Bali's cultural and religious traditions and an important economic driver among the region's fishers.

Records show that at least 35,000 green turtles were landed and sold there annually, originating from many of Southeast Asia's largest green turtle rookeries and key feeding areas in the Arafura Sea; the Raja Ampat Archipelago of West Papua; and the islands of Borneo, Java, Nusa Tenggara, and Sulawesi. In addition to green turtles, mostly consumed for their meat and oil, a large number of hawksbills also entered the Bali market and from there became part of the larger international tortoiseshell trade. The massive harvest of green turtles destined for the Bali market drove measurable downturns in nesting turtle populations throughout Indonesia.

Bold efforts spearheaded by the Indonesian and Bali governments over a period of seven years (1995–2001) introduced new policies and regulations that effectively closed the Bali turtle market in the early 2000s. Those changes were accompanied by intensive and strategic education and awareness efforts led by conservation nongovernmental organizations and supported by public media, which emphasized the high volume of trade and the significant decline of green turtle nesting populations.

One of the keys to the success of the legal shutdown of the market, and of the black-market trade in turtles, came from the effective inclusion of Balinese Hindu communities and religious leaders, who came to embrace sea turtle conservation as important to the health of the environment and, ultimately, to the sociocultural and economic well-being of the Bali community. Once aware, the Hindu community fully stopped the trade in turtles and to this day continues to conduct community-based turtle conservation on nesting beaches that aims to reverse decades of turtle losses and "pay back the karma." One of the legendary turtle traders from the turtle market's heyday confessed, "I should have learned more and believed in the bedawang nala." The *bedawang nala* is the sea turtle statue that sits at the base of every Hindu temple to support its tie to Earth. It is a holy creature that must be fully preserved and respected, not just as a mythical deity, but as a living creature.

Researchers from the Anambas Foundation monitor a nesting green turtle in Indonesia's Anambas Islands. With more than 18,000 islands, Indonesia is home to innumerable sea turtle nesting sites, many of which are unmonitored. © Anambas Foundation

quantified. Egg collection is no longer a threat, but poor hatching success is thought to still impede the recovery of the population. Collaborative research between the State University of Papua and the U.S. National Oceanic and Atmospheric Administration's Southwest Fisheries Science Center identified the threats as nest predation by pigs, dogs, and monitor lizards; extreme sand temperatures; erosion; tidal inundation; and invasion of beach creeper (*Ipomoea spp.*).

Management measures have been implemented and continually refined since 2006 to maximize hatchling production at Jeen Womom. Since 2017, the State University of Papua's Abun Leatherback Project (ALP) has protected nests by targeting a combination of threats for each beach section by season. ALP then evaluates success to increase conservation activities' effectiveness in subsequent years. The Abun people own the two main nesting beaches, and ALP has worked with them to prohibit illegal take, ensure stable access to beach work, and maximize nest protection and hatchling production. ALP's workers live in the villages and support efforts to develop local livelihoods and build trust with the community.

Nearby, in the Raja Ampat Archipelago of West Papua, conservation efforts aimed at reducing take of green turtles have delivered mixed results. In an exchange facilitated by Conservation International Indonesia, Papuan leaders from the Ayau and Asia Islands met with Balinese turtle conservation groups and learned how the Balinese had stopped hunting turtles. The leaders developed a strategy that initially stopped hunting in the Ayau Islands, where 1,000 or more green turtles were harvested annually, and built an organic piggery to substitute farm-raised pork for turtle protein. One Papuan leader commented, "To continue killing sea turtles is like stealing our children's future." Sadly, when resources to support the effort disappeared and problems arose with the piggery, locals quickly reverted to turtle hunting. The Piai Island rookery, with 1,500–3,200 green turtle nests annually, was one of the target areas of the Ayau turtle hunters. It has been protected, but Ayau islanders are still known as the most adept turtle hunters in West Papua.

To the south, in the Kei Islands of Maluku Province, villagers continue the legal, traditional hunt of leatherback turtles. Since 2016, WWF-Indonesia has worked with hunters from several villages there, and with support from church leaders and fisheries agencies, it has carefully monitored take, which in 2017 reached 104 animals. In response, a multifaceted strategy was undertaken to set limits for the hunt, a program that has reduced the harvest significantly in its initial years.

Also in Maluku Province, WWF-Indonesia has led efforts to monitor and protect recently discovered leatherback nesting beaches on Buru Island since 2017. Of the average of 160 nests laid per year, more than 60 percent were being taken by people or other predators, and up to five nesting females per year were taken as food. New laws have now been enacted in Buru to prevent egg and turtle harvest, and a community-based conservation group (Pokmaswas), is working to create a marine protected area.

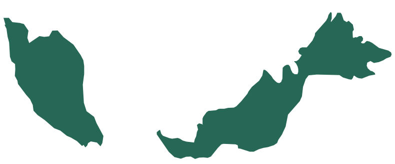
Further to the south, in the Alor Archipelago of East Nusa Tenggara Province, turtles are still relentlessly exploited and eggs are openly sold in markets. On the beach of the SAVU South Alor resort on Alor Island, hawksbill and green turtle nests are protected from September to December. The resort is spearheading awareness campaigns, as well as advocating for enhanced enforcement with local authorities.

In East Kalimantan, off the eastern coast of Borneo, the Berau or Derawan Archipelago hosts one of the largest green turtle nesting populations in all of Southeast Asia. Yayasan Penyu Indonesia and the Turtle Foundation estimate that an average of 15,000 clutches are laid annually in the archipelago, with most nesting occurring on the coral islands of Belambangan, Bilang-Bilangan, Mataha, Sambit, and Sangalaki. Historical data suggests that, due to massive and organized exploitation of eggs, this is only a remnant of a nesting population that was up to 10 times larger more than 70 years ago. In 2002, one of the islands, Sangalaki, was given year-round protection against egg collection, and in the following years, protection efforts were extended to the other islands. Today, several government agencies and nongovernmental organizations help to protect the nesting beaches, and the Derawan Archipelago has been declared a marine protected area.

The western Indonesian islands of Sumatra and Java and their offshore islands are home to numerous nesting sites and many local and international sea turtle research and conservation projects. The region primarily receives nesting green and hawksbill turtles, with at least one significant olive ridley nesting site, plus a small number of leatherbacks on the Indian Ocean coast. The Segama and Momperang Islands, north of Jakarta in the Java Sea, are another important stronghold for hawksbill turtles in Indonesia. Monitoring efforts in the Segama Islands led by Everlasting Nature of Asia (ELNA) and Yayasan Penyu Laut Indonesia (YPLI) have shown growth in nesting, from 100–150 clutches per year in 1996–1998 to more than 1,000 per year in 2016–2018. To the north, the islands of Pesemut and Momperang also host an estimated 915 hawksbill clutches per year (2016–2018) according to ELNA and YPLI.

On the Indian Ocean coast of Java, Alas Purwo National Park (East Java) hosts a robust population of olive ridleys, with 1,100 clutches reported in 2018, as well as consistent low-level leatherback nesting (5 clutches in 2016). The expansive beach is monitored and protected by park authorities. There, and in the offshore islands of Sumatra, green turtles and small numbers of leatherbacks also nest. Significant green turtle populations are found at Pangumbahan Beach in West Java and on Bangkaru Island in the Banyak Islands of Sumatra (Aceh), where approximately 2,000 clutches were recorded annually in 2022 and 2023. In 2017, leatherback nesting was also discovered off the west coast of Sumatra by Yayasan Penyu Indonesia and the Turtle Foundation, first on Sipora (Mentawai), and later on Selaut Besar and at Along Beach on Simeulue (Aceh), and high levels of poaching were observed. Protective efforts by local rangers and hatcheries are helping to reduce those pressures. Leatherback clutches on Selaut Besar Island (19) and Sipora Island (29) were reported in 2021–2022, along with green turtle and olive ridley nests.

MALAYSIA



Malaysia's 4,675 kilometers (2,905 miles) of coastline are spread across both sides of the peninsula, which shares a land border with Thailand and maritime borders with Indonesia, Singapore, Thailand, and Vietnam, and continue in the east across the South China Sea on the island of Borneo. There, the Malaysian states of Sabah and Sarawak share a land border with Indonesia to their south (Kalimantan) and with the

Sea Turtle Biogeography of Southeast Asia

The maps on pp. 30–31 display available nesting and satellite telemetry data for sea turtles in Southeast Asia. Because the Andaman and Nicobar Islands are biogeographically part of the Southeast Asian region (see sidebar, p. 37), they were also included in these maps. The data include 642 nesting sites and 234 satellite tags representing greens, hawksbills, leatherbacks, and olive ridleys (note that historical records of loggerhead nesting in the region exist, but recent nesting could not be confirmed, so they were excluded from the maps). Data were compiled through a literature review or were provided directly to SWOT by hundreds of data contributors. For metadata and information about data sources, see the data citations on pp. 54–57 or visit https://www.seaturtlestatus.org/maps/southeast-asia-sea-turtles.

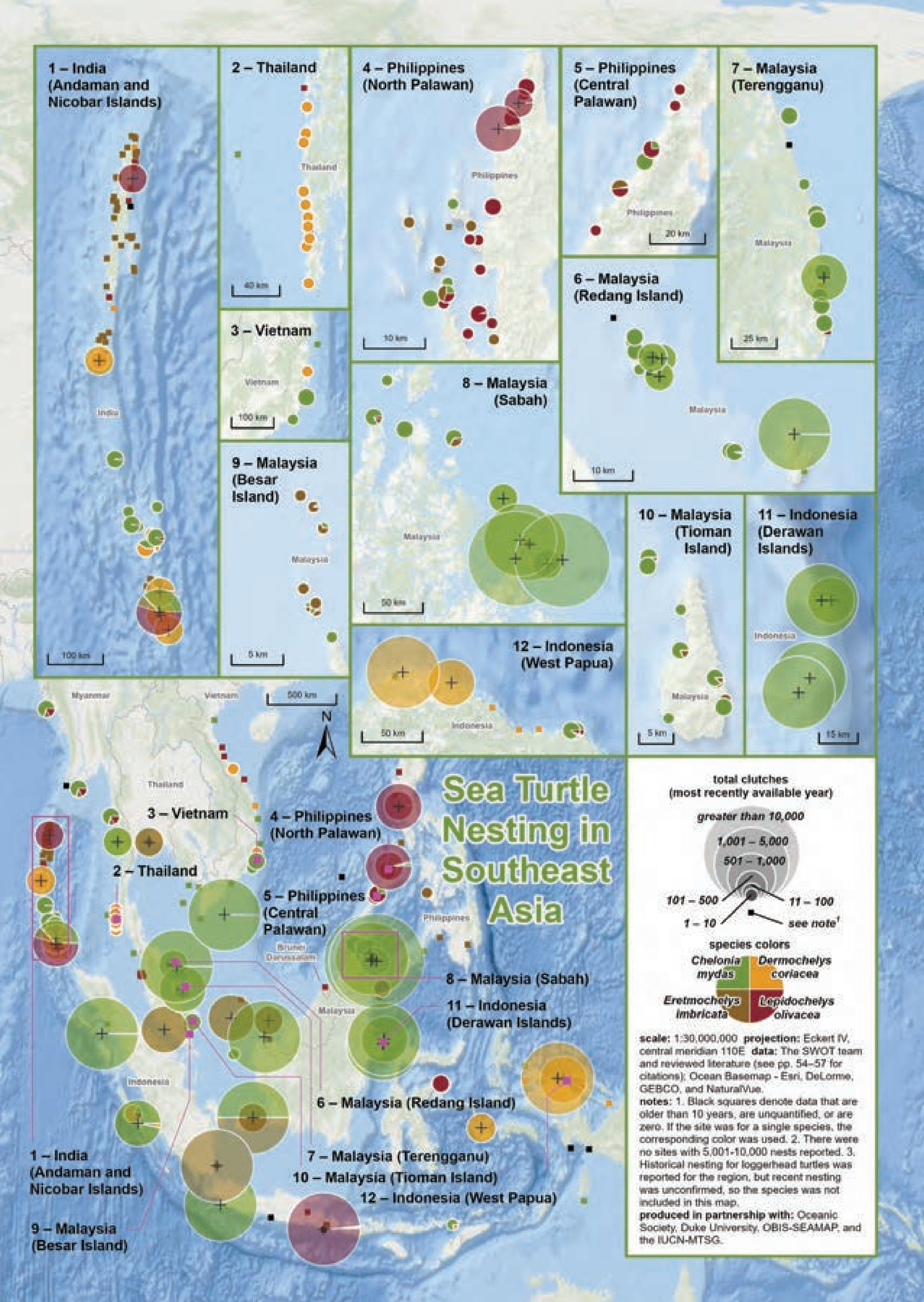
NESTING BIOGEOGRAPHY

On the map of sea turtle nesting in Southeast Asia on p. 30, nesting sites are represented by dots colored by species and scaled according to their relative nesting abundance in the most recent year for which data are available. At sites where multiple species nest, data from all species were combined to form an abundance-scaled pie chart that indicates the proportion of each species nesting at that site. For uniformity, all types of nesting counts (e.g., number of nesting females, number of crawls) were converted to number of clutches as needed. Conversion factors ranged from 2.2 to 5.0 clutches per female and 0.55 to 0.81 crawls per clutch.

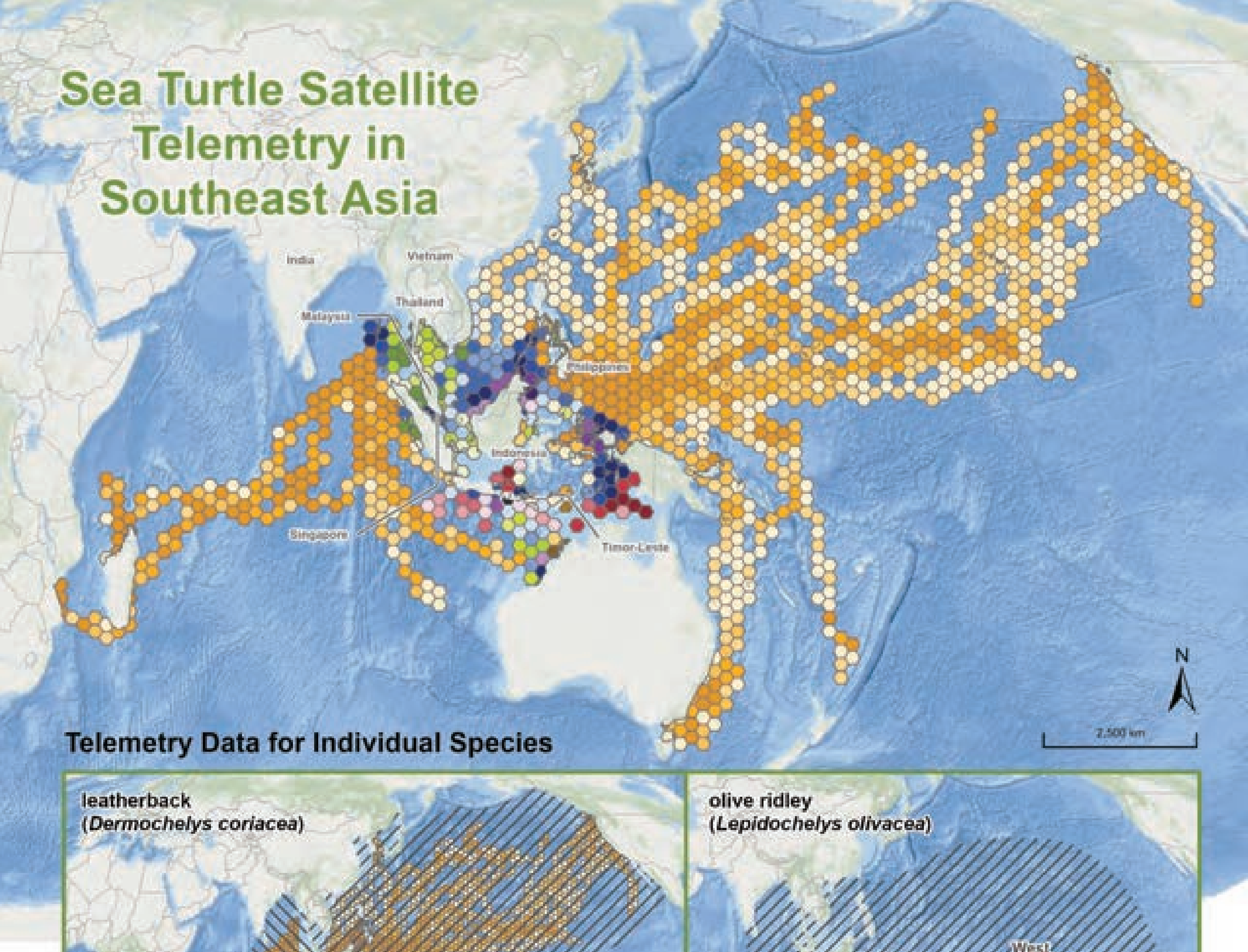
SATELLITE TELEMETRY

The satellite telemetry map on p. 31 presents data from green, leatherback, hawksbill, and olive ridley turtles and represents more than 47,000 animal locations. Only tracks from tags deployed in Southeast Asia and the Andaman and Nicobar Islands were included, thereby excluding some turtles that were tracked from outside of Southeast Asia into the region's waters. For more information on the mapping methodology, see the map's legend.

We are grateful to all of the data contributors and projects that participated in this effort. For details, please see the complete data citations on pp. 54–57.



Sea Turtle Nesting in Southeast Asia
1 – India (Andaman and Nicobar Islands)
2 – Thailand
3 – Vietnam
4 – Philippines (North Palawan)
5 – Philippines (Central Palawan)
6 – Malaysia (Redang Island)
7 – Malaysia (Terengganu)
8 – Malaysia (Sabah)
9 – Malaysia (Besar Island)
10 – Malaysia (Tioman Island)
11 – Indonesia (Derawan Islands)
12 – Indonesia (West Papua)
India
Thailand
Vietnam
Philippines
Malaysia
Indonesia
Myanmar
Brunei Darussalam
100 km
40 km
10 km
20 km
25 km
50 km
5 km
15 km
500 km
N
total clutches (most recently available year)
greater than 10,000
1,001 – 5,000
501 – 1,000
101 – 500
11 – 100
1 – 10
see note[1]
species colors
Chelonia mydas
Dermochelys coriacea
Eretmochelys imbricata
Lepidochelys olivacea
scale: 1:30,000,000 projection: Eckert IV, central meridian 110E data: The SWOT team and reviewed literature (see pp. 54–57 for citations); Ocean Basemap - Esri, DeLorme, GEBCO, and NaturalVue.
notes: 1. Black squares denote data that are older than 10 years, are unquantified, or are zero. If the site was for a single species, the corresponding color was used. 2. There were no sites with 5,001-10,000 nests reported. 3. Historical nesting for loggerhead turtles was reported for the region, but recent nesting was unconfirmed, so the species was not included in this map.
produced in partnership with: Oceanic Society, Duke University, OBIS-SEAMAP, and the IUCN-MTSG.



scale: 1:90,000,000
projection: Eckert IV (central meridian 110E)
data: The SWOT team and reviewed literature (see end of report for citations), Ocean Basemap - Esri, GEBCO, Garmin, NaturalVue
notes: Data are displayed as given by the providers and with minimal processing to remove locations on land and visual outliers. Some tracks are raw locations, while others have been more extensively filtered or modeled. Polygons are colored according to the combination of species present and number of locations they contain, with darker colors representing a higher number of locations; color bins were determined by splitting the count data into quantiles. Small numbers in the legend indicate the maximum number of locations in a hexagon for each species or combination in the main map. Countries of origin are labeled in the map. Insets show regional management units (updated in 2023 by Wallace et al.) and single species data. This map is not intended to be a comprehensive representation of all extant telemetry data or an authoritative source for the studies cited.
produced in partnership with: Oceanic Society, Duke University, OBIS-SEAMAP, and the IUCN-MTSG.

tiny Sultanate of Brunei, nested within Sarawak on the island's northern coast. Malaysian Borneo also shares maritime borders with Indonesia and the Philippines.

Four sea turtle species (green, hawksbill, olive ridley, and leatherback) have active nesting beaches in 10 Malaysian states, though ongoing threats have led to diminished numbers of most species. The once-robust Malaysian leatherback population is considered extinct (see sidebar, p. 33), hawksbills have declined to fewer than 200 clutches per year in Sabah (though nesting has increased significantly in Malacca to about 1,000 clutches in 2022), and olive ridley nesting is now exceptionally rare (fewer than 5 clutches per year). Only the green turtle population is considered stable, or potentially increasing, with 15,000–20,000 clutches per year in Sabah and 5,000–10,000 clutches per year in Terengganu.

Adjacent seas are foraging and migration grounds for green turtles and hawksbills, which are the most common species, and for rare olive ridleys and leatherbacks. The largest foraging grounds for green turtles and hawksbills are in the southeast of Sabah (Celebes Sea), and other foraging grounds are found in the Sulu and South China Seas and in the Strait of Malacca. A single living loggerhead was seen in Malaysia in 2021, though loggerheads are known to occur in the South China Sea, may once have nested in Sarawak, and are occasionally found stranded on the west coast of Peninsular Malaysia.

Green turtle eggs from Sarawak's Turtle Islands (Talang-Satang Islands) were traded with the Chinese going back to the 1600s, and there was a commercial hatchery on Pulau Talang-Talang Besar beginning in 1951. In 1999, those islands were transformed into Talang-Satang National Park, Sarawak's first marine protected area, providing full protection for turtles on land and sea. Sarawak today hosts 3,000–5,000 clutches annually. Meanwhile, in Sabah, the British North Borneo Company issued decrees to protect the egg trade in 1927. There too, in 1977, a former turtle farm became part of Turtle Islands Park, which includes Selingaan, Gulisaan, and Bakkungaan Kecil Islands. The Turtle Islands Heritage Protected Area was later established to include both the Turtle Islands of Sabah and the Philippines (see "Philippines" section), making it the world's first transboundary marine protected area for sea turtles.

In addition to government authorities, numerous nongovernmental organizations contribute to sea turtle research and conservation in Malaysia, including WWF-Malaysia, the Marine Research Foundation, the Perhentian Turtle Project, Lang Tengah Turtle Watch, Juara Turtle Project, Bubbles Turtle Conservation, Kapas Turtles, Tengah Island Conservation, Kampung Penyu Pulau Pangkor, Kudat Turtle Conservation Society, TRACC (Tropical Research and Conservation Centre), Scuba Junkie Sipadan, and the Gaya Island Resort Marine Center. Educational institutions—including the Sea Turtle Research Unit (SEATRU) of the Universiti Malaysia Terengganu, the Universiti Sains Malaysia, and the Universiti Malaysia Sarawak—are also engaged in sea turtle research and conservation. One of those institutions, the Sea Turtle Research Group of the Borneo Marine Research Institute (Universiti Malaysia Sabah), contributes to the understanding and conservation of sea turtles through research on genetics, foraging grounds, and migratory routes as well as improvements to hatchery management, tagging, and the establishment of regional networks.

Sea turtles are protected under various federal and state laws in Malaysia. But not all states provide legal protection for sea turtles. Although trade and consumption of turtle eggs is illegal in most states, including Sabah, Sarawak, and Terengganu, it is still allowed in some states in Peninsular Malaysia. Turtle eggs are often seen in markets in some parts of Malaysia, and illegal egg harvest remains an ongoing threat. There is strong evidence of continued exploitation of green turtles at some sites, and hawksbills are still illegally harvested for their shells around Semporna (Sabah) and elsewhere.

Fishers using gillnets, trawls, and longlines also kill many turtles incidentally in Malaysian waters. Additional challenges to Malaysia's turtles include plastic ingestion and entanglement, habitat destruction (including nesting habitat), and boat strikes.

Efforts to reverse the decline of sea turtles in Malaysia have begun to succeed in some cases, and populations of green turtles in Sabah and Terengganu are considered stable or increasing, as are populations of hawksbills in Malacca.

MYANMAR

Myanmar is the westernmost nation in Southeast Asia, and its 2,227 kilometers (1,384 miles) of coastline along the Andaman Sea are contiguous with Bangladesh to the north and Thailand to the south. Five of Southeast Asia's sea turtle species ply the waters of Myanmar while feeding and migrating, and all of them except the loggerhead nest there. The most common are green, olive ridley, and hawks-bill turtles, with only rare occurrences of leatherbacks and loggerheads. Studies done on Thameehla Island (Ayeyarwady Region) by FFI and local partners show a near doubling in nesting as well as an increase in hatching rates at sites on the island since 2017. Nesting has also been documented on Wa Ale Island (Tanintharyi Region) and on the Mawtin Coast (Ayeyarwady Region). The main threats to sea turtles nationally are trawl and artisanal fisheries, with secondary impacts coming from egg harvest, especially in Rakhine State, though the harvesting is not on a commercial scale. Turtles are protected by national law, and enforcement falls to the Myanmar Department of Fisheries. Nongovernment institutions also aid in conservation efforts, including the FFI Myanmar sea turtle project, which works to build local and national capacity and fill gaps in knowledge for priority turtle populations in Rakhine State, the Ayeyarwady Delta, and the Tanintharyi Region. The project addresses threats to turtles on beaches and at sea, implements public education programs, supports the Department of Fisheries' efforts to spread the use of TEDs (turtle excluder devices), and more. Rescue operations have also proven effective, with some 43 green turtles, hawksbills, and leatherbacks recovered from fishery bycatch and later released alive in just the past three years in Ayeyarwady Region alone.

PHILIPPINES

A country of more than 7,600 islands lying on the eastern extreme of Southeast Asia, the Philippines has one of the longest coastlines of any country, extending some 36,289 kilometers (22,549 miles). Two long tendrils of land reach across the sea toward the west: the island of Palawan and the chain of Turtle Islands that stretch across the border between the Sulu and Sulawesi (Celebes) Seas. The story of sea turtle conservation in the Turtle Islands is one of the most striking examples of success and binational partnership in Southeast Asia.

An in-depth analysis of 37 years (1984–2021) of nesting data from the Turtle Islands reveals a 388 percent increase in nesting across the five islands of Taganak, Baguan, Lihiman, Great Bakkungaan, and Langaan. Baguan Island alone—only 34 hectares (84 acres) of land, with some 1,200 meters (0.75 miles) of beach—showed an extraordinary increase of 1,002 percent in nesting, escalating that tiny island's contribution to the aggregate from 36 percent in 1984 to 80 percent in 2021! That remarkable success stems from stringent monitoring, protection, hatchery management, and research by the Pawikan Conservation Project in the 1980s, with support from WWF-Philippines (1993–2003) and Conservation International Philippines (2003–2012) under the leadership of Romeo Trono (1982–1993).

When the effort began, turtle nesting in the islands had shown a distressing 88 percent decline since the 1950s. The designation of Baguan Island as a marine turtle sanctuary gave the Pawikan Conservation Project team a legal mandate to enforce regulations. Every night the team patrolled the beach taking measurements, saturation tagging, transferring eggs to hatcheries, and releasing thousands of hatchlings. What began as the Baguan Island sanctuary ultimately became the Turtle Islands Wildlife Sanctuary (TIWS), comprising six islands and an impressive expanse of 242,958 hectares (600,362 acres). Through a diplomatic accord between the governments of Malaysia and the Philippines, the Turtle Islands Heritage Protected Area emerged as the world's first transboundary protected area for green turtles, earning the prestigious J. Paul Getty Wildlife Conservation Prize in 1996.

The successes of TIWS formed the foundations of several sea turtle conservation efforts across the country in partnership with the Philippines' Department of Environment and Natural Resources. Of note are the El Nido Marine Turtle Conservation Network (ENMTCN), in Palawan; Large Marine Vertebrates Research Institute Philippines (LAMAVE), working across the Philippines; and Coastal Underwater Resource Management Actions (CURMA), in La Union, where poachers have been turned into patrollers, leading to the protection and release of more than 200,000 hatchlings. Areas such as La Union and Palawan—as well as others where civil

The Once-Thriving Leatherback Population at Terengganu, Malaysia

By Jeanne A. Mortimer

Each year in the late 1960s, between June and September, an estimated 2,000 female leatherbacks laid approximately 10,000 egg clutches along a 15-kilometer (9-mile) stretch of coastline at Rantau Abang, Terengganu, on the east coast of Peninsular Malaysia. At that time, it was the nesting area of one of the largest and most famous leatherback populations in the world. The eggs had been collected by the coastal inhabitants since at least 1920, and in 1960 an estimated 1.66 million leatherback eggs were consumed annually. The eggs appeared to be an inexhaustible resource. Unfortunately, from the 1960s onward, the leatherback population declined precipitously. By the late 1980s, only 40 females were nesting annually; that dropped to a mere 5 animals by the early 2000s, and by 2010, the population was considered functionally extinct.

What went wrong? In short, almost everything. By the late 1950s nearly 100 percent of all leatherback eggs laid were consumed by people. So a hatchery management program was implemented during the 1960s. Sadly, resource managers at the time believed that protecting 1 percent of all the eggs laid and consuming the other 99 percent would be sufficient to maintain the population. Apparently, it was not. To make matters worse, high incubation temperatures in the hatcheries produced primarily females. By the late 1980s, a high proportion of the hatchery eggs were infertile, possibly because too few males had been produced and adult females were unable to find mates.

But those were not the only problems faced by the leatherbacks of Terengganu. Reportedly, the greatest population decline coincided with the rapid expansion of fisheries in Malaysia. Studies showed that trawl nets, drift nets and gillnets, and bottom longlines were capturing at least several hundred turtles each year within Malaysian territorial waters during the 1970s and 1980s. In the late 1980s, at least 8 percent of the estimated 40 females nesting annually were found washed ashore dead at Rantau Abang, tangled in fishing gear. Meanwhile, outside of Malaysian waters where the pelagic leatherbacks spent most of their lives, they were often caught incidentally by fishers in the high seas.

In 1988, the Terengganu state government enacted several remarkable measures based on recommendations spearheaded by Dr. Chan Eng Heng (see "Living Legends," p. 52). The measures stopped the commercial sale and consumption of leatherback eggs, mandating that 100 percent of eggs be incubated in hatcheries; and the government established the Rantau Abang beach sanctuary to prevent disturbance to turtles and further development of the critical nesting beaches. In 1989, the government banned large-meshed gillnets throughout Malaysian coastal waters. And in 1990 and 1991, it established the Rantau Abang Offshore Turtle Sanctuary—extending to 18.5 kilometers (11.5 miles) offshore along some 30 kilometers (18 miles) of coastline—and it banned destructive fisheries practices within the sanctuary's boundaries. Unfortunately, those actions, which probably would have met with success had they been implemented two decades earlier, came too late to save the leatherback turtles of Malaysia. Nevertheless, the lessons learned are being applied toward saving the hard-shelled turtles of Malaysia, especially the green turtles and the hawksbills.

society organization–led conservation is in place, such as Zambales, Bataan, and Cavite—see a predominance of olive ridley turtle nesting.

Despite all those successes, several challenges remain. Governance authorities often grapple with flagging technical and financial resources, and the ever-rising tides brought by climate change diminish nesting areas. Egg poachers may exploit that vulnerability, so the situation requires immediate attention to avoid backsliding on nearly four decades of success for TIWS and more recent efforts.

SINGAPORE

Singapore lies off the southern tip of Peninsular Malaysia and shares a southern maritime border with Indonesia. Land reclamation efforts that have been underway since 1819 have increased its coastline significantly from 480 kilometers (300 miles) in 1993 to 505 kilometers (315 miles) in 2011, with plans to expand to more than 600 kilometers (370 miles) by 2030, including through the Long Island reclamation plan, covering the entire coastal front of East Coast Park. As a result, many natural coastlines and turtle nesting beaches have been and will be disrupted to protect human infrastructure against sea-level rise. Nonetheless, hawksbills (nesting) and green turtles (foraging) persist, though both species are listed as critically endangered on the national Red List of Threatened Species. A turtle hatchery was established in the Sisters' Islands Marine Park in 2018 to incubate hawksbill clutches found on both public and private beaches, including Sentosa Island. Hawksbill nesting has seen an increase in recent decades because of improved reporting from citizen scientists, and genetic work has revealed that Singapore nesters exhibit five distinct haplotypes: three that are new to science, and two that also occur in Malaysia. Population genomic analysis has also revealed inbreeding within the hawksbill population and even identified related parents within a multiple-paternity clutch. Green turtles do not nest in Singaporean waters but are found foraging around the islands south of Singapore, where seagrass habitats are still intact. Stranded green turtles are often found with wounds indicating boat strikes as the cause of death. A single leatherback was captured in Singaporean waters and is currently kept on display at the Lee

A leatherback turtle returns to the Indian Ocean after nesting on Selaut Besar in Aceh, Indonesia. Southeast Asia is home to two subpopulations (regional management units) of leatherbacks (Northeast Indian Ocean and West Pacific). © Hiltrud Cordes

Kong Chian Natural History Museum. It is possible that loggerheads are also present in Singaporean waters, since they have been reported nearby in Malaysia (Penang and Malacca). Although a single dead olive ridley carcass was also found in 2018, olive ridleys are not known to forage or nest in Singapore.

THAILAND

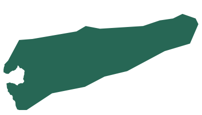
Thailand shares land borders with Cambodia, Malaysia, and Myanmar and has 3,148 kilometers (1,956 miles) of coast on both the Gulf of Thailand to the east and the Andaman Sea to the west. It also has approximately 250 small islands. A large number of coastal zones host beach habitats that are appropriate for sea turtle nesting, though many are crowded with human development (e.g., hotels, restaurants, urban areas) that can hinder or prevent nesting. Historically, Thailand hosted five species of sea turtles, with hawksbills, green turtles, and (infrequently) leatherbacks found in the Gulf of Thailand and leatherbacks, green turtles, olive ridleys, and loggerheads in Andaman Sea waters. Generally, in-water sightings of leatherbacks, olive ridleys, and loggerheads have been very low, and most data on Thailand's turtles are collected from stranding events, with hundreds of animals of all four species washed ashore dead, alive, or injured every year since the early 1990s.

Sea turtles nest in relatively small numbers on Thai beaches today. On the Andaman coast, mainly leatherbacks (October–February), green turtles (March–July), and ever-declining numbers of olive ridleys (October–February) are found. Hawksbills and green turtles also nest sporadically in the Gulf of Thailand (May–September) in several provinces, including in Koh Khram, according to data from the Royal Thai Navy, as well as in Koh Samet, Koh Kudi, Koh Talu, Koh Kula, Koh Kra, Koh Tau, Thap Sakae, and Chumphon. Koh Khram, which has been protected by the Royal Thai Navy since 1950, has shown promising increases in hawksbill nesting in recent years.

Although sea turtles have been protected under national law since 1947, populations have declined significantly. Intensive egg harvesting from the mid-1940s to the late 1970s was the likely culprit, though today that threat has dramatically declined. Instead, the main threats are now from fisheries bycatch, beachfront development, habitat degradation, and some black-market trade in turtle products.

Head-starting (captive rearing of hatchling turtles before release) has been the country's main sea turtle conservation strategy since the 1970s, though little information is available on releases, survival rates, and returns of head-started animals, and there is uncertainty about the effectiveness of those efforts. Genetic, distribution, and nesting studies are now adding new information to the state of knowledge of sea turtles in Thailand.

TIMOR-LESTE



Although the government has imposed laws to protect the country's five sea turtle species since 2015, commercial and artisanal hunting remains a severe threat in the tiny island nation of Timor-Leste, and turtle meat, eggs, and tortoiseshell are regularly seen in local markets. Predation of eggs and hatchlings by feral dogs, rats, and pigs is also a threat on nesting beaches.

The main international organizations that focus on sea turtle conservation with the Timor-Leste government are Conservation International Timor-Leste, Arafura and Timor Seas Ecosystem Action, and the Coral Triangle Center. Lenuk Tasi is a sea turtle rescue center led by students from the National University of East Timor and located near the capital of Dili. The group conducts research and educates the public and decision-makers about sea turtles. To date, Lenuk Tasi has rescued 24 olive ridley, green turtle, loggerhead, and hawksbill nests. It also partners with Sustainable Ocean Alliance Timor-Leste, Ocean Heroes Bootcamp, and government authorities to address the threat of sea turtle consumption and to host hatchling releases and other activities to advance public engagement in sea turtle conservation.

At a recent historic meeting in Bali—the Archipelagic and Island States Forum—Prime Minister Xanana Gusmão announced Timor-Leste's intent to establish a transboundary park between Timor-Leste and Indonesia that will encompass a network of marine protected areas and extend around the border of those two nations. Positioned just east of Komodo Island, Timor-Leste is a remarkable area for marine biodiversity, and the park is just one step in the country's broader efforts to transition to a blue economy as a pathway for development.

VIETNAM

Green turtles, hawksbills, olive ridleys, and leatherbacks have all nested along Vietnam's lengthy 3,260-kilometer (2,030-mile) coastline in the past, and all have severely declined in recent decades. Green turtles represent 99 percent of the total nesting population in Vietnam today, with occasional nesting leatherbacks also reported. Nesting hawksbills and olive ridleys have been absent for more than a decade. Consequently, all sea turtle species appear on the Vietnamese Red List of Threatened Species and are prioritized for legal protection.

A nesting population of leatherbacks that was estimated to include 500 females laying 10–20 nests per night prior to the 1960s declined to a small remnant population with 10–20 nests per year by 2002. Leatherbacks still nest occasionally, last seen at Cat Dai beach in Cam Lam District (Khanh Hoa Province) in 2013, and at Trieu Lang (Quang Tri) in 2010.

Currently, only around 700 green turtles nest regularly throughout Vietnam, and Con Dao National Park (Ba Ria–Vung Tau Province) is home to the largest rookery by far, with an average of 624 nesting turtles per season on 14 beaches. The nesting population at Con Dao is considered stable and has experienced a noticeable increase in nesting activity in recent years. Other nesting areas include Nui Chua National Park (Ninh Thuan Province), with an average of six nesting females per season on three main beaches (Thit, Dai, and Mong Tay) and Hon Cau Island (Binh Thuan Province), with three to five nesting females per season.

About 20 green turtles per year nest across other regions of Vietnam, including on a 70-kilometer-long beach (43 miles) in Quang Tri Province, at Hai Giang and Hon Kho Island in Binh Dinh Province, and in Cam Lam District and on the islands in Nha

Trang Bay in Khanh Hoa Province. Several other former nesting sites—such as the islands in Bai Tu Long Bay (Quang Ninh Province), the Cat Ba Archipelago (Hai Phong City), the Son Tra Peninsula (Da Nang) and the Phu Quoc Archipelago (Kien Giang Province)—have lacked sea turtle nesting for a considerable period. The nesting season in Vietnam spans from March to November, with some 83 percent of nesting taking place from June to September.

Interviews with fishers suggest that the aforementioned four species, along with a fifth, the loggerhead, still occur in Vietnamese waters. Green turtles inhabit shallow waters with seagrass beds around offshore islands such as Phu Quy Island (Binh Thuan Province), Phu Quoc (Kien Giang Province), Con Dao (Ba Ria–Vung Tau Province), the Hoang Sa Archipelago (Da Nang), the Truong Sa Archipelago (Khanh Hoa Province), and Bach Long Vi (Hai Phong City). Green turtles also feed in coastal areas, specifically coastal lagoons such as Tam Giang–Cau Hai or Thuy Trieu (Thua Thien Hue Province). Loggerheads have been found in the central provinces (Nghe An and Binh Thuan), and leatherbacks are rarely sighted in shallow waters, predominantly residing in deep offshore waters, where they are seen only a few times per year.

An olive ridley dines on a sea tomato jellyfish (*Crambione mastigophora*) in the Kei Islands of Indonesia. © Tui de Roy/Princeton University Press

The postnesting migrations of Vietnamese green turtles from Con Dao take them to foraging sites in Malaysia (Pahang State), the Philippines (Palawan), and Indonesia (Natuna Islands), and to Phu Quy Island and the Truong Sa Archipelago. Additionally, green turtles that nest in Lamma Island (Hong Kong) and Koh Khram Island (Thailand) return to their feeding grounds in Bach Long Vi Island (Hai Phong City), Son Tra (Da Nang), and the Con Dao Archipelago (Ba Ria–Vung Tau Province).

Threats to sea turtles in Vietnam include bycatch, habitat degradation, tourism development, harvest of eggs and adults, and climate change. Sea turtle research and conservation efforts in Vietnam have been led by IUCN Vietnam and WWF-Vietnam for more than two decades. Recently, the concerted efforts of additional organizations, such as FFI, Humane Society International, Education for Nature of Vietnam, the Center for Biodiversity Conservation and Endangered Species, TRAFFIC, and Wildlife At Risk have contributed significantly to those initiatives. The comprehensive approach to conservation involves a variety of strategies, including volunteer programs, outreach and education, establishment and maintenance of a population database, development of species distribution models for foraging populations, mitigation strategies to minimize the impact of climate change, GPS tracking of nesting turtles for more accurate monitoring, plastic litter monitoring, and improvements to sea turtle nesting and foraging habitats.

Hopeful Signs

In Southeast Asia, like so many places in the world, sea turtles have survived with varying degrees of success. Some populations have sadly become extinct, and many have declined significantly, yet others are steadily growing and even thriving in areas where conservation has taken hold. Sea turtle protection efforts at all scales are growing, and the overall attention paid to conserving marine biodiversity is on the rise both here and worldwide, evidenced by a proliferation of locally based programs, increasing engagement by governments, and the emergence of a robust and concerned new generation of conservationists.

The most significant historical threat to turtles in this region—rampant take and trade—has diminished dramatically in recent decades, and nine Southeast Asian countries are now parties to CITES. Moreover, ongoing multinational efforts like the Indian Ocean–South-East Asian Marine Turtle Memorandum of Understanding and the Coral Triangle Initiative point to the region's strong commitment to effective conservation programs that transcend national boundaries.

Significant obstacles remain for sea turtles in Southeast Asia—namely, climate change, coastal development, habitat loss, pollution, overexploitation, illegal trade, and fisheries impacts. But it is clear that there is reason for hope, thanks to an active conservation movement that is working to overcome those obstacles and ensure a brighter future for sea turtles and their ocean homes in Southeast Asia. •

Sea Turtles of the Andaman and Nicobar Islands

By Adhith Swaminathan and Kartik Shanker

India's Andaman and Nicobar Islands (ANI), located east of mainland India in the Andaman Sea, are biogeographically (though not politically) part of the Southeast Asian region, connected to both the Indo-Burma and Sundaland hotspots. The islands are home to four of the five species of sea turtles found in Indian waters and are the only location in India where green, hawksbill, leatherback, and olive ridley turtles all nest. The archipelago, in addition to having significant nesting beaches, also hosts foraging grounds in the surrounding coral reefs and seagrass meadows, which are critical habitats for hawksbill and green turtles.

Satish Bhaskar (see "In Memoriam," p. 58), a pioneer of sea turtle biology and conservation in India, first visited ANI in 1978 and over a span of nearly two decades carried out extensive surveys in the islands, which have since been followed by numerous research and conservation initiatives throughout the islands. The ANI Department of Environment and Forest actively monitors important olive ridley nesting beaches in the North and Middle Andaman Islands, where hatchery programs have been running for several decades. In 2014, a small mass nesting site was discovered at Cuthbert Bay on Middle Andaman Island, leading to the establishment of a permanent monitoring camp there.

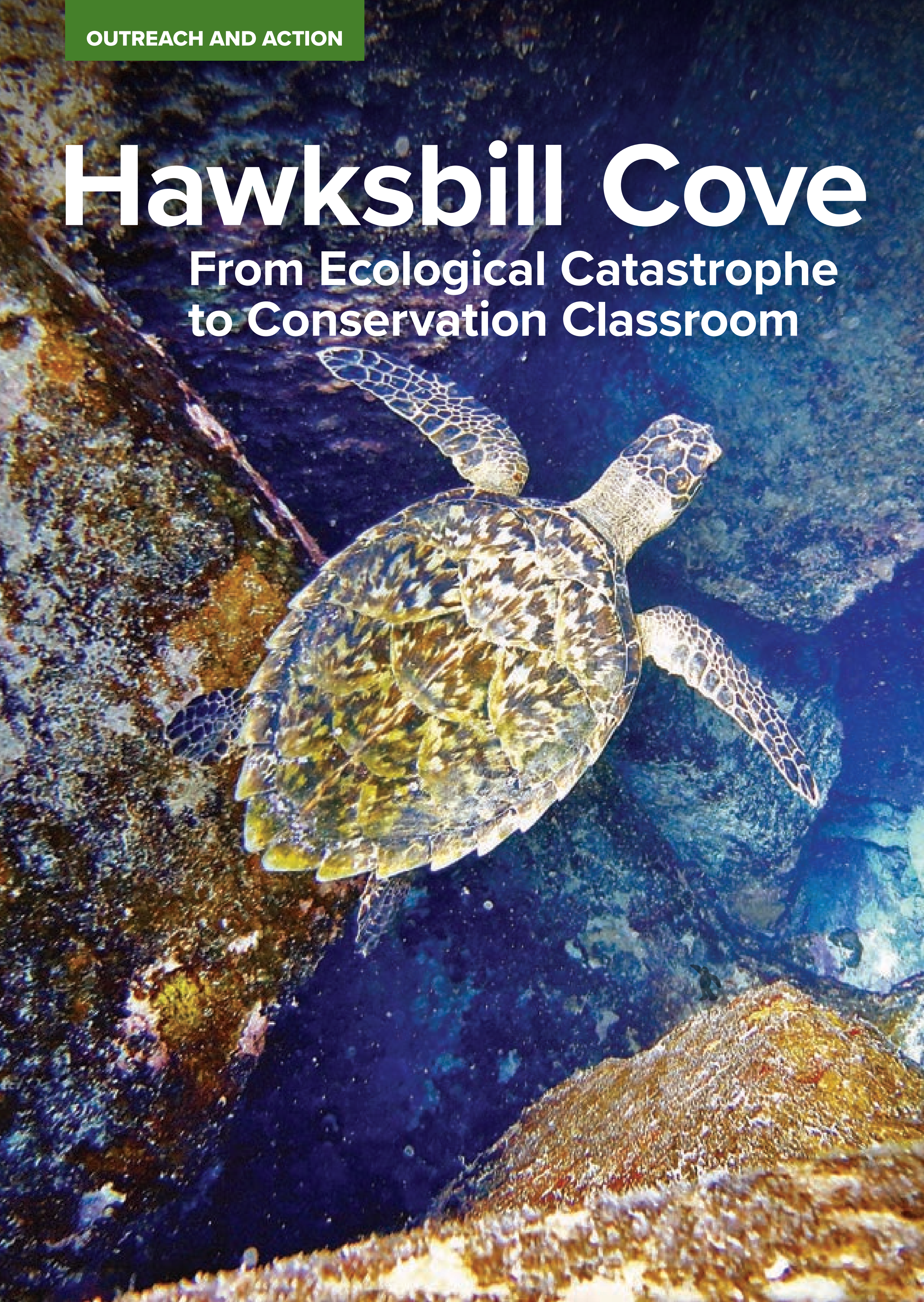
ANI also hosts India's best nesting beaches for leatherback, hawksbill, and green turtles. Leatherback nesting has been monitored for the past four decades through periodic surveys of remote nesting sites and, more recently, through long-term annual monitoring. Of the more than 500 islands in the archipelago, leatherbacks nest in consistently high numbers on just three islands: Little Andaman, Little Nicobar, and Great Nicobar Islands. With annual numbers of about 1,000 nests in the Nicobar group and 100–200 nests on Little Andaman Island, these are the most significant nesting grounds for leatherback turtles in the northeastern Indian Ocean.

Following the 2004 Indian Ocean tsunami and earthquake, nesting on Little Andaman Island has remained stable. Beaches in the Nicobar Islands now witness nesting comparable to the pre-tsunami period, including on some beaches that were completely destroyed and have since formed again. Leatherbacks that originate in ANI migrate to foraging grounds in the Indian Ocean, as far east as Western Australia and as far west as Mozambique and Madagascar (see map p. 31). Demonstrating their resilience to natural calamities like the tsunami of 2004, those leatherbacks have continued to return to their ANI nesting and foraging grounds year after year.

OUTREACH AND ACTION

Hawksbill Cove

From Ecological Catastrophe to Conservation Classroom



By Scott Eanes

On April 27, 1976, an aircraft crashed shortly after taking off from Harry S. Truman Airport in St. Thomas, U.S. Virgin Islands (USVI). The plane struck an antenna, plowed through a chain link fence, and ultimately came to rest in a gas station. The devastating accident killed 37 people and set off a chain of events that would eventually lead back to sea turtle conservation.

As an effort to prevent a repeat of the 1976 disaster, a massive infrastructure project was undertaken to lengthen the runway. The project buried a portion of the adjacent coral reef under tons of rubble, boulders, and dolosse (cast-concrete tetrapods designed to break waves and prevent coastal erosion). At the time of its completion, the new 2,100-meter (6,890-foot) runway (christened the Cyril E. King Airport, or STT, using official airport nomenclature) replaced a natural hawksbill habitat with roughly 6 hectares (15 acres) of fully artificial substrate, at depths ranging from 8 to 27 meters (26 to 89 feet). Today, STT is the busiest airport in USVI and one of the principal airports in the eastern Caribbean, serving more than 1.4 million people annually.

Thirty-three years later, the University of Virgin Islands Sea Turtle Research and Conservation program (UVISTRC), led by renowned sea turtle biologist Paul Jobsis, has documented an astounding transformation of the once-sterile construction site into a flourishing habitat for juvenile hawksbills. The change is due in large measure to the dolosse and large granite boulders that have created an extremely rugose habitat. The countless crevices, caverns, and tunnels have proven to be ideal habitat for juvenile hawksbills, allowing them maximum safety while resting, hiding, and sleeping.

When the study began in 2014, the UVISTRC team found some two dozen hawksbills using the runway habitat. And month after month, year after year, the numbers of new recruits to the resident population continued to increase. Through 2023, more than 70 hawksbills have been documented. These animals range from newly arrived oceanic hawksbills (carapace lengths of 19–25 centimeters, or 7–10 inches) to subadults of more than 60 centimeters (24 inches) that have been resident for more than a decade.

The past 10 years have revealed some intriguing observations. First, hawksbill turtles that only spend time near the runway are known as runway turtles, and they are distinct from the hawksbills found elsewhere in Brewer's Bay, which are affectionately called Black Point turtles. Second, there is very little, if any, intermixing among the runway turtles and the Black Point turtles. Habitat partitioning and even spatial competition has been documented and published in a paper titled "Habitat Selection and 3D Space Use Partitioning of Resident Juvenile Hawksbill Sea Turtles in a Small Caribbean Bay," research that included data from 10 turtles equipped with acoustic tags in 2017.

The timing of the acoustic tag study could not have been worse, as five weeks after the turtles' release, the strongest Atlantic hurricane in history, Irma, raked across St. Thomas, leaving a wake of destruction. Two weeks later, the island was struck by Hurricane Maria, another category 5 maelstrom of mayhem. Despite those staggering catastrophes, the acoustic tags held on, and so did the turtles. Indeed, every one of the tagged turtles remained in the habitat before, during, and after the storms. Astonishingly, the tags revealed that they weathered the storm by staying submerged for longer-than-average periods and at greater-than-normal depths (27-plus meters, or 89-plus feet). That documentation led to the first published paper on the behavior of hawksbill turtles during hurricanes.

AT LEFT: A hawksbill turtle swims above rubble that was dumped while extending an airport runway in St. Thomas, U.S. Virgin Islands. © Scott Eanes

The extension of the Cyril E. King runway into Brewer's Bay effectively split the bay in two. Twenty-five years later, the southern body of water was christened "Hawksbill Cove," inspired by the flourishing hawksbill population discovered there. © Scott Eanes

The tale of the Cyril E. King Airport runway initially caused people to lament the loss of a pristine habitat, but with time it became a case study for nature's resilience. Humanmade sites like Brewer's Bay can bounce back to become important ecosystems and essential habitats for critically endangered species. We then find ourselves marveling at and, more importantly, preserving an area that was once considered a conservation failure. ●

A Personal Tale

In 2014, when I was doing my master's research, I realized the "new" body of water south of the airport had been nameless for more than 25 years. That epiphany led me down a Google rabbit hole starting with "How do places get their name?" and my discovery of the Board on Geographic Names, the U.S. agency responsible for naming geographical locations. A phone call was made. An awkward voicemail was left. This culminated in a friendly connection, and in 2015, after a lengthy process, my proposal to name the body of water was unanimously approved. It is now officially Hawksbill Cove, USVI.

More Turtles, Less Plastic

By Brad Nahill, Timothy Kakai, Estrela Matilde, Sabine Berendse, and Daniel Gonzalez-Paredes

If there is an iconic animal for the worldwide epidemic of plastic pollution, it is certainly one of the world's seven sea turtle species. Although the public is newly aware of the actual impacts of plastic pollution on sea turtles, researchers have known about the threat for decades, and many organizations that work on nesting beaches have been cleaning up plastic pollution since long before it became a popular cause.

Beach cleanups can help keep nesting beaches clear for nesting females and can lessen the impacts of plastic pollution, but cleanups can create a secondary challenge: what to do with collected waste to ensure that it does not simply reenter the environment. Many places where sea turtles nest lack adequate waste management systems, and even in countries with well-developed infrastructure, it is well known that less than 10 percent of plastic is actually recycled. Much of the rest litters the land and water, becomes part of overburdened landfills, or is burned, thereby damaging both human health and the climate.

The nonprofit organization SEE Turtles recently noticed that a number of sea turtle projects were starting to invest in efforts to recycle the waste they collect and to convert it into products that support conservation efforts and community livelihoods. To support those efforts, SEE Turtles launched the Sea Turtles & Plastic program, which provides financial support so community organizations can create recycling infrastructure. Projects thus far supported include the purchasing of recycling equipment, training of local residents, and more. To date, the program has made 15 grants totaling more than US$75,000. The funded projects have recycled more than 13,608 kilograms (30,000 pounds) of plastic and have made a positive effect on the lives of nearly 1,000 coastal residents.

Supported projects include the following:

KENYA | In Kenya, COBEC (Community Based Environmental Conservation) is dedicated to protecting and restoring the marine and coastal ecosystems, which are crucial to the region's well-being and vitality. COBEC's work includes efforts to tackle marine waste through beach cleanups and mangrove restoration. To date, COBEC has recycled more than 12 tons of marine debris while creating new business opportunities in local communities by shredding and crafting products from used plastic bottles and flip-flops. The project has had a significant effect by improving livelihoods, resilience, income generation, and overall environmental health.

SÃO TOMÉ & PRÍNCIPE | Fundação Príncipe is a nonprofit conservation organization based in Príncipe. After leading small initiatives focused on recycling glass beads and flip-flops, the organization began a larger-scale project to (1) understand plastic pollution on the island, (2) work with regional authorities

AT RIGHT: A volunteer participates in a beach cleanup with Green Phenix in Curaçao. © Green Phenix to develop legislation to address the problem, and (3) support five business ideas to transform plastic into useful products such as bricks and furniture. The organization also launched a project to build community capacity that would monitor Príncipe's growing scourge of marine plastic, as well as to introduce alternative revenue opportunities that deal with existing plastic. Work includes the creation of a Plastic Re-use Women's Hub, which will make advanced recycling and upcycling equipment available to the five pilot recycling businesses. Fundação Príncipe also implemented the Captain Fanplastic program, a global environmental literacy curriculum, which now reaches every child on the island. Today, with support from SEE Turtles, the Darwin Initiative, and the Whitley Fund for Nature, Príncipe has a powerful strategy in place for combating plastic pollution.

CURAÇAO | Green Phenix was founded in 2019 as an offshoot of Sea Turtle Conservation Curaçao to combat the extensive marine debris along Curaçao's windward shoreline. Inspired by Precious Plastic, a global open-hardware plastic-recycling project, the program repurposes waste into meaningful products. Starting with two extruders, a shredder, and a 3D printer, as well as 12 learn-and-work participants, Green Phenix has made significant strides. Today, it is transforming plastic waste into bricks, beams, and a variety of items such as vases, wall decorations, and tables. It conducts tours, hosts an e-learning course, and oversees collection points and partnerships throughout the island. Since October 2021, Green Phenix has removed 12,871 kilograms (28,376 pounds) of marine debris and has collected 20,230 kilograms (44,600 pounds) of post-consumer plastic. The team now comprises 14 staff members and 24 learn-and-work participants.

URUGUAY | Karumbé is pioneering an innovative circular-economy project to combat marine plastic pollution. Alongside local communities, Karumbé conducts beach cleanups in areas frequented by sea turtles. It then sorts and cleans waste materials for recycling by Plasticoin, a project that exchanges waste by weight for virtual currency. Next, Karumbé reinvests its virtual revenues in veterinary supplies and other resources for rehabilitating sea turtles, thereby completing the economic circle and turning the tide on plastic pollution. The activities aim to increase environmental awareness about plastic pollution in coastal communities, thus providing a hands-on approach for creating a positive effect.

Given the tremendous amount of plastic waste in the environment today, cleaning our oceans and coasts and finding ways to ensure that waste does not reenter the environment are critical to protecting wildlife and people. Nevertheless, we all know that such cleanup efforts, though undeniably important, are symptomatic treatments that do not address the root cause of the pervasive global crisis of plastic pollution. Solving that crisis will require that we ultimately end the production of single-use plastic. But as we work toward that goal, strategies like those described herein can help to minimize the negative impact of plastic pollution on sea turtles. •

How Behavioral Science (and Team BEACH) Can Help Sea Turtles

A young boy participates in a hatching release on Colola Beach in Michoacán, Mexico. © Tui de Roy/Princeton University Press

By Lindsay Mosher, Kelley Anderson, Ashleigh Bandimere, Brian J. Hutchinson, Roderic B. Mast, and Rachel Smith

Many of us who work in sea turtle conservation have experienced a moment of epiphany when it becomes clear that our work is really more about people than it is about turtles. After all, the threats to sea turtles originate from two causes: what people put into and what people take out of the seas. Sea turtle—and ocean—conservation begins and ends with people. Nonetheless, traditional conservation science has focused almost entirely on ecological and biological research. A recent study by Stefan Partelow and colleagues published in the journal *Nature* reports that less than 5 percent of all academic publications relating to ocean science from 1990 to 2021 were social science. Although biology and ecology undoubtedly play an important role in wildlife conservation, it is imperative that we shift our focus to the true culprit behind species loss: human behavior. It's time to acknowledge the leatherback turtle in the room and to strike a more appropriate balance between biological and human-centered approaches to sea turtle conservation.

Moving Beyond Awareness with Team BEACH

The idea that we need to engage people in sea turtle conservation is certainly not a new one. Indeed, sea turtle conservationists worldwide have been implementing programs to reach and engage the public for decades. Overwhelmingly, those programs focus on raising awareness and educating people. The common belief—and sincere hope—is that imparting knowledge will lead to behavior change: Once people are aware of the problem and how they contribute to it, they will act.

Unfortunately, social science has widely found that knowledge and awareness alone seldom lead to behavior change. Such a disconnect stems from the complexity of what it means to be human. Logic, reason, and rational thinking do not drive our decisions and behaviors as one might expect. Rather, we are most influenced by our social identity, basic needs, desire for acceptance and belonging, worldview and value systems, and behavioral norms surrounding us. Those influences often conflict with prioritizing the conservation of wildlife.

Thankfully, there's an entire field dedicated to understanding those complexities and using them to affect behavior change. By integrating such knowledge into sea turtle conservation, we can vastly improve the effectiveness and effect of our outreach efforts. Such an interdisciplinary approach will mean codeveloping projects with local and indigenous communities and designing outreach programs informed by behavior change metrics and social science principles. In practice, the approach may look like this:

- Conducting audience research to learn about motivations and barriers that most affect behaviors underlying the conflict between humans and sea turtles
- Partnering with social scientists to develop behavior change strategies and evaluations for outreach programs
- Working alongside fishers to understand their needs and motivations, and designing tools that both reduce sea turtle bycatch and build operational efficiency
- Collaborating with coastal communities to encourage sea turtle–friendly recreational or business practices

Acknowledging that many sea turtle conservationists do not have social science training, we have recently built a global network within the SWOT community called Team BEACH (for "**Be a Ch**angemaker"). Our aim is to build expertise that will advance effective interventions of behavior change through sharing lessons and through workshops, webinars, training, and guidelines. The graphic at the bottom of the page lists simple recommendations are simple recommendations for incorporating behavioral science into conservation efforts.

Team BEACH Guide to Getting Started on a Behavior Change Strategy

EVALUATION IS KEY

Social science creates and is driven by a body of evidence that guides us in determining which strategies will be most successful in specific contexts. That concept should also ring true of education and outreach efforts. Evaluation is a critical concern when designing strategies for behavior change, because it can inform iterative improvement and adaptive program design. For a good start when planning for evaluation, consider the intended and clearly defined outcomes of the program and how they might be measured. We suggest partnering with a social scientist to help design a robust evaluation. As in the biological sciences, our using low-quality data stemming from poor research design or faulty methods to inform decisionmaking often has worse consequences than not having any data at all.

BE A CHANGEMAKER

Though people have been the main driver of sea turtle decline, conservationists can help people become part of the solution rather than further contributing to the problem. By learning from and implementing strategies based in social and behavioral science, we can inspire individuals, communities, businesses, decisionmakers, and future generations to embrace pro-environmental behaviors, thereby catalyzing systematic change and creating a brighter future for both people and wildlife. To join the global behavior change community for sea turtle conservation and to gain access to additional resources, visit the Team BEACH website at www.seaturtlestatus.org/team-beach. Join our community and help us drive change for sea turtle populations around the world by embracing the science of behavior change. ●

WHAT?

- Identify the **threat** or **challenge**: Think about the contributing factors and trace the threat back to the source.
- Identify **behaviors** to help mitigate the threat: Many different behaviors might be beneficial, but which are most feasible and have the potential for the greatest effect?

WHY?

- Identify **motivations** for current behavior: Why might your audience choose to continue their current behaviors?
- Identify **barriers** to adopting the desired behavior: What might prevent your audience from engaging in the desired behavior?

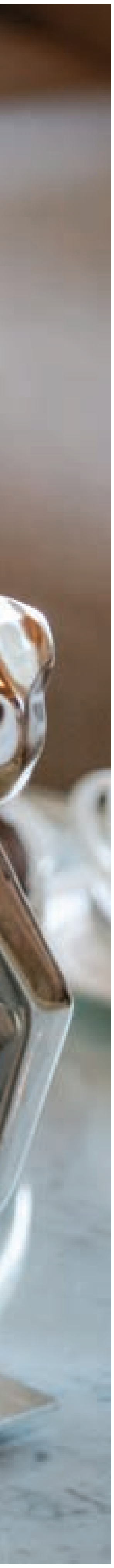
WHO?

- Identify your **target audience**: Be as specific as possible and avoid developing strategies for the "general public."
- What do you know and not know about your target audience? What **assumptions** are you making and how might you get additional information about your audience?
- **Stakeholder** analysis: Whom do you need on your team to successfully change this behavior?

HOW?

- Identify potential **pathways, theories**, or **frameworks** grounded in social science to help guide your strategy.
- Determine your **key message** and how you will frame it: Keep your message clear, concise, and consistent.
- Determine the **mode of delivery** to best reach your audience and **key spokes-people**: Think about whom your audience trusts and how it typically consumes information.

A display of desserts served during Turtle Tea at the Jumeirah Al Naseem's Al Mandhar Lounge in Dubai, United Arab Emirates. Photo courtesy of Jumeirah; **AT RIGHT:** Chef Julien Jacob, artist Idriss B, Barbara Lang-Lenton, and H. E. Sheikh Fahim Al Qasimi (from left to right) pose in front of the Burj Al Arab. Photo courtesy of Jumeirah



Afternoon Tea with a Sea Turtle Twist

By Barbara Lang-Lenton

Glamorous afternoon teas are not uncommon in the luxury hotel scene in Dubai, United Arab Emirates. But afternoon tea at Jumeirah Al Naseem's Al Mandhar Lounge has a special twist: Welcome to Turtle Tea, or *Thé à la Mode*. This special afternoon tea, designed by Jumeirah Al Naseem's executive pastry chef, educates guests about the conservation work to rehabilitate sick and injured sea turtles spearheaded by the Jumeirah Group through its Dubai Turtle Rehabilitation Project (DTRP), which has been in operation for 20 years.

Chef Julien Jacob joined Jumeirah in June 2021, and during his first week on the job, he participated in a turtle release event honoring World Sea Turtle Day. That memorable experience inspired him to use his skills to do more to build awareness and to actively contribute to the DTRP's outreach and education efforts. The result is a stunning collaboration between Al Mandhar Lounge and the Dubai-based French-Tunisian artist Idriss B, who is famous for creating angular, polygonal installations of wildlife such as mammoths, bears, and sharks.

The architecturally striking and iconic Burj Al Arab Jumeirah hotel is also home to large aquarium facilities. In collaboration with Dubai's Wildlife Protection Office, and with the support of the Dubai Falcon Hospital and the Central Veterinary Research Laboratory, Burj Al Arab Jumeirah's dedicated aquarium team founded the DTRP in 2004 to care for sick and injured sea turtles from all seven emirates. The group was established with these goals:

- Rescue, rehabilitate, and release sick and injured sea turtles.
- Educate local children, citizens, and international guests about sea turtle biology and conservation.
- Understand and improve sea turtle rehabilitation techniques and research turtle movements throughout the region and beyond through a satellite tracking initiative.

After intensive medical treatment at Burj Al Arab Jumeirah turtle clinic, turtle patients are transferred to a protected sea-fed turtle lagoon, the Turtle Sanctuary, at Jumeirah Al Naseem, where they complete the final phase of their rehabilitation to acclimate to ambient conditions and build their fitness levels prior to their release into the wild. Dubai residents, international hotel guests, and visitors can learn more about sea turtles and their conservation, witness their recovery, and even participate in daily educational and feeding sessions.

In addition, every year the Turtle Sanctuary receives around 2,000 schoolchildren between October and April. Local and international schools throughout the United Arab Emirates send students to learn about sea turtle biology and the threats that sea turtles and our oceans face and to witness what the DTRP and the Dubai government are doing to help. The kids also enjoy a superb breakfast, courtesy of Jumeirah Group.

To date, more than 2,100 turtles have been rescued and returned safely to the Arabian Gulf, and 77 animals have been fitted with satellite transmitters, generating helpful information about the region's sea turtles. The project is one of the key corporate social responsibility initiatives of Jumeirah Group, and it is featured in many local and international media publications every year. •

FAQs ABOUT SEA TURTLES

Researchers watch as a satellite-tagged leatherback hatchling dives into the ocean. Tags like these have helped researchers learn about sea turtles' diving abilities. © Lazaro Ruda

How Deep Do Sea Turtles Dive?

By George Shillinger

Sea turtles spend most of their lives underwater. Hard-shelled species generally stay close to shore in shallow waters, but leatherbacks mostly stay in the open sea, diving deep and often while migrating over vast distances. Some hard-shelled turtle species can dive to beyond 300 meters (980 feet), but leatherbacks are the true record holders. They can descend to below 1,000 meters (3,280 feet), deeper than any other reptile, where pressures are intense (more than 100 atmospheres) and temperatures can drop to less than 5 degrees Celsius (41 degrees Fahrenheit). Among air breathers, leatherbacks share those depths with sperm whales and elephant seals, which are capable of reaching depths of more than 2,000 meters (6,560 feet)!

All sea turtles have special adaptations that allow them to hold their breath underwater for extended periods, as described in the article on the opposite page. And even among sea turtles, leatherbacks are especially adapted to store oxygen in their blood and tissues to help them dive. Beyond their breath-holding abilities, leatherbacks have also evolved unique physiological adaptations that allow them to brave the extreme conditions of the deep sea. Those adaptations include:

- **Compressible carapace:** The thick, leathery shell of a leatherback can compress during descent and expand during ascent, unlike the shells of hard-shelled turtles.
- **Nitrogen absorption:** Leatherbacks can absorb nitrogen through their carapace, thereby avoiding decompression sickness while diving.
- **Thermal inertia:** Their giant size means that leatherbacks cool slowly. Their black color also helps them recuperate heat more rapidly when basking on the surface after a dive.
- **Countercurrent heat exchange:** A leatherback's arteries, which carry warm blood, lie close to the veins returning colder blood to the core, so that heat is conserved.

There is now an array of sensor-equipped satellite tags, animal-borne cameras, and multisensor recorders that help scientists understand those enigmatic underwater behaviors. While using early satellite tag technology in the 2000s, I was astounded to see leatherbacks diving to depths that maxed out our sensors at 1,210 meters (3,970 feet)! But now we know that leatherbacks routinely dive into the bathypelagic zone (1,000–4,000 meters' depth, or 3,280–13,120 feet). But why?

During 2004 to 2008, our team equipped 35 adult eastern Pacific leatherback turtles with satellite relay data loggers integrated with thermistors and pressure sensors, with the goal of better understanding the whys behind leatherbacks' deep-diving behavior. From 42,234 recorded dives, we observed that during the day the leatherbacks dove deeper and shorter than at night, when their dives were shallower and longer. Those observations pointed to a few possible explanations. One is that the turtles may be searching for prey during the daytime and feeding at night, when their prey also migrate closer to the surface. Another is that the turtles may be staying near the surface during daytime to warm up via solar radiation. We also observed that the turtles dove deeper when warmer water allowed them to, suggesting that temperature regulation is an important factor influencing their diving behaviors.

Not only are adult leatherbacks deep and frequent divers, but juveniles are too! A team of scientists from Upwell and Florida Atlantic University observed that among dozens of individuals studied, several dove over 40 meters (130 feet), including one to over 100 meters (330 feet) shortly after being released. As a group, those young animals spent more than 70 percent of their time underwater and made routine dives to beyond 70 meters (230 feet).

From a conservation perspective, understanding diving behavior in sea turtles is important because the threats they face occur throughout the water column. Impacts can come from deep-set longlines (30–100 meters deep, or 100–330 feet), to ghost nets at any depth, to boat strikes on the surface. By integrating turtle movement datasets (both horizontally and vertically) with those on anthropogenic threats, such as datasets on fisheries, vessel traffic, or offshore development activities, we can develop new tools that identify areas of highest risk to inform targeted conservation strategies.

How Long Can Sea Turtles Hold Their Breath?

By Sarah Milton

How long can you hold your breath? A minute? Maybe two? Even the current world record for underwater breath holding by a human, an astounding 24 minutes and 37 seconds, pales in comparison to sea turtles' breath-holding abilities. Because sea turtles are ocean-dwelling air breathers, it's clear that they must hold their breath for at least several hours in order to forage for food, avoid predators, and sleep underwater. But they may be able to go much longer—several days or even months.

In the early 1970s, scientists learned from the Seri indigenous people and from other Mexican fishermen about green turtles that were believed to hibernate underwater in the Gulf of California during the winter, maybe for months. Shortly thereafter, turtles were pulled up when Port Canaveral (Florida, U.S.A.) was dredged, and the stained condition of the turtles' shells suggested they had been buried in the mud for days at least. However, there was no proof of how long those animals were really submerged.

More recent studies have sought to better understand sea turtles' breath-holding limits in laboratory settings and in the wild using time-depth recorders. The studies have found that under most conditions, sea turtles will dive for 20 to 40 minutes while foraging and up to several hours when sleeping. Additionally, when the water gets cold, some turtles are able to remain underwater for much longer. The longest recorded submersion by a wild sea turtle was when a loggerhead turtle stayed submerged for seven hours while overwintering in Greece. But how do they do it?

How long air-breathing animals can stay underwater is a function of three factors: (1) how much oxygen they can store in their blood and muscles, (2) how fast they use the oxygen when diving, and (3) how tolerant they are to low oxygen. Sea turtles have several adaptations that help them stay underwater for long periods of time, including:

- **Oxygen storage:** Sea turtles have high concentrations of hemoglobin and red cells in their blood and myoglobin in their muscles, enhancing oxygen storage during dives. The turtles can also move the oxygen into their bloodstream even when lung oxygen levels are very low.
- **Low metabolic rates:** All sea turtles, except the leatherback, are cold-blooded, with metabolic rates only about 10 percent of ours. As a result, they use oxygen more slowly. Cold temperatures further slow their metabolic rates, helping them stay submerged for even longer.
- **Bradycardia:** Sea turtles decrease their heart rate while diving. In a study of diving leatherbacks, heart rates decreased about 30 percent for dives of less than 10 minutes. One turtle's heart rate declined from 27 beats per minute at the surface to 3.6 beats per minute during a 34-minute dive. Some turtles' heart rates briefly go as low as 1 beat per minute during dives.
- **Peripheral vasoconstriction:** Green turtles can shunt blood away from less important organs and tissues to conserve oxygen during dives up to half an hour long, but they appear unable to maintain the vasoconstriction for longer. Though turtles' vasoconstriction abilities are not as developed as those of diving marine mammals, the combination of lower heart rates and altered blood flow still helps reduce turtles' metabolic rate.
- **Hypoxia tolerance:** Although most dives are relatively short and the turtles don't use all their stored oxygen, they also have a much better ability than mammals to survive low oxygen. Their brains are adapted to prevent the damaging effects that happen when we run out of oxygen (as might happen during a stroke), so they can potentially live up to a few hours without oxygen.

Understanding how and for how long diving sea turtles remain submerged is important for conservation efforts, because turtles face threats of drowning when caught or entangled. As a practical example, when turtle excluder devices (trap doors in shrimp nets that allow large animals such as turtles and sharks to escape but not small fish and shrimp) were first being developed, one argument against them was that shrimp net tow times were only 30 minutes and turtles could hold their breath for hours, so surely the fisheries were not responsible for the many drowned turtles along the coast each summer. But a sea turtle that is struggling and swimming frantically to escape a net will have an elevated heart rate and will use up its oxygen stores very quickly and indeed can drown. Continuing research into sea turtles' breath-holding abilities may help further elucidate species-specific differences and provide a more definitive answer to the question of how long sea turtles can hold their breath; that research may even provide clues as to how the human brain might survive longer without oxygen. •

Acting Globally

SWOT SMALL GRANTS 2023

Since 2006, SWOT's small grants have helped field-based partners around the world to realize an array of important research and conservation goals. Fully 160 grants have now been awarded to 125 applicants in more than 57 countries and territories for work addressing three key themes: (1) networking and capacity building, (2) science, and (3) education and outreach. The following are overviews of SWOT's 2023 grantees. Visit www.seaturtlestatus.org/grants for application instructions and a list of all past SWOT grantees.

TOP ROW: © Tetepare Descendants' Association; **MIDDLE ROW:** © Carlos Delgado-Trejo; Science of Identity Foundation; **BOTTOM ROW:** Fundação Tartaruga

© Abdulrahman Ritonga/Anambas Foundation

Science of Identity Foundation (SIFCare)—Philippines

The SIFCare CURMA (Coastal Underwater Research Management Actions) Reef Experience Program will educate children and community members about plastic pollution mitigation and sea turtle conservation. Participants will strengthen their connection to nature through beach cleanups and activities to maintain sea turtle hatcheries.

Fundação Tartaruga—Cabo Verde

Fundação Tartaruga staff members will bring one of their beach patrol protection dogs, Kelo, to local schools in Boa Vista to raise awareness and inspire children to care for nature by protecting sea turtles, rather than consuming or selling turtle products, and by reducing and recycling plastic waste.

Sea Sense—Tanzania

Sea Sense will expand its current conservation and research programs by training groups of community conservation officers in techniques for better understanding, monitoring, and protecting sea turtle foraging habitats and ensuring safe connectivity to nesting beaches.

Tetepare Descendants' Association (TDA)—Solomon Islands

By providing necessary field equipment and training to its rangers, TDA will strengthen its sea turtle nesting beach monitoring program, which protects animals and gathers valuable conservation data in partnership with local and international partners.

Anambas Foundation—Indonesia

By combining socioecological research and community engagement, Anambas Foundation aims to encourage local involvement in sea turtle conservation and tourism in the Anambas Islands Marine Protected Area.

Safe Earth Foundation (SEF)—Nigeria

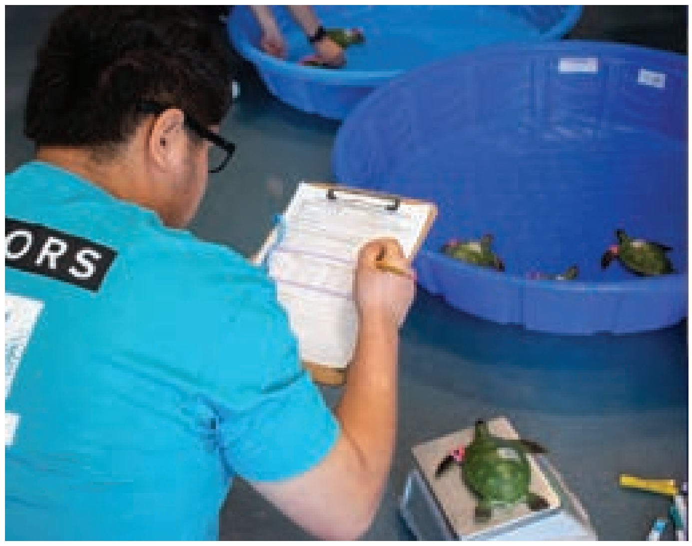
SEF will hold a workshop for artisanal fishers and law enforcement agencies to strengthen local participation in marine conservation and bycatch data collection and to encourage more proactive and efficient enforcement of illegal take laws.

National Center for Environmental Research (CNRE)—Madagascar

CNRE will conduct a field-based assessment in the Besalampy District, a coastal region in northwestern Madagascar, to fill data gaps on nesting sea turtles that will allow researchers to estimate populations, create an inventory of nesting sites, understand habitat use, and build a conservation strategy.

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 several annual grants for projects related to the conservation of two of the top global priorities for sea turtle conservation—eastern Pacific leatherbacks and Kemp's ridley turtles.



TOP ROW: Campamento Tortuguero Ayotlcalli A.C.; South Carolina Department of Natural Resources; **MIDDLE ROW:** Mildred Alpizar Quezada; Sea Turtle, Inc.; **BOTTOM ROW:** JUSTSEA Foundation; Kuemar

Sea Turtle, Inc.—U.S.A.

Through a STEM (science, technology, engineering, and mathematics) summer camp, teenagers will study ocean conservation through water-quality measurement, marine species identification, and field trips to document microplastics. Participants will advance their scientific literacy and learn how to help oceans and Kemp's ridleys.

Centro ECOMAR (Centro de Investigación, Protección y Conservación de la Tortuga Marina)–UAgro (Universidad Autónoma de Guerrero)—Mexico

Centro ECOMAR–UAGro will teach students and fishers from Guerrero, Mexico, about sea turtles, including eastern Pacific leatherbacks, and teach them how to diminish fishery bycatch and behave in ways that positively affect sea turtles and the ocean.

Campamento Tortuguero Ayotlcalli—Mexico

Campamento Tortuguero Ayotlcalli will lead an outreach and education campaign, Warriors of the Rainbow, aimed at school-age children, community members, fishers, and service providers, to keep eastern Pacific leatherbacks and their habitats safe.

Kuemar—Costa Rica

Kuemar will conduct educational talks for tourists and operators at three important eastern Pacific leatherback sites. The project aims to reduce disturbances to nesting females and raise awareness about the consequences of improper waste disposal.

South Carolina Department of Natural Resources (SCDNR)—U.S.A.

SCDNR will post bilingual signs at coastal piers in South Carolina with the National Oceanic and Atmospheric Administration's "Recommendations to Reduce Injuries if You Hook or Entangle a Sea Turtle." The signs will include stranding hotline information to ensure the rescue of injured and cold-stunned Kemp's ridleys.

JUSTSEA Foundation—Colombia

By providing portside training, workshops, and presentations to anglers and fishing cooperatives, JUSTSEA hopes to reduce leatherback bycatch, foster collaboration, and promote sustainable fishing practices that reduce sea turtle impacts.

Universidad Michoacana de San Nicolás de Hidalgo—Mexico

University faculty and students will conduct research at Mexiquillo, a historically important nesting beach for eastern Pacific leatherbacks, that will determine the sex ratio of hatchery nests and help to inform conservation efforts for that rookery.

Elizabeth Labastida-Estrada—Mexico

For the first time, viral sequences of ChHV5, the virus that causes fibropapillomatosis, will be obtained from Kemp's ridley turtles in Rancho Nuevo for researchers to determine whether there are genetic variations that distinguish the Kemp's ridley viral strain from that found in other sea turtle species.

César Paúl Ley-Quiñónez—Mexico

Toxic pollutants are a poorly known threat to Kemp's ridley turtles. This research will quantify the concentrations of trace elements in the blood of nesting Kemp's ridleys at Rancho Nuevo to determine potential threats to population health.

Mildred Alpizar Quezada—Mexico

Mildred Alpizar Quezada's research will evaluate the concentration of trace metals in dead leatherback hatchlings found at Playa Tierra Colorada, one of the main nesting beaches for eastern Pacific leatherbacks in Mexico.

GroBios—Mexico

GroBios is creating standard protocols for projects in Guerrero to conserve eastern Pacific leatherbacks and their habitats. The nonprofit conducts training and provides institutional strengthening support to fill data and protection gaps throughout the state.

Gladys Porter Zoo—Mexico

The Gladys Porter Zoo (Brownsville, Texas, U.S.A.) will initiate a PIT (passive integrated transponder) tagging program at Altamira and Miramar, two important satellite nesting beaches for Kemp's ridleys near Rancho Nuevo, as part of the Mexico–U.S. Binational Kemp's Ridley Recovery Program.

LIVING LEGENDS OF Sea Turtle Conservation

In our field, there are leaders—icons—whose work and longevity of commitment stand out and whose impact on our common goal is outsized by any number of metrics. Each successive generation has advanced our cause, and along that continuum are influential people of all ages and from all over the world who are working in many arenas on countless topics and tasks. The following are just a few of our community's living legends.

Chan Eng Heng

Malaysia's "Turtle Lady," Dr. Chan Eng Heng has dedicated her life to protecting sea turtles through scientific research, lobbying, education, outreach, grassroots activism, and art. She has served as a professor at the Universiti Malaysia Terengganu, where she has inspired many students over the years, some of whom now hold key turtle conservation positions in Malaysia.

In 1993, Chan initiated Malaysia's first in situ nest protection effort for the green turtles on Redang Island, a program that continues to this day thanks to the volunteer and turtle adoption schemes that she created. She lobbied passionately for the long-term protection of Redang's nesting beaches, and three new beach sanctuaries were created as a result. She also cofounded the Turtle Conservation Society of Malaysia, which remains dedicated to restoring depleted wild turtle populations through research, conservation, rehabilitation, education, and public outreach. Chan has published widely and received international awards and accolades for her turtle work. There is even a street named in her honor in Terengganu: Chan's "Turtle Alley" is adorned with dozens of mosaics designed to celebrate turtles and to build awareness for their conservation.

What Is Your Proudest Accomplishment in Sea Turtle Conservation?

It is certainly the recovery of the green turtle nesting population in Redang Island. When I first began protecting nests on Chagar Hutang Beach, turtle nesting was sparse, with numbers barely reaching 500 nests. Today this beach hosts up to 2,000 nests per year! I am very thankful indeed to have lived to see this turnaround since I started working there some 30 years ago.

Jacques Fretey

A lifelong herpetologist, Jacques Fretey began to focus on marine turtles thanks to encouragement from Dr. Archie Carr and Dr. Peter Pritchard while he was working in French Guiana as a researcher for the Muséum National d'Histoire Naturelle in the late 1970s. While there, he conducted an inventory of chelonians in French Guiana and led studies of leatherbacks for more than two decades, tagging more than 10,000 animals. He later discovered the importance of the beaches of Gabon for leatherback nesting and beaches of Long Island (Antigua and Barbuda) for hawksbill nesting.

In 1998, together with Doug Hykle, Jacques created the Convention on Migratory Species (CMS) Abidjan Memorandum of Understanding, which was signed by 23 African states. He founded sea turtle field projects in Cameroon, Gabon, Guadeloupe, Guinea, Mauritania, Mayotte, São Tomé and Príncipe, Togo, and beyond. In 2018, with the help of Patrick Triplet, Jacques drafted an important habitat resolution for the Ramsar Convention on Wetlands, which is currently being considered for adoption by France and Senegal. Jacques has written or coauthored 30 books and some 230 publications about sea turtles, natural history, and conservation.

What Is Your Proudest Accomplishment in Sea Turtle Conservation?

I'm proud of many things, such as the 10 or so French ministerial decrees and the creation of the Amana Nature Reserve (French Guiana) and the Cameroon National Marine Park, which I initiated. But my proudest and most spectacular achievement is perhaps Resolution 13.24 of the Ramsar Convention. That international resolution has taken on an importance that I never imagined. Thanks to the resolution, many sites around the world will henceforth be classified as "untouchable."

Lily Venizelos

Lily Venizelos spent a great part of her youth on the Greek island of Hydra, where as a girl she got into trouble scaring away game birds that her father and his friends had intended to shoot. In 1974, a storm brought her yacht to shelter in Laganas Bay, Zakynthos, Greece, and she was completely enchanted by its pristine beauty. Five years later, she witnessed the invasion of bulldozers and jet skis that came with uncontrolled tourist development.

Having realized that the bay was rimmed with important nesting beaches, she vowed to fight for its protection. She was unfazed by being chased into the sea by an angry landowner's dog. Even after being throttled by a bishop, she continued to fight the good fight for the turtles of Laganas Bay. She went on to found the Mediterranean Association to Save the Sea Turtles (MEDASSET) in 1988, and MEDASSET turned itself into a fearless and effective lobbying and advocacy organization that today operates across the Mediterranean region. Her work has been honored by the United Nations and IUCN (International Union for Conservation of Nature), and Lily has been recognized by the International Sea Turtle Society with a Lifetime Achievement Award.

What Is Your Proudest Accomplishment in Sea Turtle Conservation?

I'm glad to have been part of the long campaign to achieve the formation of Greece's first marine park at Zakynthos. That great, protracted, and ongoing struggle was and is a battle for protection that I have fought in the corridors of power nationally and internationally. I'm proud that what started as a localized effort focused on one Greek island now extends to six more nesting beaches around the Mediterranean rim, thanks in part to our annual presentations to the Bern Convention. •

Visit **seaturtlestatus.org/legends** to see a Q&A and learn more on each of these living legends.

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 contributors and sources are cited throughout the following pages. For information about how the feature maps of sea turtle biogeography in Southeast Asia were created, please see the text on p. 29.

GUIDELINES OF DATA USE AND CITATION

The nesting and satellite telemetry data that follow correspond to the maps of sea turtle biogeography in Southeast Asia on pp. 30–31. More details about nest data records can be found on the virtual version of this map at https://www.seaturtlestatus.org/maps/southeast-asia-sea-turtles. To use data for research or publication, you must obtain permission from the data providers.

Nesting Data Citations

Additional metadata, including nesting beach names, nest counts, and year of data collection, may be found online on the interactive web version of this map found at https://www.seaturtlestatus.org/maps/southeast-asia-sea-turtles, at http://seamap.env.duke.edu/swot, or by viewing the original data source (if published).

BRUNEI DARUSSALAM

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MYANMAR

Data Sources: (A) Howard, R., K. Myint, P. Maw, P. Zaw, and M. Tiwari. 2019. Improving marine turtle conservation in Myanmar. *Oryx* 53 (3): 409–414; **(B)** Pilcher, N. J. 2023. Green turtle nest counts. Personal communication. In *SWOT Report—The State of the World's Sea Turtles*, vol. XIX (2024); **(C)** Thorbjarnarson, J. B., S. G. Platt, and S. T. Khaing. 2000. Sea turtles in Myanmar: Past and present. *Marine Turtle Newsletter* 88: 10–11.

SWOT Contact: Nicolas Pilcher

PHILIPPINES

Data Sources: (A) Anvaya Environmental Foundation, Morong Bataan Association of Marine Turtle Conservation Network, and 1Bataan Pawikan Conservation Alliance Network (1PawiCAN). 2023. Personal communication. In *SWOT Report—The State of the World's Sea Turtles*, vol. XIX (2024); **(B)** Asian Conservation Foundation and El Nido Marine Turtle Conservation Network. 2023. Personal communication. In *SWOT Report—The State of the World's Sea Turtles*, vol. XIX (2024); **(C)** Cruz, R. 2008. Hawksbill nesting in the Philippines. Personal communication. In *SWOT Report—The State of the World's Sea Turtles*, vol. III (2008); **(D)** Cruz, R. D. 2002. Marine turtle distribution in the Philippines. In I. Kinan (ed.), *Proceedings of the Western Pacific Sea Turtle Cooperative Research and Management Workshop*, pp. 57–66. Western Pacific Regional Fishery Management Council, Honolulu, HI; **(E)** Dethmers, K. E., D. Broderick, C. Moritzi, et al. 2006. The genetic structure of Australasian green turtles (*Chelonia mydas*): Exploring the geographical scale of genetic exchange. *Molecular Ecology* 15 (13): 3931–3946; **(F)** Duli Beach Resort and El Nido Marine Turtle Conservation Network. 2023. Personal communication. In *SWOT Report—The State of the World's Sea Turtles*, vol. XIX (2024); **(G)** El Nido Marine Turtle Conservation Network. 2023. Personal communication. In *SWOT Report—The State of the World's Sea Turtles*, vol. XIX (2024); **(H)** H Hospitality Group and El Nido Marine Turtle Conservation Network. 2023. Personal communication. In *SWOT Report—The State of the World's Sea Turtles*, vol. XIX (2024); **(I)** Palawan Biodiversity Conservation Advocates. 2023. Personal communication. In *SWOT Report—The State of the World's Sea Turtles*, vol. XIX (2024); **(J)** Philippine Reef and Rainforest Conservation Foundation. 2023. Personal communication. In *SWOT Report—The State of the World's Sea Turtles*, vol. XIX (2024); **(K)** Project CURMA (Coastal Underwater Resource Management Actions). 2023. Personal communication. In *SWOT Report—The State of the World's Sea Turtles*, vol. XIX (2024); **(L)** Sagip Pawikan Sitio Fuerte Association, Morong Bataan Association of Marine Turtle Conservation Network, and 1PawiCAN. 2023. Personal communication. In *SWOT Report—The State of the World's Sea Turtles*, vol. XIX (2024); **(M)** Ten Knots Group and El Nido Marine Turtle Conservation Network. 2023. Personal communication. In *SWOT Report—The State of the World's Sea Turtles*, vol. XIX (2024); **(N)** Torres, D. S., E. T. Santa Cruz, L. I. O. Manzanero, and G. A. T. Santa Cruz. 2004. Conservation of a remnant hawksbill nesting habitat in Punta Dumalag, Brangay Matina Aplaya, Davao City, Philippines. *Agham Mindanaw* 2: 35–39; **(O)** Trono, R. B., and C. Fischer. 2019. *Marine Turtle Conservation Action Plan for the Philippines* (*2020 to 2030*). Department of Environment and Natural Resources, Biodiversity Management Bureau.

SWOT Contacts: 1PawiCAN, Anvaya Environmental Foundation, Renato Cruz, El Nido Marine Turtle Conservation Network, Bataan Association of Marine Turtle Conservation Network, Palawan Biodiversity Conservation Advocates, Philippine Reef and Rainforest Conservation Foundation, Project CURMA, Sagip Pawikan Sitio Fuerte Association, and Romeo Trono

THAILAND

Data Sources: (A) Aureggi, M. 2006. Leatherback nesting in Thailand. Personal communication. In *SWOT Report—The State of the World's Sea Turtles*, vol. II (2007); **(B)** Chantrapornsyl, S. 1992. Biology and conservation olive ridley turtle (*Lepidochelys olivacea*, Eschscholtz) in the Andaman Sea, southern Thailand. *Phuket Marine Biological Center Research Bulletin* 57: 51–66; **(C)** Charuchinda, M., and S. Monanunsap. 1998. Monitoring survey on sea turtle nesting in the Inner Gulf of Thailand, 1994–1996. *Thailand Marine Fisheries Research Bulletin* 6: 17–25; **(D)** Hamman, H., F. Flavell, J. Frazier, C. J. Limpus, J. D. Miller, and J. A. Mortimer. 2021. *Assessment of the Conservation Status of the Hawksbill Turtle in the Indian Ocean and South-East Asia Region*. IOSEA Marine Turtle MOU; **(E)** Kaewmong, P., V. Punyapornwithaya, C. Wongfu, et al. 2022. Nest relocation of Leatherback turtles (*Dermochelys coriacea*) decrease the rate of non-developed eggs. *Veterinary Integrative Sciences* 20 (2): 279–289; **(F)** Pilcher, N. J. 2023. Green turtle nest counts. Personal communication. In *SWOT Report—The State of the World's Sea Turtles*, vol. XIX (2024); **(G)** Settle, S. 1995. Status of nesting populations of sea turtles in Thailand and their conservation. *Marine Turtle Newsletter* 68: 8–13; **(H)** Wongfu, C., W. Prasitwiset, A. Poommouang, et al. 2022. Genetic diversity in leatherback turtles (*Dermochelys coriacea*) along the Andaman Sea of Thailand. *Diversity* 14 (9): 764; **(I)** Yasuda, T., H. Tanaka, K. Kittiwattanawong, H. Mitamura, W. Klom-in, and N. Arai. 2006. Do female green turtles (*Chelonia mydas*) exhibit reproductive seasonality in a year-round nesting rookery? *Journal of Zoology* 269: 451–457.

SWOT Contacts: Monica Aureggi and Nicolas Pilcher

VIETNAM

Data Sources: (A) Chu, C. T. 2023. Con Co MPA. Personal communication. In *SWOT Report—The State of the World's Sea Turtles*, vol. XIX (2024); **(B)** Chu, C. T. 2023. Con Dao National Park. Personal communication. In *SWOT Report—The State of the World's Sea Turtles*, vol. XIX (2024); **(C)** Chu, C. T. 2023. Hon Cau MPA. Personal communication. In *SWOT Report—The State of the World's Sea Turtles*, vol. XIX (2024); **(D)** Chu, C. T. 2023. IUCN Vietnam. Personal communication. In *SWOT Report—The State of the World's Sea Turtles*, vol. XIX (2024); **(E)** Chu, C. T. 2023. Nui Chua National Park. Personal communication. In *SWOT Report—The State of the World's Sea Turtles*, vol. XIX (2024); **(F)** Hamann, M., C. The Cuong, N. Duy Hong, P. Thuoc, and B. Thi Thuhien. 2006. Distribution and abundance of marine turtles in the Socialist Republic of Viet Nam. *Biodiversity and Conservation* 15: 3703–3720; **(G)** Hien, T. M. 2002. Status of sea turtle conservation in Vietnam. In I. Kinan (ed.), *Proceedings of the Western Pacific Sea Turtle Cooperative Research and Management Workshop*, pp. 191–194. Western Pacific Regional Fishery Management Council, Honolulu, HI; **(H)** Shanker, K., and N. J. Pilcher. 2003. Marine turtle conservation in South and Southeast Asia: Hopeless cause or cause for hope? *Marine Turtle Newsletter* 100: 43–51.

SWOT Contacts: The Cuong Chu and Mark Hamann

Telemetry Data Citations

The following data records refer to satellite telemetry datasets from tags that were deployed on sea turtles in Southeast Asia and were combined to create the maps on pp. 31. In addition, we have included telemetry data deployed on sea turtles in India's Andaman and Nicobar Islands because of their geographic proximity to Southeast Asia as part of the Sunda Arc. The data are organized by country of deployment. For information on data processing and filtering, see the note on the map on p. 31. 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, A. Bandimere, B. Wallace, B. Hutchinson, J. Cleary, P. Halpin, and R. Mast. 2023. The State of the World's Sea Turtles Online Database. Data provided by the SWOT Team and hosted on OBIS-SEAMAP. Oceanic Society and Marine Geospatial Ecology Lab, Duke University. https://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.

INDIA

DATA RECORD 1

Project Title: Tracking Leatherback Turtles from Little Andaman Island
Metadata: 10 *Dermochelys coriacea*
Data Sources: (A) Swaminathan, A., N. Namboothri, and K. Shanker. 2019. Tracking leatherback turtles from Little Andaman Island. *Indian Ocean Turtle Newsletter* 29: 8–10. **(B)** Namboothri, N., A. Swaminathan, B. C. Choudhury, and K. Shanker. 2012. Post-nesting migratory routes of leatherback turtles from Little Andaman Island. *Indian Ocean Turtle Newsletter* 16: 21–23.
SWOT Contacts: Adhith Swaminathan, Naveen Namboothri, and Kartik Shanker

INDONESIA

DATA RECORD 2 | SWOT ID: 413

Project Title: Piai Island Green Sea Turtle Tracking
Metadata: 2 postnesting *Chelonia mydas*
Data Sources: (A) Ratha, I. 2023. Piai Island green sea turtle tracking. Data downloaded from OBIS-SEAMAP (http://seamap.env.duke.edu/dataset/413) and originated from STAT (http://www.seaturtle.org/tracking/index.shtml?project_id=223). **(B)** OBIS-SEAMAP. **(C)** STAT.
SWOT Contact: I Made Jaya Ratha

DATA RECORD 3 | SWOT ID: 419

Project Title: Sangalaki Green Turtles Tracking
Metadata: 2 adult female *Chelonia mydas*
Data Sources: (A) Ratha, I. 2023. Sangalaki green turtles tracking. Data downloaded from OBIS-SEAMAP (http://seamap.env.duke.edu/dataset/419) and originated from STAT (http://www.seaturtle.org/tracking/index.shtml?project_id=234). **(B)** OBIS-SEAMAP. **(C)** STAT.
SWOT Contact: I Made Jaya Ratha

DATA RECORD 4 | SWOT ID: 447

Project Title: Satellite Tracking of Hawksbill Turtle in West Sumbawa, Indonesia
Metadata: 1 adult female *Eretmochelys imbricata*
Data Sources: (A) Ratha, I. 2023. Satellite tracking of hawksbill turtle in West Sumbawa, Indonesia. Data downloaded from OBIS-SEAMAP (http://seamap.env.duke.edu/dataset/447) and originated from STAT (http://www.seaturtle.org/tracking/index.shtml?project_id=266). **(B)** OBIS-SEAMAP. **(C)** STAT.
SWOT Contact: I Made Jaya Ratha

DATA RECORD 5 | SWOT ID: 449

Project Title: Green Sea Turtles Tracking in Sukamade, Meru Betiri National Park–East Java
Metadata: 4 adult *Chelonia mydas*
Data sources: **(A)** Ratha, I. 2023. Green sea turtles tracking in Sukamade, Meru Betiri National Park–East Java. Data downloaded from OBIS-SEAMAP (http://seamap.env.duke.edu/dataset/449) and originated from STAT (http://www.seaturtle.org/tracking/index.shtml?project_id=275). **(B)** OBIS-SEAMAP. **(C)** STAT.
SWOT Contact: I Made Jaya Ratha

DATA RECORD 6 | SWOT ID: 485

Project Title: Crossing the Tide
Metadata: 3 adult female *Lepidochelys olivacea*
Data Sources: (A) Ratha, I. 2023. Crossing the tide. Data downloaded from OBIS-SEAMAP (http://seamap.env.duke.edu/dataset/485) and STAT (http://www.seaturtle.org/tracking/index.shtml?project_id=348). **(B)** OBIS-SEAMAP. **(C)** STAT.
SWOT Contact: I Made Jaya Ratha

DATA RECORD 7 | SWOT ID: 503

Project Title: Bali Turtles
Metadata: 1 subadult *Chelonia mydas* and 2 adult female *Chelonia mydas*
Data Sources: (A) Udayana University of Bali and WWF-Indonesia. 2023. Bali turtles. Data downloaded from OBIS-SEAMAP (http://seamap.env.duke.edu/dataset/503) and originated from STAT (http://www.seaturtle.org/tracking/index.shtml?project_id=390). **(B)** OBIS-SEAMAP. **(C)** STAT.
SWOT Contacts: Udayana University of Bali and WWF-Indonesia

DATA RECORD 8 | SWOT ID: 505

Project Title: Tracking on Magnifying Olive Ridley Journey in Kaironi Beach, Papua, Indonesia
Metadata: 5 adult female *Lepidochelys olivacea*
Data Sources: (A) Udayana University of Bali and WWF-Indonesia. 2023. Tracking on magnifying olive ridley journey in Kaironi Beach, Papua, Indonesia. Data downloaded from OBIS-SEAMAP (http://seamap.env.duke.edu/dataset/505) and originated from STAT (http://www.seaturtle.org/tracking/index.shtml?project_id=391). **(B)** OBIS-SEAMAP. **(C)** STAT.
SWOT Contacts: Udayana University of Bali and WWF-Indonesia

DATA RECORD 9 | SWOT ID: 540

Project Title: Tracking on Green Sea Turtles in South Misol, Raja Ampat–Papua, Indonesia
Metadata: 1 adult female *Chelonia mydas*
Data Sources: (A) Udayana University of Bali and WWF-Indonesia. 2023. Tracking on green sea turtles in South Misol, Raja Ampat–Papua, Indonesia. Data downloaded from OBIS-SEAMAP (http://seamap.env.duke.edu/dataset/540) and originated from STAT (http://www.seaturtle.org/tracking/index.shtml?project_id=437). **(B)** OBIS-SEAMAP. **(C)** STAT.
SWOT Contacts: Udayana University of Bali and WWF-Indonesia

DATA RECORD 10 | SWOT ID: 553

Project Title: Derawan Green Turtles Tracking
Metadata: 1 subadult female *Chelonia mydas*
Data Sources: (A) Ratha, I. 2023. Derawan green turtles tracking. Data downloaded from OBIS-SEAMAP (http://seamap.env.duke.edu/dataset/553) and originated from STAT (http://www.seaturtle.org/tracking/index.shtml?project_id=469). **(B)** OBIS-SEAMAP. **(C)** STAT.
SWOT Contact: I Made Jaya Ratha

DATA RECORD 11 | SWOT ID: 653

Project Title: Satellite Tracking Project, Pulau Banyak, Aceh, Sumatra, Indonesia
Metadata: 2 adult female *Chelonia mydas*
Data Sources: (A) Muurmans, M. 2023. Satellite tracking project, Pulau Banyak, Aceh, Sumatra, Indonesia. Data downloaded from OBIS-SEAMAP (http://seamap.env.duke.edu/dataset/653) and originated from STAT (http://www.seaturtle.org/tracking/index.shtml?project_id=518). **(B)** OBIS-SEAMAP. **(C)** STAT.
SWOT Contact: Maggie Muurmans

DATA RECORD 12

Project Title: Leatherbacks Tagged in Selaut Besar, West Sumatra
Metadata: 2 adult *Dermochelys coriacea*
Data Sources: Reischig, T., R. Patricio, and Balai Pengelolaan Sumberdaya Pesisir dan Laut (BPSPL) Padang. 2022. Leatherbacks tagged in Selaut Besar, West Sumatra. Personal communication. In *SWOT Report—The State of the World's Sea Turtles*, vol. XVIII (2023).
SWOT Contacts: Thomas Reischig and Rita Patricio

MALAYSIA

DATA RECORD 13 | SWOT ID: 725

Project Title: Identification of secondary foraging grounds for green turtles as they depart Mantanani, Malaysia
Metadata: 3 juvenile male and 2 juvenile female *Chelonia mydas*
Data Sources: (A) Pilcher N. J. 2023. Identification of secondary foraging grounds for green turtles as they depart Mantanani, Malaysia. Data downloaded from OBIS-SEAMAP (http://seamap.env.duke.edu/dataset/725) and originated from Satellite Tracking and Analysis Tool (STAT; http://www.seaturtle.org/tracking/index.shtml?project_id=593). **(B)** OBIS-SEAMAP. **(C)** STAT.
SWOT Contact: Nicolas Pilcher

DATA RECORD 14 | SWOT ID: 975

Project Title: Satellite Tracked Green Turtles in the South China Sea, 1993–1994
Metadata: 5 adult female *Chelonia mydas*
Data Sources: (A) Luschi, P. 2013. Satellite tracked green turtles in the South China Sea, 1993–1994. Data

downloaded from OBIS-SEAMAP (http://seamap.env.duke .edu/dataset/975). **(B)** Luschi, P., F. Papi, H. C. Liew, E. H. Chan, and F. Bonadonna. 1996. Long-distance migration and homing after displacement in the green turtle (*Chelonia mydas*): A satellite tracking study. *Journal of Comparative Physiology* 122: 171–175. **(C)** Papi, F., H. C. Liew, P. Luschi, and E. H. Chan. 1995. Long-range migratory travel of a green turtle tracked by satellite: Evidence for navigational ability in the open sea. *Marine Biology* 122: 171–175. **(D)** OBIS-SEAMAP.
SWOT Contact: Paolo Luschi

DATA RECORD 15 | SWOT ID: 1502

Project Title: Tracking Rehabilitated Green Turtles from Mabul Island, Sabah, Malaysia
Metadata: 3 juvenile *Chelonia mydas*
Data Sources: **(A)** Pilcher N. J. 2023. Tracking rehabilitated green turtles from Mabul Island, Sabah, Malaysia. Data downloaded from OBIS-SEAMAP (http://seamap.env.duke.edu/dataset/1502) and originated from STAT (http://www.seaturtle.org/tracking/index .shtml?project_id=1276). **(B)** OBIS-SEAMAP. **(C)** STAT.
SWOT Contact: Nicolas Pilcher

DATA RECORD 16

Project Title: Sea Turtle Tracking in Malaysia
Metadata: 80 green and 22 *Eretmochelys imbricata*
Data Source: 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: Nicolas Pilcher

PHILIPPINES

DATA RECORD 17

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

SINGAPORE

DATA RECORD 18

Project Title: Hawksbills Tracked in Singapore
Metadata: 8 *Eretmochelys imbricata*
Data Source: Uchida, I., H. H. Chng, M. Rice, D. Parker, and G. H. Balazs. 2010. Hawksbills tracked in Singapore. Personal communication. In *SWOT Report—The State of the World's Sea Turtles*, vol. XVII (2022).
SWOT Contacts: Itaru Uchida, Chng Hwee Hong, Marc Rice, Denise Parker, and George H. Balazs

TIMOR-LESTE

DATA RECORD 19

Project Title: Sea Turtles of the Coral Triangle
Metadata: 1 *Lepidochelys olivacea*, 5 *Eretmochelys imbricata*, and 4 *Chelonia mydas*; all internesting females
Data Sources: Gearheart, G. Sea turtles of the Coral Triangle. Data downloaded from ZoaTrack (https:// zoatrack.org/projects/560/map) on October 20, 2023, under a Creative Commons Attribution-NonCommercial-NoDerivs License (https://creativecommons.org/licenses /by-nc-nd/3.0/#ref-appropriate-credit).
SWOT Contact: Geoffrey Gearhart

VIETNAM

DATA RECORD 20 | SWOT ID: 373

Project Title: Vietnam Sea Turtle Tracking Project
Metadata: 6 adult female *Chelonia mydas*
Data Sources: **(A)** Pilcher, N. J. 2023. Vietnam Sea Turtle Tracking Project. Data downloaded from OBIS-SEAMAP (http://seamap.env.duke.edu/dataset/373) and originated from STAT (http://www.seaturtle.org/tracking/index .shtml?project_id=179). **(B)** OBIS-SEAMAP. **(C)** STAT.
SWOT Contacts: Nicolas Pilcher and Thuy Nguyen

MULTINATIONAL

DATA RECORD 21 | SWOT ID: 1300

Project Title: Identification of Important Turtle Areas for Green Turtles in the Sulu Sulawesi Marine Ecoregion
Metadata: 25 adult female and 2 adult male *Chelonia mydas*
Data Sources: **(A)** Pilcher, N. J. 2023. Identification of important turtle areas for green turtles in the Sulu Sulawesi marine ecoregion. Data downloaded from OBIS-SEAMAP (http://seamap.env.duke.edu/datase t/1300) and originated from STAT (http://www.seaturtle .org/tracking/index.shtml?project_id=1114). **(B)** OBIS-SEAMAP. **(C)** STAT.
SWOT Contact: Nicolas Pilcher

DATA RECORD 22

Project Title: Large-Scale Movements and High-Use Areas of Western Pacific Leatherback Turtles, *Dermochelys coriacea*
Metadata: 126 adult and subadult *Dermochelys coriacea*
Data Source: Benson, S. R., T. Eguchi, D. G. Foley, et al. 2011. Large-scale movements and high-use areas of western Pacific leatherback turtles, *Dermochelys coriacea*. *Ecosphere* 2 (7): 1–27.
SWOT Contact: Scott Benson

In Memoriam

In recent years, a number of beloved members of our global community have passed away, including those memorialized here and many more whose legacies remain in the communities they served. SWOT is grateful to all the sea turtle researchers, conservationists, and enthusiasts who are no longer with us, and we recognize all those people—past and present—who dedicate their lives to helping ensure that future generations can experience and enjoy abundant sea turtles in healthy oceans.

Satish Bhaskar (1946–2023)

A legendary sea turtle pioneer, Satish Bhaskar surveyed most of India's coast, the shores of West Papua (Indonesia), and nearly all the beaches of the Andaman and Nicobar Islands. His sojourns in the late 1970s provided the first information about sea turtles in that remote archipelago. Among many epic tales of Satish's career was a 1982 stint monitoring greens on the uninhabited island of Suheli Valiyakara in the Lakshadweep Islands, India, from which he corresponded with his wife—successfully—via messages sent afloat in a bottle. He presented a landmark paper at the World Conference on the Biology and Conservation of Sea Turtles in 1979, which was a historic event in the history of sea turtle biology. Satish inspired a generation of researchers and conservationists and set unmatched examples of tireless, passionate effort to fill knowledge gaps in sea turtle status. He received the International Sea Turtle Society (ISTS) Sea Turtle Champions Award in 2010 in recognition of his lifetime of iconic work.

Catherine McClellan (1970–2022)

Raised by the Mississippi River, Catherine became an international conservationist after studies at the University of Wisconsin–Madison, followed by graduate degrees in marine ecology from Duke University and a postdoctoral fellowship at the University of Exeter in Cornwall, England. She had a passion for animals, and she centered her studies on marine megafauna, from blackfish to basking sharks, but especially sea turtles. Her work focused on fisheries bycatch, migratory connectivity, behavior, and conservation. She loved the outdoors and felt blessed to have explored many amazing places during her life, but she was especially touched by the coastal region and people of Gabon, where she conducted fieldwork with the largest leatherback sea turtle population in the world. She spoke French and worked elsewhere in francophone Africa also. In addition, she worked in the Americas (South Carolina), the United Kingdom (English Channel), and beyond. She strove for excellence in her research and loved her family, friends, and animals tenaciously.

Chuck Schaffer (1956–2021)

Chuck was one of those rare people who bridged the oddly large gap that exists between the sea turtle community and the freshwater turtle and tortoise community. A regular attendee at the annual Sea Turtle Symposium, he coordinated a special freshwater turtle and tortoise session for many years that attracted terrestrial chelonian experts from many countries and piqued the curiosity of experts from both worlds. He was an accomplished writer and served as editor of the IUCN's *Turtle and Tortoise Newsletter* for several years; he loved and collected antiquarian books and (mostly turtle-themed) memorabilia; and his memory of every meeting he attended, every country he visited, and every turtle he had seen in the field was truly astounding. He not only adored turtles but also cared about conserving them. His smile, lively spirit, jovial and outgoing personality, love of travel and nature, and commitment to family and friends will be deeply missed.

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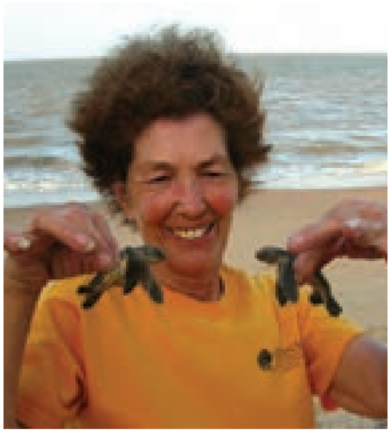
Gail Schofield (1975–2023)

A highly published marine biologist concerned with ocean megafauna conservation, Gail passionately pursued research about loggerhead behavior and conservation as a volunteer at ARCHELON's conservation project in Laganas Bay, Zakynthos, Greece, and ultimately through her job at Queen Mary University of London (UK), where she gained the respect and admiration of coworkers, students, and all who knew her. Gail was a role model who taught and mentored with strength and kindness. She encouraged students to reach their highest potential and cultivated their passion for conservation. She was a full-time sea turtle fanatic and spent countless weeks tracking and observing turtles on the beaches of Zakynthos and elsewhere while sharing her enthusiasm with her son, who loved the exhibits at the Natural History Museum in London. Her tireless efforts to raise awareness about the importance of protecting sea turtles drove countless others to take up the cause. A colleague, mother, mentor, and friend, Gail remains an inspiration to all those who knew her.

Eleanor Sterling (1960–2023)

Eleanor Sterling began her career studying lemurs in Madagascar and came to sea turtles later. However, she spent her entire professional life honoring the interconnectedness of nature and people among indigenous peoples and local communities around the world. She led the American Museum of Natural History as scientist and director across two decades while growing the Center for Biodiversity and Conservation. She later became the director of the Hawaiʻi Institute of Marine Biology at the University of Hawaiʻi–Mānoa, where she remained until her untimely death. In all areas of her work, Eleanor centered her efforts on equity, inclusion, and diversity. Those who attended the Sea Turtle Symposium in Goa (2010) will recall Eleanor's compassion and kindness in assisting fellow conservationist Lily Venizelos after Lily suffered a serious injury. Eleanor received the IUCN's prestigious Fred Packard Award in recognition of more than 30 years of advancing just and effective conservation and for her extraordinary lifetime contributions to conservation.



Nancy Wotkyns (1942–2023)

An activist and sea turtle enthusiast who traveled with Oceanic Society for more than two decades, Nancy, with her love of and dedication to supporting local communities, has left a lasting mark in Suriname, Mexico, and elsewhere. She managed a mobile home park in rural Michigan (U.S.A.) and was a no-nonsense, fiercely independent individual who loved connecting with nature and exploring the remote corners of the world. When she volunteered on the leatherback beaches in Suriname, she was the first to hit the beach at dusk and the last one off at dawn. Her boundless enthusiasm was infectious. Nancy made deep and personal connections with the local communities in the places she visited, never failing to bring multiple suitcases of gifts and essential items to leave behind and with only a tiny carry-on for herself. As we mourn her loss, we are also filled with gratitude for her generous spirit and the posthumous gift she made in support of SWOT.

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Thank you!

We are grateful to the following donors for their support of the SWOT Program in 2023–2024: Betlach Family Foundation, Marisa I. Hormel Trust, Moore Family Foundation, Seiko, Joseph and Diane Steinberg, Mark Swingle, and Upwell Coffee, as well as the Association of Zoos & Aquariums' Sea Turtle SAFE (Saving Animals From Extinction) Program and its partners, including: Adventure Aquarium, Aquarium of the Pacific, Audubon Nature Institute, Florida Aquarium, Gladys Porter Zoo, Mystic Aquarium, National Aquarium, New England Aquarium, North Carolina Aquarium on Roanoke Island, OdySea Aquarium, Remote Ecologist Inc., SEA LIFE Arizona Aquarium, South Carolina Aquarium, Texas State Aquarium, The Aquarium at Moody Gardens, The Maritime Aquarium at Norwalk, Topeka Zoo & Conservation Center, and Virginia Aquarium & Marine Science Center.

We are particularly indebted to and wish to recognize **Gordon Moore (1929–2023)** and his beloved wife of 72 years, **Betty Moore (1928–2023)**, for their decades of support to SWOT. As the founder of Intel, a semiconductor pioneer, and the author of Moore's Law, Gordon gave us the technology that shapes our everyday lives. Betty is remembered as an advocate for patients and families, a champion of nursing, and a pioneer for improving health care. She was responsible for founding a school to transform health care, and together she and Gordon built the Gordon and Betty Moore Foundation to seek durable change in environmental conservation, scientific research, and higher education. Their generosity will shape the world for generations to come.

Gordon and Betty, along with their sons, Ken and Steve, and daughters-in-law, Kris and Kathleen, were believers in SWOT since its inception in 2003. One family member shared with SWOT's cofounders that "Gordon stated on several occasions . . . that SWOT had accomplished the kind of thing he and Betty set out to do back in 1986—make an important difference that could be measured. Gordon thought SWOT was a perfect example of how our family could make an impact because of the grantee's scientific, thorough, and consistent approach; SWOT's filling of the gaps in knowledge of sea turtles, especially as indicator species for the state of our oceans, gave him great satisfaction." Those who knew Gordon and Betty will be forever inspired by their wisdom, humility, and generosity.

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SWOT report
The State of the World's Sea Turtles

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