SWOT report

SPECIAL 10th ANNIVERSARY EDITION

The State of the World's Sea Turtles

SEA TURTLES OF COSTA RICA

ALSO INSIDE:

HANDS-OFF SCIENCE

KEMP'S RIDLEY

UPDATES FROM THE MEDITERRANEAN

AND MORE…

A hawksbill turtle in Kimbe Bay, Papua New Guinea. © DAVID DOUBILET FRONT COVER: An aerial view of an *arribada*, or mass nesting, of olive ridley turtles at Ostional National Wildlife Refuge in Costa Rica. © SERGIO PUCCI / WWW.PUCCI.CR

Editor's Note

Returning to Our Natal Shores

Sea turtles are global citizens. And that is why the State of the World's Sea Turtles (SWOT) program has always been global as well: a global network of people, a global scale database, global outreach through *SWOT Report*, and global support to field projects through SWOT grants. But if it can be said that SWOT had a birthplace and nationality, it would certainly be Costa Rica.

The concept for the SWOT program was born on the beaches of Costa Rica in 2003, and SWOT was first introduced to the world community at the 24th Annual Sea Turtle Symposium in San José, Costa Rica, in 2004. The leatherback had been chosen as the symposium's mascot to draw attention to its plight on Costa Rica's Pacific coast, and Costa Rica's President Abel Pacheco opened the symposium with an impassioned speech underscoring the importance of his country for sea turtle research and conservation. That same day, SWOT's first call for data contributions was announced, which ultimately resulted in the publication of the first global-scale map of leatherback nesting sites in *SWOT Report*, vol. I (2006).

Now, after more than a decade of global-scale data aggregation, mapping, and priority setting that has touched all seven species on their nesting beaches and at sea in every sea turtle-harboring country on Earth, it is only fitting that SWOT returns to its roots with a centerpiece map highlighting Costa Rica's rich, varied, and superlative sea turtle bounty. This all-species map of sea turtle nesting in Costa Rica (pp. 22–23) distills a portion of our global database into a country-scale overview for the first time and marks a new era in which SWOT will work with national experts worldwide to present sea turtle biogeography in geopolitical terms. It is sovereign nations, after all, that hold the ultimate responsibility for managing their living resources, so country-scale maps such as this can be powerful tools to guide conservation.

In this issue, we also highlight the stories of SWOT team members in the Cayman Islands, Cyprus, Greece, Mexico, the Persian Gulf, and beyond who are working hard to assure a future for sea turtles. We examine trends in "hands-off technology," we consider the "true value" of sea turtles, and we take a trip back in time with an engaging look at the history of the Kemp's ridley.

Most important, we celebrate this 10th anniversary of *SWOT Report* by recognizing our SWOT team community as a whole, including all the authors, data contributors, designers, mapmakers, data managers, artists, photographers, and donors who have made *SWOT Report* possible over the past decade.

Thank you all,

Roderic B. Mast

AT LEFT: Olive ridley hatchlings emerge at Ostional National Wildlife Refuge in Costa Rica.
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State of the World's Sea Turtles
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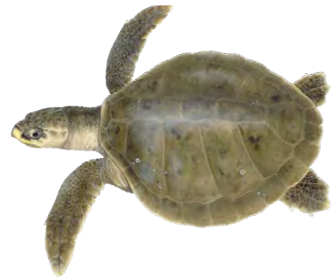
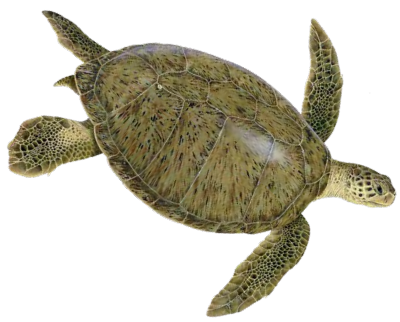
meet the turtles

The seven sea turtle species that grace our oceans belong to a unique 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.

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

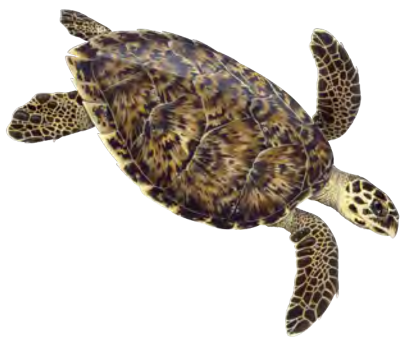


Kemp's ridley (*Lepidochelys kempii*)
IUCN Red List status: Critically Endangered



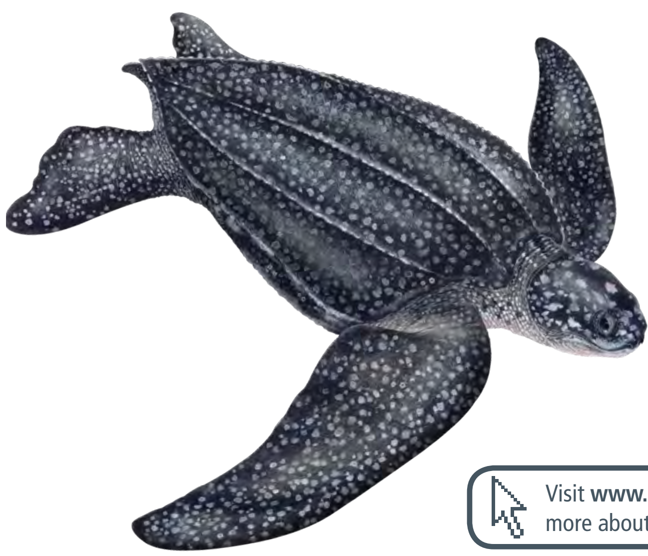
Green (*Chelonia mydas*)
IUCN Red List status: Endangered

Loggerhead (*Caretta caretta*)
IUCN Red List status: Endangered



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

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



Leatherback
(*Dermochelys coriacea*)
IUCN Red List status:
Vulnerable

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

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

THIS PAGE: A close-up of a green turtle in Tenerife, Canary Islands. © SERGI GARCIA FERNÁNDEZ ILLUSTRATIONS, AT LEFT: © DAWN WITHERINGTON

HANDS-OFF SCIENCE
through Technology

For the past 50-plus years, modern sea turtle biology has been a largely hands-on affair. Methods such as flipper, microchip, and satellite tagging; hand and net capture; blood and tissue sampling; captive observation; laparoscopy; hatchling dissection; gastric lavage; and other methods that involve physically handling sea turtles have been fundamental to our ever-improving knowledge of sea turtle biology. Yet given that sea turtles are threatened throughout much of the world, the potential impacts (however minor) of such invasive methods have always been a concern. Moreover, many of the most important data collection methods in sea turtle biology—such as nightly nesting beach patrols and saturation tagging, aerial surveys, satellite tag deployment, and boat-based surveys—not only are expensive but also are labor intensive.

Fortunately, advances in technology are increasingly allowing researchers to take a more hands-off approach without sacrificing results, thereby generating the same data more cheaply, in less time, with fewer people, and with less of an impact on the turtles. The articles that follow in this section present three examples of ways in which scientists across the world are using technology to advance their research through less-invasive and less-intensive methods. The examples barely scratch the surface. Other hands-off methods including stable isotope analysis, remote temperature data logging, time-lapse photography, passive acoustic monitoring, and remote sensing are also being used for various aspects of sea turtle research. The availability of such techniques will only increase as computers become smaller, cheaper, and faster.

eyes in the sky

HELP SEA TURTLE RESEARCH

By ERIC ANGEL RAMOS

As the sun peeks over the ocean horizon, a group of scientists and volunteers begin their morning patrols along a remote beach. They are searching for the scratchy signs of turtle nesting activity. They are accompanied by a small remote-controlled quadcopter drone, buzzing high above their heads. It glides over kilometers of shoreline in minutes and returns by itself to a preset base with images that will be rapidly processed to reveal nesting activity from high altitudes. This could be a common scene in the near future as the conservation world is transformed by the use of drones—also called unmanned aerial vehicles (UAVs)—for monitoring terrestrial and marine ecosystems.

The conservation and management of migratory marine megafauna is costly and challenging. Sea turtles such as the leatherback travel thousands of kilometers in a single year between their foraging and nesting habitats in tropical and subtropical regions. This migration creates challenges for researchers and others who are attempting to estimate turtle abundance or to elucidate threats to their survival.

The use of small manned aircraft, such as biplanes or helicopters, to perform aerial surveys has long been a standard practice in monitoring populations of marine megafauna. The higher the eye, the more it can see. But those flights are generally costly, and engine noise can adversely affect animals' behavior during low flybys.

Small, maneuverable, inexpensive, and no louder than the hum of a beehive, drones provide a solution to the deficits of manned flight surveys. One person, acting from land or boat, can easily deploy and operate a drone without aid, either guiding the UAV by remote control or sending it on an autonomous preprogrammed mission with a preset return point. The unsupervised drone will fly, collect data, and then come home to land by itself. A stabilized high-resolution camera is used to gather imagery from on high, which allows for species identification and observation of marine animals from a range of altitudes.

UAVs are already being used in this way around the world. Scientists from the National Oceanic and Atmospheric Administration (NOAA) deploy custom-built hexacopters to examine the reproductive health of killer whales in the North Pacific and to collect genetic samples from the exhalations of sperm whales off New Zealand. Moreover, images acquired from UAVs deployed in the Antarctic are being used to remotely measure the weight and size of leopard seals.

Traditionally, monitoring of sea turtle nesting relies on observers walking long hours along often remote nesting beaches. With the aid of UAVs, performing those sweeps is a lot easier. On the beaches of Sint Maarten, rangers from the Nature Foundation pilot a low-cost remote-controlled drone to conduct daily turtle monitoring activities. A short flight saves hours of searching and reduces the likelihood of disturbing nesting females or trampling freshly laid nests. Their drone will help to identify the species that frequent their beaches during the breeding season. It will even assess threats to the turtles: sources of pollution, illegal harvesting of turtles and their eggs, and degradation of beach habitat by coastal development. Equipped with a small light and with a low risk of disturbance, their drone could even monitor the beaches at night when female turtles are actively nesting.

The use of UAVs will benefit turtle observers at sea as well as on land. Scientists at the Inwater Research Group, in collaboration with NOAA's Florida Keys National Marine Sanctuary, are preparing to use UAVs during their boat-based transects of foraging grounds of the green sea turtle. The UAVs may greatly improve the accuracy of the team's turtle counts, particularly in cases with too many turtles for observers to reliably count on their own. Green turtles at this location also tend to be boat-shy, fleeing from research vessels before observations can be made. Quieter, less-invasive UAVs may solve this problem.

Of course, all methods have their drawbacks. Surface glare and variations in water depth and clarity may interfere with turtle identification when using an airborne camera. Polarizing filters on the cameras' lenses may help to overcome glare, but turtle identification at depths greater than 6 meters (20 feet) may still require unusually calm sea conditions.

Before designing a drone research program, each research team must carefully consider the merits of the various UAVs available. Copter-style drones, propelled with multiple rotors, are highly maneuverable, typically small, and easily portable, and they can hover stably while changing altitudes, but they provide only 20 minutes or so of flight time per battery. Fixed-wing airframes modeled after small planes or gliders can travel long distances for upward of an hour, but they lack the ability to hover in place and typically require more space for landing.

As UAV technology develops, sea turtle research will benefit from the proliferation of customizable drones as costs drop and capabilities skyrocket. Drones for conservation are here to stay, and the unique perspective they can give us shows a vast potential for elucidating the lives of sea turtles and other marine megafauna. In the capable hands of scientist-pilots working from the beach or by boat, drones are a remarkable tool that will enable ever-smarter marine conservation. ■

Researchers prepare a quadcopter drone for aerial surveys in Turneffe Atoll, Belize. © KATHI KOONTZ AT LEFT: The researchers' boat can be seen above seagrass habitat in this image captured by a quadcopter drone during research in Turneffe Atoll, Belize. © ERIC ANGEL RAMOS

A NEW WAY TO TAG

By BRIAN M. SHAMBLIN and CAMPBELL J. NAIRN

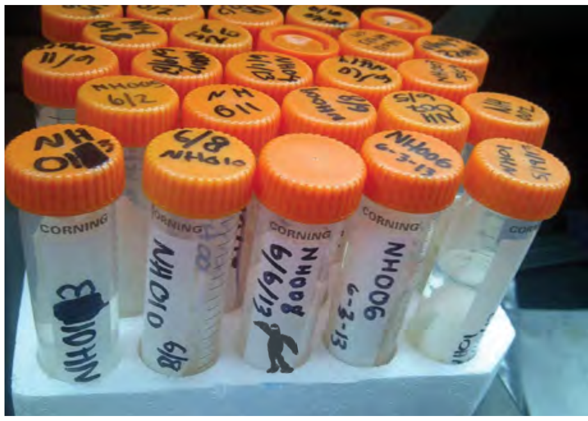
If you have ever worked on a sea turtle nesting beach project, then you have probably had the experience of snapping a metal tag to the trailing edge of a sea turtle's flipper. You have probably also thought about how the process of tagging itself might have affected the behavior of that turtle, or you may have wondered if you would ever see her or the tag again. Tagging studies have taught us a lot over the years, but the fact is that for some populations, most tagged females are indeed never seen again, likely because of low nest site fidelity relative to the scale of the tagging effort. And saturation tagging is difficult; patrolling a study area every hour during the nesting season to intercept nesting females can require an enormous number of participants and can pose significant and costly logistical challenges. Yet until recently, flipper tagging has been the only option for obtaining reliable demographic data about how many females are nesting, how many clutches of eggs they are laying, and how often they are remigrating (i.e., how frequently they are returning to nest).

In recent years, however, a new technique has emerged as an alternative means of collecting individual fecundity data. The method uses genetic tagging of females through nest sampling. Each female leaves behind a DNA record in her eggshells, and researchers can now exploit nuclear genomic variation between turtles to identify unique genetic fingerprints for each individual. Those intrinsic genetic tags permit researchers to assign clutches sampled during morning surveys to individual females without the need to physically intercept the adult turtles. The data collected are analogous to those collected through conventional tagging, and they allow researchers to estimate nesting female population size and annual survival, as well as clutch frequency and remigration intervals.

Nest sampling confers a few critical advantages over conventional tagging. First, the ability to fingerprint eggs opens up possibilities for tagging on geographical scales that would be logistically impossible with standard tagging patrols. Second, nest sampling is noninvasive to nesting females and alleviates concerns about how tagging might affect their behavior. Perhaps most significantly, the same genetic markers used for individual identification can clarify relationships among nesting females. Long-term projects linking daughters to their mothers could ultimately assess natal site fidelity, reproductive longevity, reproductive fitness, and recruitment patterns.

Genetic tagging of eggs is not without its drawbacks, however. Eggs ideally would be sampled within the first few days of incubation to reduce the likelihood of contamination from embryonic nuclear DNA. This approach requires the collection of a single viable egg from each clutch, unless eggshells are available through depredation or natural breakage. Also, genetic analysis must currently be conducted in a specialized laboratory. However, with rapidly evolving genetic technologies, we may one day be able to undertake such work at field sites.

Undeveloped eggs sampled following hatchling emergence can yield maternal DNA. Unfortunately, the warm, moist conditions ideal for embryo development promote rapid degradation of the maternal nuclear DNA present in the eggshell. Even in fresh eggs, the amount of DNA present is markedly lower than in a tissue or blood sample, so additional analyses are often necessary in approximately 10 to 15 percent of samples to resolve genetic fingerprinting errors. Nevertheless, the wealth of information gained through egg-derived tagging outweighs the disadvantage of destructive sampling and the technical challenges of analyzing small amounts of DNA. Moreover,



Each female leaves behind a DNA record in her eggshells, and researchers can now exploit nuclear genomic variation between turtles to identify unique genetic fingerprints for each individual.

researchers can use stable isotope signatures of yolks from sampled eggs to assign females to major foraging areas. By having researchers combine those powerful techniques, it is possible to determine the reproductive consequences of foraging in different regions.

We are currently conducting a genetic tagging project with the goal of sampling every recorded loggerhead nest north of Florida in collaboration with state agency sea turtle programs and with state and federal biologists, researchers, and volunteer groups in Georgia, Maryland, North Carolina, South Carolina, and Virginia. This range encompasses the majority of nesting habitats of the Northern Recovery Unit of loggerheads that nest in the southeastern United States. Genetic tagging is ideal for this subpopulation because nesting densities are low to moderate. Moreover, validating the egg chamber is standard morning survey protocol for all nests in this region.

Genetic tagging of unincubated eggs is a robust technique for individual identification in situations where direct interception of nesting females is not feasible or is too expensive and labor intensive. Some projects have ceased flipper tagging altogether. For instance, the Little Cumberland Island Sea Turtle Project, one of the longest-running saturation tagging efforts in the world (1964–present), switched entirely to genetic tagging in 2010. Former intern Jocelyn Coulter inspired the idea of egg tagging in 2005 when she froze depredated eggs from a freshly laid clutch where the turtle had evaded patrollers. We were later able to match the eggs' genetic fingerprint to a skin sample from a female they had tagged earlier in the season.

Although this modern approach is not appropriate for all nesting populations, it provides an alternative to flipper tagging for turtle rookeries where nest sampling is logistically manageable. Fully exploiting the benefits of egg sampling requires partnerships with agencies and volunteer networks that conduct nest surveys across the potential range of the nesting population. For rookeries where all those elements come together, this technique will continue to yield novel insights into sea turtle behavior for the foreseeable future. ■

CLOCKWISE, FROM TOP: An olive ridley deposits eggs into her nest chamber. © SERGIO PUCCI / WWW.PUCCI.CR ; A researcher collects an eggshell for genetic analysis to identify the individual turtle that laid the eggs. © MATTHEW GODFREY / NCWRC; Eggshell samples await analysis. © MATTHEW GODFREY / NCWRC

Picture Perfect

PHOTOGRAPHY FOR TURTLE MONITORING

By STEPHEN G. DUNBAR and HARUKA ITO

In July 2010, a local fisherman in Roatán, Honduras, brought us two hawksbill turtles that he had accidentally captured while fishing. In the past, the turtles would simply have been killed and eaten, but since 2006 we have been working with fishermen in Roatán to take their incidentally captured turtles as part of the ongoing research of the Protective Turtle Ecology Center for Training, Outreach, and Research, Inc. (ProTECTOR). Each turtle brought to us (or that we capture during surveys) is systematically weighed, measured, flipper tagged, etched with a number on the shell, and photographed. If the turtle is recaptured, it provides us with important information about its movements, growth rate, and life history, and it can contribute to our understanding of the population as a whole.

Upon examining the turtles brought to us that day in July 2010, we clearly knew that we had previously tagged and released them. However, their tags had been removed and the shell etching had almost fully healed over, making them unidentifiable using our normal methods. Our only hope was to compare new photographs of them to our database of hundreds of old photographs so we could find a match. After much searching, we found matches for both turtles and determined that they had originally been captured and released in 2007. We learned that each had gained more than 6 kilograms (13 pounds) and had grown in length and width since their last capture, which was important information for our research. But searching through the hundreds of photographs was a tedious and time-consuming process, and it was not a method we could regularly use.

However, the process made us wonder: could we digitally manipulate the photographs in a way that would allow a computer to take on the task of searching the photo database to come up with a possible match? If digital matching were possible, not only could it help us the next time a turtle's tag was lost or unreadable, but also it could replace the tagging process altogether. After all, recapturing sea turtles in the water requires significant resources, including watercraft, fuel, time, and people power, and it may also cause the turtles unnecessary stress. Finding a way to identify and reidentify turtles over time without the need to physically capture them could open up many possibilities for us and for hundreds of other projects that use similar techniques. So we began to look for an answer.

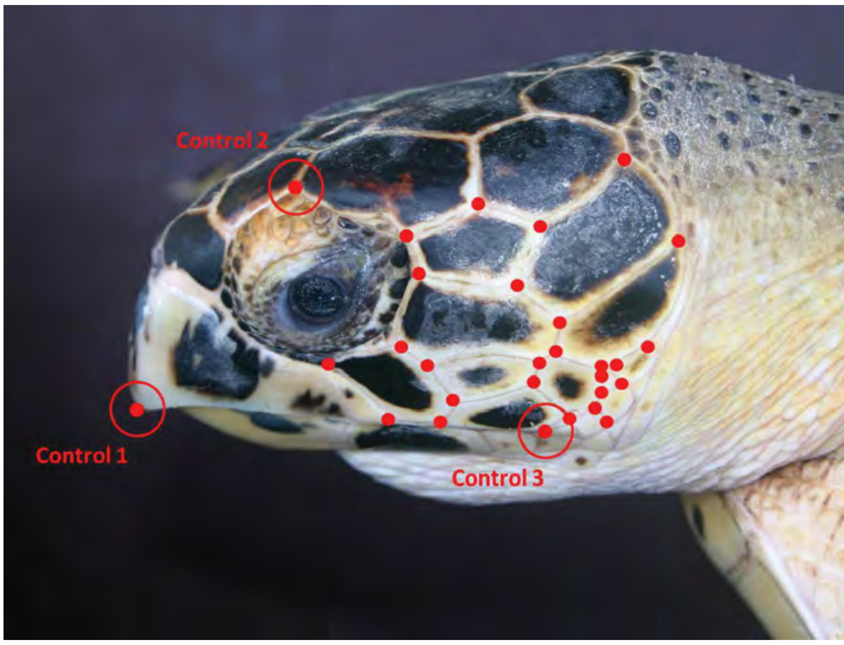
Finding a way to identify and reidentify turtles over time without the need to physically capture them could open up many possibilities for us and for hundreds of other projects that use similar techniques.

Although photographic identification of animals is not a new technique, relatively few sea turtle studies have put it to use. For turtles, the process requires that baseline photographs be taken of the turtle's head or face to create a database against which new photos can be carefully compared for matching scale patterns. The method works because the scale pattern of each turtle's face is unique, and though the scales change in size as the turtle grows, they do not change in orientation or pattern. Scale patterns can, therefore, be used to reidentify individual animals—even several years after the initial encounter. A few previous studies have had success with this technique, but the process has involved manually searching through a database of turtle photographs, which can be a daunting and laborious task.

We could not find a computer program that would allow us to trace the shape and arrangement of the scales and compare them from one photo to another, but we did find the Interactive Individual Identification System (I³S) program, which identifies patterns of spots and has been used for matching photographs of whale sharks. We decided to try using the program to "spot" the junction of each scale in a select area of scales on the face and head of our turtles, and the program quickly and easily found matches of the new photographs to the old photographs of our two recaptured turtles.

After that promising first result, we began running single-blind tests for turtle photographs in the database and random turtle photographs from outside sources, and we found that I³S did a good job of detecting potential matches quickly! We have since been testing a new version of I³S (Pattern, a version specifically designed for turtles), and though it does help with identification, we have found that it has some limitations. A more dynamic photo ID detection and manipulation system is ultimately still needed for sea turtles.

Even with limitations of the software that is currently available, we see far-reaching potential for use of a global computer-assisted photo ID system for sea turtles. Such a system would help scientists track movements and monitor growth in individual turtles in different areas of their ranges. A global photo database could also be open to citizen science contributions by divers and snorkelers, thus extending the effect of sea turtle conservation efforts around the world. ■



The face of a hawksbill turtle, illustrated to show the "spots" at the junctions between scales that were used in testing pattern recognition software. © STEPHEN DUNBAR AT LEFT: A snorkeler photographs a green turtle. Researchers are exploring ways to combine photography and computer software to identify individual turtles. © WAYNE SENTMAN

Important Turtle Areas
in the Arabian Gulf

By NICOLAS PILCHER, MARINA ANTONOPOULOU, LISA SHRAKE PERRY, and OLIVER KERR

Very few sea turtle nesting beaches are yet to be discovered in the world, but if you ask where turtles spend their lives at sea, many people will draw a blank. The generic answer of "Well, they go offshore and we don't see them until they return to coastal habitats as juveniles—often known as the *lost years*" is a common response. But this answer applies only to the early years of a turtle's life. What about the rest of the time? Sea turtles spend the vast majority of their lives at sea and only brief periods on beaches, either (a) as eggs during incubation, or briefly (b) as hatchlings frantically making their way to sea, or (c) as adult females laying eggs. That's it. They are waterborne for the rest of the time. For sea turtle conservation to work, it must be effective on beaches, to be sure, but it also must be effective at sea.

Because sea turtles traverse vast areas of ocean, identifying their most important at-sea habitats is a crucial first step. The same is true for other highly migratory species, including many birds, which led BirdLife International to pioneer the concept of Important Bird Areas (IBAs) in the 1980s. This valuable and now globally recognized methodology helps to prioritize bird conservation efforts to sites of particular importance, and it provides a worthy model to test with sea turtles.

Knowing where turtles are in a particular life stage is a critical first step to defining Important Turtle Areas (ITAs), and recent advances in technology are allowing scientists across the planet to begin to unravel many of the mysteries of where turtles go while at sea. One area where this technology was recently applied with great results is the Arabian region, a part of the world not well known for its sea turtles. The study area comprised the Arabian (also known as the Persian) Gulf, along with the Oman and Arabian seas. The area supports large green turtle populations in Saudi Arabia and in Oman; smaller nesting aggregations in Iran and Kuwait; and hawksbills nesting in Iran, Kuwait, Oman, Qatar, Saudi Arabia, and the United Arab Emirates (UAE).

Oman is also home to one of the largest loggerhead rookeries in the world, with thousands of nesting loggerheads and a handful of olive ridleys. We know a lot about the nesting populations and a bit about at-sea behavior of olive ridleys and loggerheads, but we know nothing about hawksbill at-sea habitat. That lack is what this study set out to resolve.

The Gulf is a unique environment. It undergoes extreme water and air temperature fluctuations, and its climate has a profound effect on sea turtles. Surface waters typically exceed 30°C (86°F) for sustained periods, so in many ways the Gulf can be likened to a natural living laboratory for understanding how turtles might adapt to climate change and elevated global temperatures. The region is also one of the world's most important exploration and extraction areas for oil and gas, and it has some of the highest shipping traffic in the world. In addition, commercial, artisanal, and recreational fisheries further affect sea turtles, along with endless coastal development. Given those pressures, focused conservation strategies must target the full range and extent of turtles' life cycles, not just their time on nesting beaches.

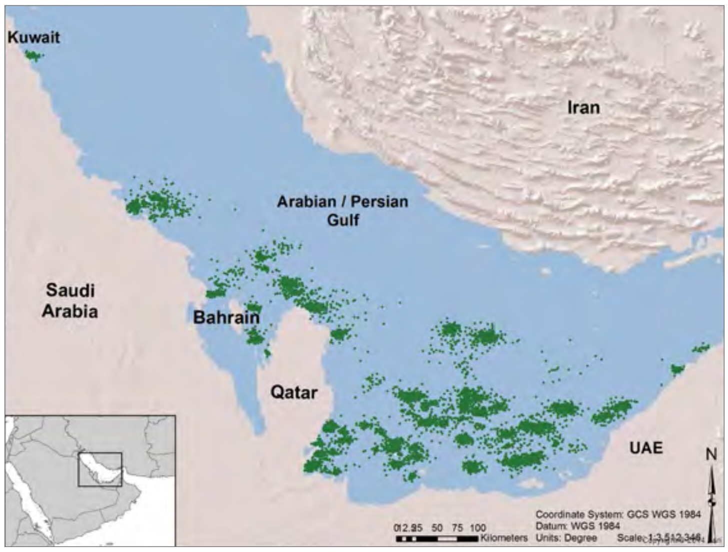
Against this backdrop and in partnership with numerous colleagues from many government agencies, the private sector, and nongovernmental organizations (NGOs), we four were part of a recent project spearheaded by the Emirates Wildlife Society in association with WWF (EWS-WWF) and the Marine Research Foundation, which used satellites to track 75 postnesting female hawksbills from Iran, Oman, Qatar, and the UAE. Our aim was to identify key foraging grounds, temporal activity patterns, and potential migration bottlenecks, which we deemed to be ITAs. Other project partners provided tracking data of an additional 15 turtles from their own work to supplement the massive dataset we had accumulated.

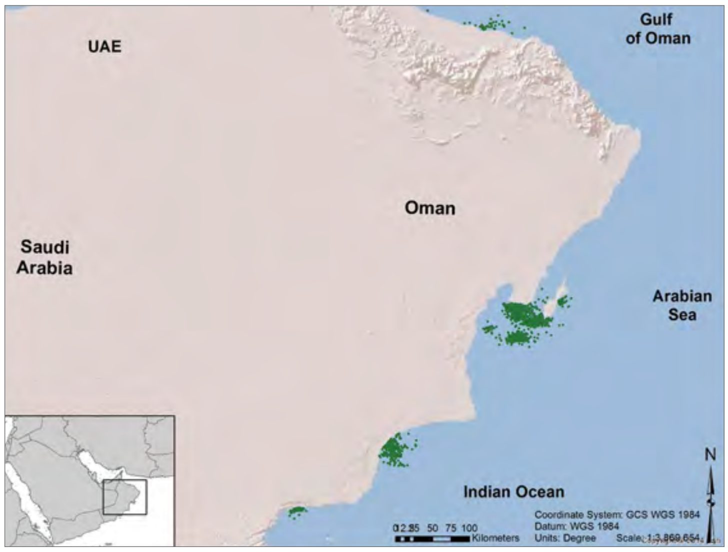
The satellite tracks showed that turtles tended to stay near their nesting sites for varying periods of time, thus allowing us to estimate that they laid between three and six clutches of eggs per season. As they left their nesting grounds, most turtles moved south or southwest toward the corner of the Gulf shared by Qatar, Saudi Arabia, and the UAE, with only a few traveling into the Gulf of Salwa (between Qatar and Saudi Arabia). Even fewer went northward toward Saudi Arabia and Kuwait. Surprisingly, no turtles headed east toward Iran and the eastern reaches of the UAE, an area that receives the cleaner waters entering the Gulf from the Sea of Oman. Outside the Gulf, Omani turtles headed south from the Damaniyat Islands, hugging the coast of Oman, rounding Ras Al Hadd toward foraging sites along the mainland coast between Masirah and Yemen. Masirah turtles were the laziest of all, moving just a few kilometers across to the mainland.

The most important results of this study, though, were the identification of the feeding grounds where turtles spend most of their time. Once they reached their destinations, the Gulf turtles occupied discrete and isolated foraging grounds that are dispersed across a huge swath of the southwest Gulf, then usually returned to the same areas following two- to three-month summer migrations. Their home ranges varied in size but overall were relatively large, averaging some 50 km^2 (19 mi^2). In contrast, core areas were extremely precise and were limited to individual shallow patches averaging only about 1 km^2 (1/3 mi^2). Each turtle essentially lived on its own little feeding patch consisting of shallow areas with sparse hard substrate.

Omani turtles were different: most of them moved to just a handful of collective feeding areas off Shannah, close to Masirah, and a few went to Quwayrah, approximately 300 km (186 mi) farther south. The Omani turtles' core areas were also small but were home to numerous turtles, unlike in the Gulf, where turtles were highly dispersed and lived mostly alone.

Contrary to our earlier expectations that Gulf hawksbills would inhabit discrete areas that might have been demarcated for protection, the widespread dispersal of hawksbills across the southwest Gulf limits the habitat protection options available to managers. Hawksbill foraging habitats are predominantly located in shallow waters where commercial shipping is less of an issue but where most traditional fisheries operate.





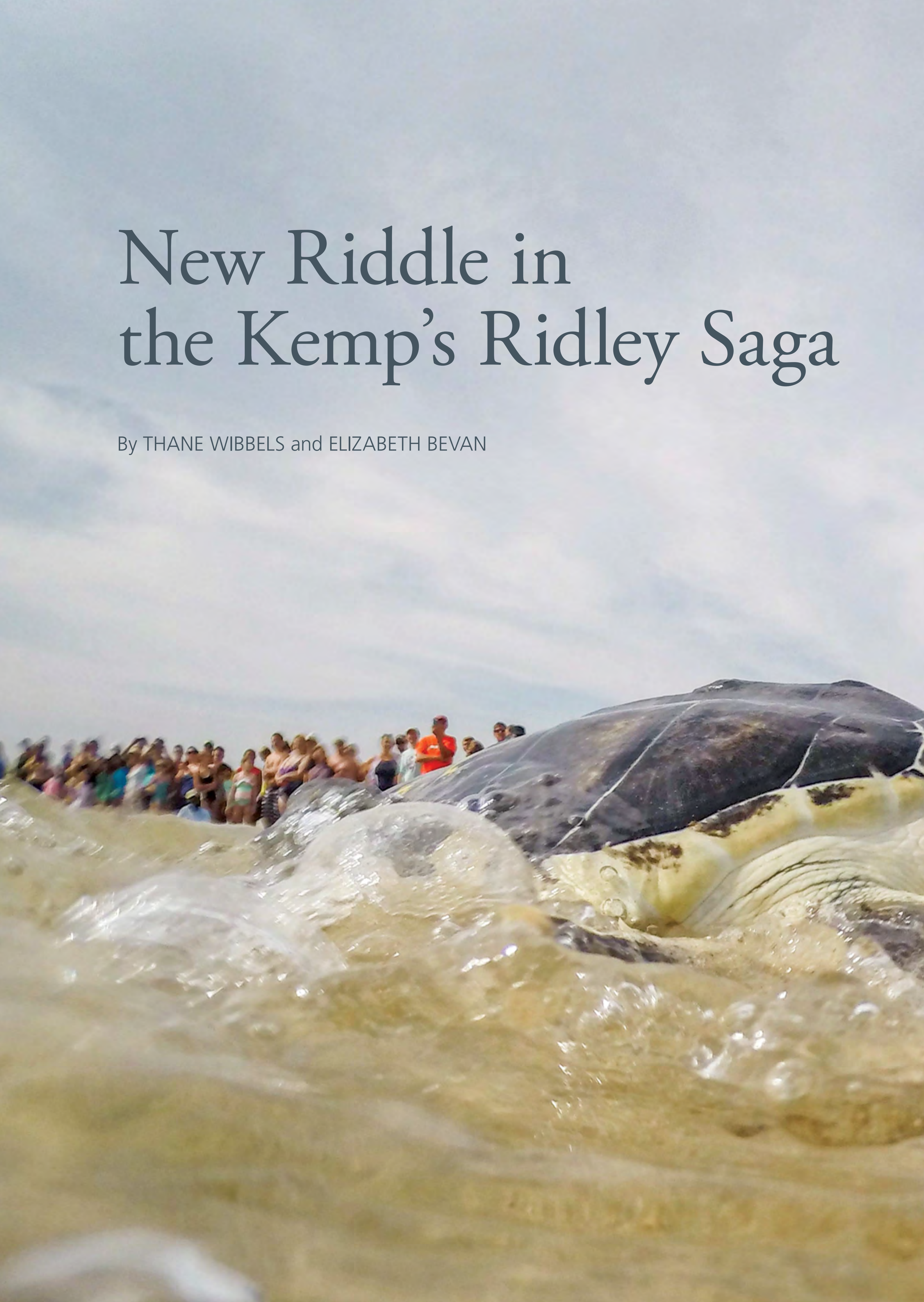
Maps of the Gulf (TOP) and coast of Oman (BOTTOM) showing locations of satellite-tagged hawksbill turtles concentrated at foraging grounds. AT LEFT: A satellite-tagged hawksbill returns to sea at Sir Bu Nair Island, United Arab Emirates. Seventy-five hawksbills were tracked from four different countries as part of efforts to identify Important Turtle Areas in the Gulf. © OLIVER KERR / EWS-WWF

As a result of our findings, we have suggested (a) that industrial development (particularly urban and industrial infrastructure) of shallow water areas should be limited, thereby maximizing available foraging habitats for hawksbills, and (b) that fishery activities should be controlled to limit their effect on hawksbills. In Oman, the identification of ITAs was clearer, with Shannah and Quwayrah identified as being key foraging habitats for most turtles and with the waters off Ras Al Hadd—specifically a 20 km (12 mi) band along the shores between Damaniyat, Muscat, and Masirah—constituting an important bottleneck for hawksbill turtles.

We now know a lot more about where Gulf turtles spend their time at sea. Those data improve our understanding of hawksbill habitat and behavior in a climate-challenged environment. The data also contribute to the delineation of ITAs that can now be used to assess risks from urban and industrial development, oil and gas industries, climate change, fishery pressure, and shipping activities, thereby setting the stage for effective conservation and management actions. We hope that ITAs become a mainstream conservation concern along with their IBA counterparts and that they be included in large-scale risk assessments and delineation of important habitats, such as through the Ecologically and Biologically Sensitive Areas process of the United Nations Convention on Biological Diversity. ■

New Riddle in the Kemp's Ridley Saga

By THANE WIBBELS and ELIZABETH BEVAN



They said that it was "peculiar," "evil-natured," even "mad" and that its heart would break if you put it on its back. They called it the "ridley."

The history of Kemp's ridley turtles is rich in folklore, unexpected and extraordinary biology, and an inspiring and ongoing story of what it takes to save a species. Kemp's ridleys evaded the notice of scientists until the late 1800s. Once discovered, scientists took nearly 100 years to find out where and how they reproduce. Archie Carr, the historic dean of sea turtle biology, spent decades studying what he called "the riddle of the ridley." Just as the riddle came to light, scientists discovered that Kemp's ridleys were heading toward extinction. Intensive efforts set them on an exponential path to recovery that lasted for more than two decades. But in the past five years, an unexplained precipitous population decline has scientists scrambling to solve yet another riddle, one that will determine if the future of this critically endangered species is again in jeopardy.

The story starts in the late 1800s in Key West, Florida, which is the former center of the sea turtle industry in the United States. Most of the world's sea turtles had already been identified, but the Kemp's ridley had eluded scientists. Richard Kemp was a businessman and avid naturalist. He had grown up in The Bahamas, where sea turtles were a part of his everyday life. After moving to Key West, just a few blocks from where sea turtles were landed on a daily basis, he became fascinated by a "peculiar" species of sea turtle that did not occur in Bahamian waters but was abundant in the Florida Keys. He sent descriptions and specimens of this new creature to the Harvard Museum of Comparative Zoology, and in 1880 the species was named in his honor because of "the great interest Mr. Kemp takes in the matters pertaining to natural history."

The species now had a name, but the mystery of its biology was just beginning. Kemp noted that it was commonly called the bastard turtle and was thought to be a hybrid between a green and a loggerhead. This belief would stand for the next 58 years, until this peculiar turtle caught the attention of the most famous of sea turtle biologists, Archie Carr.

Archie Carr had just finished his PhD studying Florida reptiles when he was contacted by a colleague who ran a shark fishing business in the Keys. As noted in Archie's 1956 book *The Windward Road*, this colleague reported that there was an "evil-natured" sea turtle that was flat and gray with a big head and that it would tear up their fishing nets when captured. The locals called it the "ridley," but no one seemed to know the origin of the name. Archie traveled to the Keys in 1938 and saw his first Kemp's ridley with a local turtle fisherman who told him, "We don't know where they lay.… Some say these ridleys is crossbreeds.… They are made when a loggerhead pairs with a green." He also said that "ridleys is always mad.… You can't keep a ridley on its back.… They're crazy; they break their hearts."

Archie noted, "That is how I got to know the Atlantic ridley.... That is how the great ridley mystery started for me."

... the Kemp's ridley had quickly become the most endangered sea turtle in the world and was on a trajectory toward extinction.

Unwilling to blindly accept the folklore and notion of a hybrid turtle, Archie spent another two decades unsuccessfully searching for the Kemp's ridley's nesting grounds throughout Florida, The Bahamas, the northern Gulf of Mexico, and the Caribbean. Archie considered the Kemp's ridley to be one of the most mysterious animals in North America, and his eloquent writings set the scene for others who would contribute to the ridley story.

In his book *Tales from the Thebaide*, Peter Pritchard, a former student of Archie Carr, notes that Archie worried that the great ridley mystery might not end with a bang, but rather with a series of widespread individual nesting reports. In reality, he worried in vain, because the ridley's biology was far more interesting than anyone had ever anticipated.

Solving the riddle of the ridley would require two more individuals. The first was Andrés Herrera, a rancher and businessman from Tampico, Mexico. He was an outdoorsman who enjoyed fishing and hunting, a pilot with his own small airplane, and an amateur 16-millimeter movie photographer. He often flew to fishing sites along the Gulf coast, and during trips to Barra del Tordo (located about 100 kilometers, or 62 miles, north of Tampico), he repeatedly heard that on certain days in the spring, sea turtles would nest by the thousands during the daytime.

Herrera became fascinated with the idea of documenting this amazing biological phenomenon on film. He flew a total of 33 surveys to the area over a two-year period. On June 18, 1947, he hit the jackpot by stumbling upon a large mass nesting event (*arribada*) in progress, just north of the small town of Rancho Nuevo. He landed his plane on the beach and recorded the famous Herrera film, which not only provides the earliest documentation of the location of the Kemp's ridley nesting beach, but also represents the first documentation of arribada nesting in sea turtles.

Herrera understood the importance of his film as the first documentation of this amazing biological phenomenon, but he did not yet realize its significance in unraveling the Kemp's ridley mystery. For several years, Herrera tried unsuccessfully to market the film to magazines and movie studios, including *Life Magazine*, Disney, MGM, 20th Century Fox, and RKO. Meanwhile, the answer to the great ridley mystery lay dormant on a closet shelf in Tampico, while scientists continued to search far and wide. Connecting the pieces of this puzzle would require another person who had become fascinated by the great ridley mystery, Henry Hildebrand.

Henry Hildebrand was a college professor specializing in fishery biology at Corpus Christi University in south central Texas. He was a classic field biologist and felt that scientists should learn from nature, not just from books. He was an expert on the biology of the Gulf of Mexico, was fluent in Spanish, and had traveled widely, including many trips to Mexico. His forte as a scientist was his down-home logical approach as he gathered firsthand knowledge from local fishermen about sea turtles and the sea turtle fishery. He had also read Archie Carr's books and articles and was fully aware of the riddle of the ridley; thus he had all the right ingredients to solve the great ridley mystery.

During a field trip to Mexico in 1961, Hildebrand visited the Campo Andrés fishing camp near Barra del Tordo to inquire about sea turtles. The owner of the camp told him that large numbers of sea turtles nested on beaches to the north and mentioned that Andrés Herrera in Tampico had recorded a film of the spectacle. At that point, Hildebrand suspected that the turtles nesting near Rancho Nuevo might be ridleys because they allegedly nested during the day, unlike other sea turtles he knew about. Hildebrand hurriedly wrote a letter to Herrera asking to view the film. Andrés Herrera was elated that the significance of his film might finally be realized, and he immediately sent the film. Hildebrand watched it in amazement; he had found the fabled Kemp's ridley nesting beach and simultaneously discovered an amazing biological phenomenon, the arribada.

Hildebrand showed the film at a scientific meeting that year in Austin, Texas to a captivated scientific audience that included Archie Carr, who had flown from Florida specifically to see the film. To quote Hildebrand's interpretation of Carr's reaction to the film, "He was quite flabbergasted, I'd say for sure."

The mystery of the nesting beach had been solved. Yet at the same time, unbeknown to scientists, the Kemp's ridley was facing its greatest challenge in 6 million years: avoiding extinction. While the scientific community was consumed with the search for the nesting beach, the Kemp's ridley had quickly become the most endangered sea turtle in the world and was on a trajectory toward extinction. The Kemp's ridley's limited distribution and single primary nesting beach made it the most vulnerable sea turtle in the world. Exploitation of eggs at Rancho Nuevo had grown exponentially from local subsistence to commercial scale during the 1950s and early 1960s. This threat accompanied a vast expansion in the Gulf shrimping industry that increased incidental capture and mortality of juvenile and adult Kemp's ridleys.

Fortunately, the Herrera film drew attention to Rancho Nuevo. As scientists visited the beach in the early 1960s, they found that arribadas like the one shown in the Herrera film no longer took place. By 1966, the Mexican government was aware of the situation and sent in a team of biologists accompanied by Mexican marines to protect eggs and nesting females. Despite the Mexican government's best protection efforts at the nesting beaches, the number of nests continued to decline through the 1970s, with the annual number of recorded nests dropping below 1,000 by 1978. The continuing decline sparked intense concern in both Mexico and the United States.

In 1978, multiple U.S. government agencies (U.S. Fish and Wildlife Service, National Park Service, and National Oceanic and Atmospheric Administration [NOAA] Fisheries) and the Mexican federal fisheries institute (Instituto Nacional de Pesca) initiated a binational recovery plan that expanded and enhanced beach protection at Rancho Nuevo. The plan also launched one of the greatest scientific experiments ever: to start a secondary nesting colony by transplanting 10 to 20 nests each year from Rancho Nuevo to Padre Island National Seashore in Texas, and then to "headstart" the hatchlings for approximately nine months before releasing them (see *SWOT Report*, vol. I, 6–7).

Unfortunately, these collaborative efforts were not enough, and the number of nests at Rancho Nuevo continued to decline. By 1985, only 702 nests were recorded, representing 300 or fewer nesting females. Nesting females and hatchlings were being protected, but not enough ridleys were surviving to adulthood because of the thousands of juvenile and adult sea turtles each year that were ensnared in shrimp trawler nets. NOAA Fisheries was acutely aware of the problem, and they developed a solution: the turtle excluder device, or TED. The Kemp's ridley was the flagship species that served as the driving force for implementing TED regulations in 1989. Once implemented, the nondiscriminating TEDs immediately started saving all species of sea turtles in the Gulf and wherever TEDs were used.

The Kemp's ridley story was shaping up to be the ultimate example of how effective conservation can bring a species back from the brink of extinction. After the implementation of TEDs, the species rebounded at a rapid pace, increasing from 702 nests in 1985 to more than 21,000 nests in the state of Tamaulipas, Mexico, in 2009. Scientists' population models predicted that the exponential growth would continue into the future.

But in 2010, the ridley story once again became a riddle. Nesting numbers dropped precipitously to 13,302 nests in Tamaulipas, a 37 percent decrease from 2009, contrary to what was expected. In 2011 and 2012, the number of nests in Tamaulipas increased to approximately 21,000 nests, suggesting that the population might bounce back to its previous exponential growth rate. Unfortunately, the number of nests per season then exhibited a major downward trend, dropping to approximately 16,000 in 2013 and then to a little over 12,000 in 2014 in Tamaulipas. Had nesting numbers stayed on the exponential trajectory exhibited prior to 2010, nesting numbers would have reached 40,000 nests or more by 2014, a far cry from reality.

The basis of the recent decline is currently speculative, but it is clear that the recovery of the ridley has experienced an unexpected downturn, sending biologists searching for clues. The most obvious possible culprit is the Deepwater Horizon oil spill in 2010 (see *SWOT Report*, vol. VI, 16). An estimated 210 million gallons of oil and 1.84 million gallons of dispersant were released into the northern Gulf of Mexico, a well-documented migratory corridor, foraging ground, and developmental habitat for Kemp's ridleys. But there are other possible factors, such as the major cold-stunning event in 2010 that spanned from Florida to Tamaulipas.

A significant increase in the number of dead stranded ridleys was recorded in the northern Gulf of Mexico during 2010, as might be expected in response to the oil spill and cold stunning, but those increased levels of strandings have remained relatively high in subsequent years. It has been suggested that the recent decline in nesting may simply represent a natural fluctuation in the population, or that the ridley population may be reaching the carrying capacity of the Gulf of Mexico. However, those latter hypotheses are difficult to reconcile with Hildebrand's estimate of 40,000 nests in a single day, observed in the 1947 Herrera film, which suggests the Gulf of Mexico ecosystem historically supported a large population. The simplest explanation for the recent decline is that a combination of factors such as those mentioned earlier may have affected the population and at least temporarily derailed it from its previous exponential recovery rate. If so, the decline represents the loss of possibly a decade's worth of intense conservation efforts.

The basis for the decline has been the focus of intense discussions at recent Kemp's ridley meetings, and scientists are mobilizing to obtain data that may explain the current situation. In the meantime, the Kemp's ridley story continues with yet with another riddle, one that could simply be a bump in the road to recovery or alternatively could threaten the future survival of this critically endangered sea turtle. It is hoped that the continued dedication of scientists and conservationists will provide the answers and, ultimately, ensure the survival of the Kemp's ridley. ■

A recent Kemp's ridley arribada in Mexico. Populations have recovered to the point that arribadas are happening once again, but an unexpected drop in nesting since 2010 is causing concern among conservationists. © HÉCTOR CHENGE PREVIOUS SPREAD: A Kemp's ridley sea turtle is released following eight months of rehabilitation by New England Aquarium's Marine Animal Rescue Team due to cold stunning; Assateague Island, Maryland, U.S.A. © ESTHER HORVATH

Costa Rica

A SUPERLATIVE SEA TURTLE COUNTRY

By LUIS G. FONSECA, RANDALL ARAUZ, DIDIHER CHACÓN-CHAVERRI, RODERIC MAST, CARLOS MARIO ORREGO, SEBASTIAN TROËNG, DAVID GODFREY, EMMA HARRISON, and ROLDÁN A. VALVERDE

Costa Rica is a country of ocean, nature, and sea turtle superlatives. Despite its small terrestrial size (51,100 km^2, or 19,732 mi^2, which is about the size of the U.S. state of West Virginia), Costa Rica's marine area (568,054 km^2, or 219,327 mi^2) eclipses its land by more than 10-fold. That area extends 322 km (200 mi) seaward from both shores and encircles Cocos Island in the Pacific, some 612 km (380 mi) southwest, thereby making it truly an ocean nation. Five of the world's seven species of sea turtles nest on its shores, a number exceeded only by the significantly larger countries of Australia and Mexico. A total of nine sea turtle Regional Management Units overlap with this sea turtle-rich nation (see map, pp. 22–23). Costa Rica's abundance of sea turtles derives largely from its geographic position that spans the Central American isthmus, which thus bestows it with 1,016 km (631 mi) of Pacific coastline and with 212 km (132 mi) more on its Caribbean shore. These "rich coasts" are bounded by an array of equally rich nearshore and deep ocean habitats—from mangrove swamps, estuaries, and rocky reefs, to seamounts and undersea features such as the Costa Rica Dome, all of which are traversed by sea turtles in many stages of their lives during foraging, migration, internesting, and breeding.

A green turtle hatchling emerges from its nest in Costa Rica. © SERGIO PUCCI / WWW.PUCCI.CR; PREVIOUS SPREAD: A leatherback turtle returns to sea after nesting at Playa Grande on Costa Rica's Pacific coast. © ELLEN MCKNIGHT

Costa Rica's abundant sea turtles also stand out in remarkable ways. On the Caribbean coast, Tortuguero National Park hosts the largest green turtle rookery in the hemisphere and one of the two largest green turtle populations on Earth. Costa Rica's Pacific coast is home to two olive ridley mass nesting (*arribada*) beaches: Nancite and Ostional. The beaches are among a mere half-dozen such sites found worldwide, and Ostional is one of the two largest on the planet.

From a conservation perspective, the leatherback beaches of the Nicoya Peninsula (Pacific coast) are among the most important on Earth for the leatherback, given that the Eastern Pacific Regional Management Unit (RMU) of this species is considered the highest conservation priority of all leatherback RMUs worldwide (see *SWOT Report*, vol. VII, 26). Costa Rican sea turtles also have a connection to another famous flagship species: the largest cat in the Americas, the jaguar (*Panthera onca*). Turtle nesting beaches in Tortuguero, Santa Rosa, and Corcovado national parks are important jaguar habitats and are among the only places where those majestic cats have been documented to regularly feed on nesting turtles.

Costa Rica is considered the birthplace of modern sea turtle biology, in large part because of the important role played by Dr. Archie Carr (1909–1987), who was a pioneering conservationist, scientist, and author and whose books brought the plight of sea turtles to the world's attention. The theories and observations about sea turtle biology and conservation that emerged from Dr. Carr's work at Tortuguero beginning in the 1950s remain core to our understanding of the animals today. Dr. Carr founded the Sea Turtle Conservancy (formerly known as the Caribbean Conservation Corporation), the first nongovernmental organization dedicated to sea turtles. Thanks to his influence, Costa Rica created the first protected area dedicated specifically to sea turtle protection: Tortuguero National Park.

Several other Costa Rican protected areas have since been established to protect these marvelous creatures. Among them are Las Baulas de Guanacaste National Park and several National Wildlife Refuges, including Ostional, Gandoca-Manzanillo, Camaronal, Caletas-Arío, Playa Hermosa-Punta Mala, and Río Oro. Other national parks in Costa Rica also protect key turtle habitats, including Santa Rosa, Manuel Antonio, and Cahuita. National protection is also in place for many, though not all, marine habitats used by sea turtles. Among the most important foraging areas are the coral reefs of Cahuita and Punta Mona; the seagrass pastures of the Golfo Dulce; the mangrove areas of Golfo de Nicoya; and the rocky reefs of Santa Elena, Punta Coyote, and Isla del Caño. Cocos Island National Park is also an important developmental habitat for juvenile green and hawksbill turtles, and it provides a stopover habitat for migratory adult green turtles.

National legislation protects turtles both inside and outside of protected areas in Costa Rica, though a number of key nesting beaches have not yet received official protected status. At many of those beaches, local community volunteers and environmental organizations play a fundamental role in protecting sea turtles by helping to convert former poachers into research assistants or tour guides and by providing environmental education for children. The latter has been an essential component of long-term sea turtle conservation in Costa Rica by giving children a voice in converting their families and fellow community members to sea turtle conservationists.

A unique, albeit polemic, conservation program exists at Ostional, the site of the only community-based program that allows egg extraction. The program is considered a global model for conservation-based turtle use. At that beach, local residents are allowed to conduct a managed extraction of "doomed eggs," those that will be incidentally dug by other turtles during the early days of arribada nesting. When combined with ecotourism, the program provides sustainable income for local residents. Ostional's egg extraction program is considered to have the added benefit of reducing clutch density, thereby increasing overall hatching success and diminishing the proportion of otherwise doomed clutches.

In addition to being a global leader in biodiversity protection (27 national parks and dozens of wildlife refuges, plus protected zones that cover more than 25 percent of the country), Costa Rica has also been at the forefront of sustainable development for decades. Often called the Switzerland of Central America for the friendliness and quality of life of its citizens, Costa Rica abolished its army in 1948, an act that has contributed greatly to the country's peaceful and democratic history.

As a result of this reputation and its natural beauty, Costa Rica is visited by more than 2 million tourists each year. They are drawn by the opportunity to experience tropical beaches, protected rainforests, and wildlife, including nesting sea turtles. Tourism generates considerable revenue, at a scale far beyond what hunting of sea turtles and collection of eggs could ever provide for communities surrounding protected areas, as is the case at Tortuguero and Las Baulas de Guanacaste national parks and in Ostional National Wildlife Refuge. Using a model of local guides, regulation of tourism in those parks minimizes disturbance of nesting turtles while supporting jobs and livelihoods for local residents. Costa Rica also receives thousands of foreign volunteers every year who supply the work force and skills for conservation, and without whom effective sea turtle protection would not be possible.

Nonetheless, serious threats to sea turtles still linger in many parts of Costa Rica, such as the widespread illegal extraction of eggs, the slaughter of adults for meat and oil, and the bycatch of sea turtles in artisanal and industrial fisheries. Incidental catch by commercial fisheries and the resulting mortality of turtles are perhaps the most insidious and difficult threats to confront in Costa Rica. Costa Rica's enormous marine area makes the control and surveillance of fishing vessels very problematic, which results in the deaths of tens of thousands of turtles each year in trawls and longline fisheries. Diminishing catches from an already severely overexploited fishery has driven fishers not only to increase their effort but also to expand into new, once pristine fishing grounds, thereby causing increased turtle mortality. In the past five years, government agencies, communities, and environmental organizations in Costa Rica have increasingly addressed the topic of fisheries management, but conflicts still remain, as demonstrated by a recently announced and much-criticized government plan to allow continued high-bycatch shrimp trawling.

Although some encouraging trends are visible in Costa Rica, such as increasing numbers of green and leatherback turtles in the Caribbean, persistently large olive ridley arribadas in the Pacific, and new green turtle nesting sites that are being discovered in the Pacific, Costa Rica still faces many superlative sea turtle challenges. Government agencies, with the support of citizens and private conservation organizations, must redouble their efforts to strengthen and enforce national laws, especially those relating to fisheries' impacts and illegal egg harvests, and all must work to improve management of protected areas. Costa Rica must show the same style of leadership in establishing effective marine protected areas as it has demonstrated historically in terrestrial protection if this little country is to remain at the vanguard of turtle conservation, much as it has remained an emblem of peace and tranquility. ■

Levels of illegal egg collection in Costa Rica are close to 100 percent at some sites, such as the Caribbean beach of Moín, where turtle monitoring was abandoned after a tragedy there that drew international condemnation. While on duty protecting turtles, Jairo Mora Sandoval (1987–2013), known locally by his nickname "Foca," was murdered by poachers. After a mismanaged trial, the main suspects were acquitted. Fortunately, Costa Rica has countless local heroes who are brave and committed people like Jairo. They continue to patrol remote beaches by night while most of Costa Rica's 5 million residents sleep peacefully in their beds. The sea turtle patrollers face not only mosquitoes and inclement weather, but also the threat of a human enemy that seeks to make money from the illegal killing of Costa Rica's sea turtles.

SWOT Feature Map

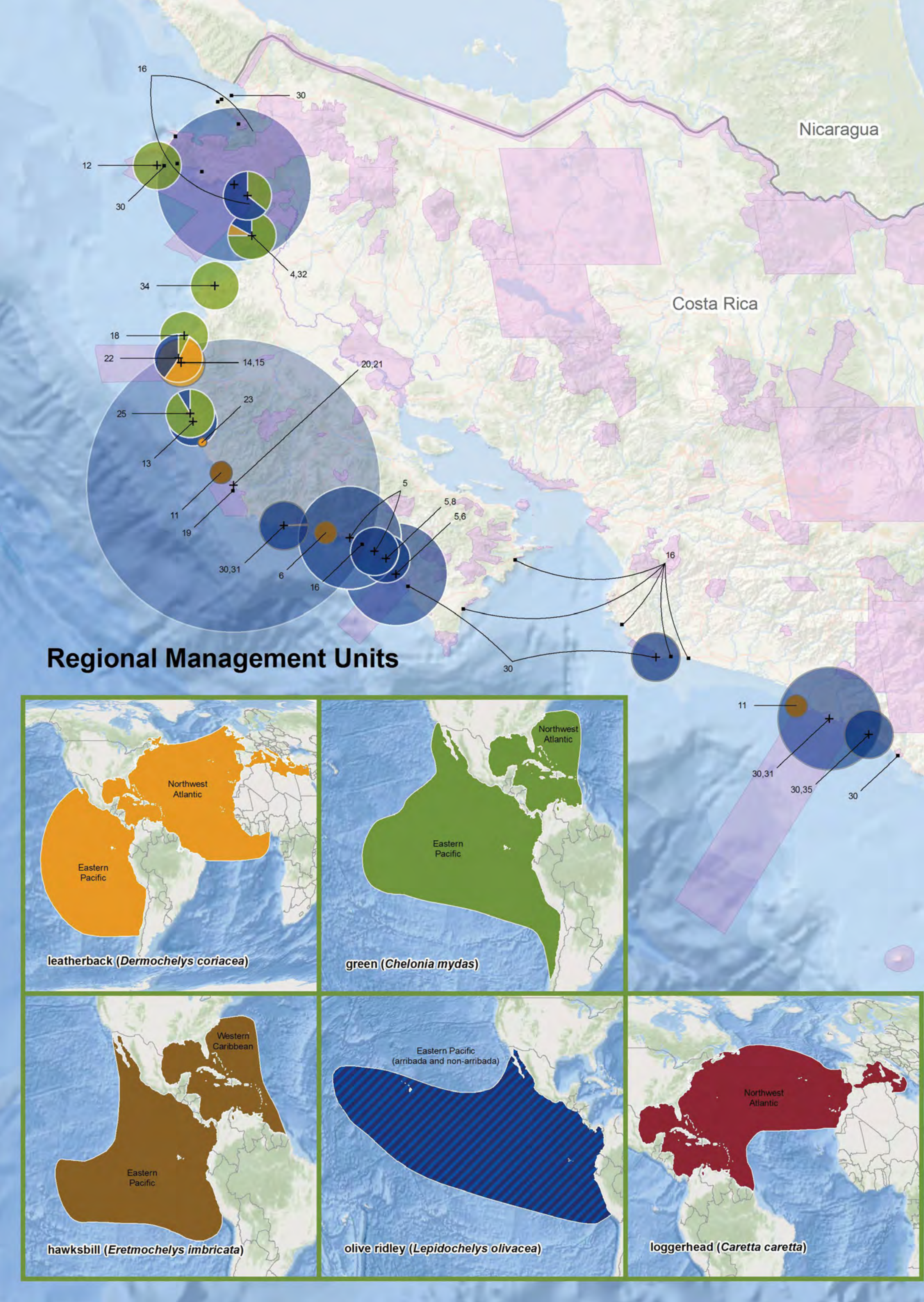
On the following pages (22–23) is the first-ever comprehensive map of sea turtle nesting biogeography in Costa Rica, produced in collaboration with dozens of individuals and organizations, and with special assistance from Luis Fonseca and LAST (Latin American Sea Turtles) Association.

The map features nesting data from 60 beaches on both the Pacific and Caribbean coasts, covering four species: green, leatherback, hawksbill, and olive ridley. While loggerhead turtles have also been recorded nesting at Tortuguero on the Caribbean coast, they were omitted from the map since their presence is considered sporadic. We have also included Costa Rican protected areas on the map in order to highlight the protection afforded to many key sea turtle nesting sites, as well as to draw attention to current gaps in protection; these are discussed in greater detail in the article at left.

The data used to create this map were provided voluntarily to SWOT or sourced from literature, and come from approximately 40 sources. Each data point is numbered to correspond with a record (see pages 43–44) that includes detailed metadata and source information. We used the most recent available data from each nesting site, and have indicated when the data used were more than five years old (see map legend). The map displays all data as numbers of clutches; when a different count type was provided by the data source (e.g., nesting females), we converted these to clutches using regionally appropriate conversion factors (see p. 44). Finally, we have included inset maps that depict the nine Regional Management Units of the five sea turtle species that occur in Costa Rica. These serve to emphasize the reality that "Costa Rica's" sea turtles are in fact highly migratory animals that do not belong to any one nation.

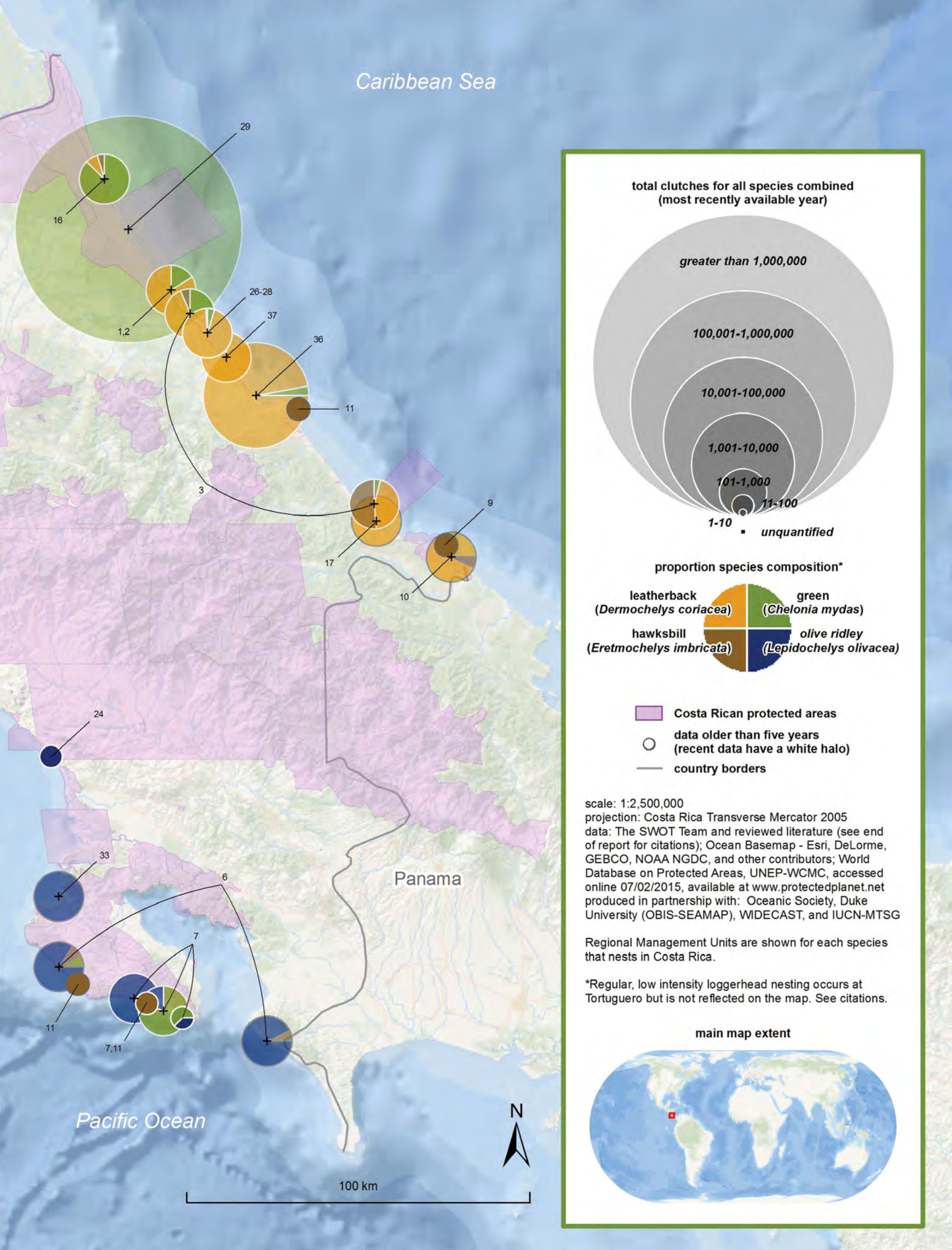
We are excited to present this map as the first national-scale, multi-species map of sea turtle biogeography that the SWOT Program has produced. It marks the beginning of a new focus on national- and regional-scale maps that we will generate in the coming years to present sea turtle data at scales that are as relevant as possible for the purposes of informing sea turtle management and conservation.

As always, you can find the complete, global SWOT database online at http://seamap.env.duke.edu/swot.



Regional Management Units
Nicaragua
Costa Rica
16
30
12
30
4,32
34
18
22
14,15
20,21
23
25
13
11
19
5
5,8
5,6
30,31
6
16
16
30
11
30,31
30,35
30
Northwest Atlantic
Eastern Pacific
leatherback (Dermochelys coriacea)
Northwest Atlantic
Eastern Pacific
green (Chelonia mydas)
Western Caribbean
Eastern Pacific
hawksbill (Eretmochelys imbricata)
Eastern Pacific (arribada and non-arribada)
olive ridley (Lepidochelys olivacea)
Northwest Atlantic
loggerhead (Caretta caretta)

Nesting Biogeography of Sea Turtles in Costa Rica



A TALE *of* Two Beaches in Greece

By DIMITRIS MARGARITOULIS, THOMAS E. RIGGALL, and ALAN F. REES

The loggerhead nesting beaches in Laganas Bay, Zakynthos Island (TOP) and Kyparissia Bay in western Peloponnese (BOTTOM), Greece host 27 percent of all loggerhead nesting in the Mediterranean. While the number of nesting turtles is in decline at Laganas, nesting is on the rise at Kyparissia. © ARCHELON

The Mediterranean Sea is home to loggerhead populations that originated from the northwestern Atlantic about 12,000 years ago, which was at the end of the last glacial period. Mediterranean loggerheads are generally smaller than their Atlantic counterparts and are genetically distinct. A little over a decade ago, the average annual nesting abundance in the entire Mediterranean was estimated to be about 5,000 nests; by 2009, this figure was raised to about 7,000 nests, with the inclusion of new nesting sites such as Libya. The two largest aggregations, representing 27 percent of all loggerhead nesting in the Mediterranean, are in Greece: Laganas Bay on Zakynthos Island and Kyparissia Bay in western Peloponnese, with Laganas Bay historically considered the largest.

Although the two areas are separated by only 90 km (56 mi) of open sea, their ecological features are remarkably different. The nesting habitat in Laganas Bay is 5.5 km (3.4 mi) and is spread over six discrete beaches with mostly fine-grained sand, while the nesting habitat in Kyparissia Bay is 44 km (27.3 mi) of continuous beach interrupted by three rivers, with mostly coarse sand. Because the predominant winds in the summertime come from the northwest, the south-facing Laganas Bay beaches are not usually affected by inundations, while west-facing Kyparissia Bay frequently receives high surf that affects nests laid close to the water. Moreover, clutches in Kyparissia Bay are affected by severe predation, mainly by foxes, whereas in Laganas Bay, such a threat is negligible. Further, Laganas Bay is characterized by severe tourist pressure, including speedboats, beach furniture, bright lights, and human presence on beaches at night, whereas Kyparissia Bay still enjoys relatively low tourist pressure and coastal development.

Since 1984, both areas have been monitored by ARCHELON, the Sea Turtle Protection Society of Greece, including locating and monitoring clutches as well as tagging nesting females. Those efforts covered all Laganas Bay beaches, but in Kyparissia Bay the entire area was monitored only during the period 1984–1989, and then turtle work was restricted to the southernmost 9.5 km (5.9 mi) of beach. That length of shore is where the majority of nesting concentrates (estimated to be 84 percent), and where all nests have been fully protected against predation and flooding since 1992. In 2006, it was noted that the annual number of clutches in this core nesting area of 9.5 km (5.9 mi) were increasing, as was the number of first-time nesters. Given that the increase was first observed in 2006 after 15 years of full protection there (coinciding with the minimum age of sexual maturity for Mediterranean loggerheads), it is our belief that the increased recruitment in Kyparissia Bay is from turtles that hatched on those beaches during the years of full protection.

In contrast to Kyparissia, annual nesting levels at Laganas are in decline, even after the establishment of a Marine Park in 1999. In addition to tourism's long-term interference on the nesting beaches, other possible reasons for this unfortunate trend are the recent increase in mortalities from interaction with fisheries, predation by endangered Mediterranean monk seals, or increased disturbance by the many boats conducting unregulated turtle watching in the waters of Laganas Bay.

Statistical examination of annual nesting levels over the past 20 years (1994–2014) shows a significant decline at Laganas Bay and a significant increase at Kyparissia Bay, to the extent that in 2013 and 2014, the number of nests at the core area of Kyparissia Bay alone surpassed those at Laganas Bay by about 21 percent. To assess how this increase relates to nesting distribution along the whole Kyparissia Bay, ARCHELON has monitored a further 4 km (2.5 mi) of beach adjacent to the core area since 2013, and in 2014 it undertook a 15-day midseason count of the remaining 30 km (18.6 mi) of the northern section. Those surveys indicated that the proportion of nests in the northern section is larger than previously assessed. Indeed, taking into account the recent data, the number of nests in the entire 44 km (27.3 mi) Kyparissia Bay exceeds Laganas Bay by about 60 percent. Hence, Kyparissia Bay now hosts the largest nesting aggregation of loggerhead turtles in the Mediterranean, making it crucial that appropriate protection status be established for this magnificent area.

> … Kyparissia Bay now hosts the largest nesting aggregation of loggerhead turtles in the Mediterranean, making it crucial that appropriate protection status be established for this magnificent area.

Since the late 1980s, the regional importance of Laganas Bay has inspired international interest in its protection, including the active participation of the European Commission and the Bern Convention (Convention on the Conservation of European Wildlife and Natural Habitats), which bore fruit in 1999 with the establishment of the National Marine Park of Zakynthos and the associated management agency. Unfortunately, though, the marine park has suffered from poor management, especially in periods of reduced funding and political support, and the significant declines in loggerhead nesting there call for a reassessment of the regulations and a redoubling of their enforcement.

Kyparissia Bay also requires greater protective status. Despite a large portion of the area being included in the European Union's NATURA 2000 network of protected areas, no specific protection measures are currently in force. As a result, a gradual degradation of the coastal ecosystem is being caused by human encroachment, resulting in beachfront construction, destruction of dunes, deforestation, and unregulated beach use. Plans for intense coastal building of holiday houses, even adjacent to the core nesting area, recently resulted in the European Commission taking Greece to the European Court of Justice for violating their directives concerning nature conservation. Shortly after, following an on-the-spot appraisal, the Bern Convention adopted a 12-measure recommendation urging Greek authorities to improve protection and to ban construction in the core nesting area.

The response from Greece's Ministry of Environment has been inadequate, and many of the major nature conservation organizations in Greece have appealed to the Supreme Court of Greece for resolution. It is hoped that the decision of the Supreme Court will be in favor of conservation and will keep Greece's valuable loggerhead nesting areas safe. This long-term project wouldn't have happened without the devotion and enthusiasm of several thousand volunteers who are from all over the world and who worked tirelessly day and night on the beaches of Laganas Bay and Kyparissia Bay. Their efforts are a testament to the immense conservation value of those natural areas and of the Mediterranean loggerheads that nest there each year. ■

Sea Turtle Farming

PAST, PRESENT, AND FUTURE?

By NEIL D'CRUZE, MARGARET BALASKAS, TOM MORRISON, and RACHEL ALCOCK

Green turtles provided a vital source of protein for settlers who arrived in the Cayman Islands more than 300 years ago. For centuries, green turtles were harvested directly from their natural habitats, but the unregulated and unsustainable harvest ultimately led to a dramatic decline in Cayman turtles in modern times. Many other nations that experienced similar declines chose to prohibit the consumption of green turtles, keeping in line with international legislation. The Cayman Islands took a different path and, in 1968, decided to turn to the commercial production of green turtles. Today, turtle stew remains the national dish, and turtle burgers are available on restaurant menus for both locals and tourists alike.

The Cayman Turtle Farm is now the only sea turtle farm left in the world, and it is still producing green turtle meat for local consumption. The farm is also engaged in turtle research and conservation. It is the most visited tourist attraction in the country, annually receiving hundreds of thousands of visitors who come to hold and have their picture taken with a farmed turtle. This government-owned tourist facility is currently home to a single hawksbill turtle, around 18 critically endangered Kemp's ridley turtles, and more than 9,500 endangered green turtles. Until recently, the farm also engaged in a "head-start" program, whereby farmed green turtles were maintained in captivity until they were 9 to 12 months old before being released into the wild when they were at a size at which natural mortality factors are minimized.

Founding green turtle "stock" was taken from Ascension Island, Costa Rica, Guyana, Mexico, Nicaragua, and Suriname between 1968 and 1978. In total, more than 477,000 eggs were collected, along with 148 adults and subadults. By 1978, the farm demonstrated that it could breed new eggs, hatch them, and rear a green turtle to maturity without needing to obtain additional wild eggs. However, deep controversy ensued over whether the farm had legitimately achieved this breeding program in a manner that met Convention on International Trade in Endangered Species (CITES) definitions of the time. As a result of those concerns, a 1979 CITES ruling prohibited the international trade of green turtles and their products.

The continued survival of green turtles in the Cayman Islands remains a conservation concern. Yet restaurateurs are quick to allay any unease that a conscientious consumer (both Caymanian and tourist) might have. After all, the turtle meat in their burger was reared in captivity, so consumption poses no threat to wild populations. Some go as far as to claim that the farm is a critical conservation tool and was directly responsible for the increases in nesting greens that have been observed in the Caymans. The restaurateurs argue that the legal sale of farmed turtle meat is the only effective way to stop people from taking green turtles from the wild. Moreover, the farm has released more than 31,000 captive-born green turtles into the wild as part of its head-start program, which has been in place for 37 years.

For four decades, sea turtle conservationists have been at odds regarding the exact contribution that the farm has made. Debate has focused on whether the two strategies used at the farm—sale of farmed turtle meat and release of farmed turtles—are having a positive or a negative effect on wild sea turtle populations. Those who oppose the farm have expressed concerns that any increase in the availability of turtle meat on the market will only stimulate demand. Furthermore,

A breeder removes eggs from the nest of a green turtle at Cayman Turtle Farm. © DAVID DOUBILET AT LEFT, TOP: Green turtles in a tank at Cayman Turtle Farm. © NEIL D'CRUZE BOTTOM: Green turtles are found on menus throughout the Cayman Islands. © NEIL D'CRUZE

poaching will likely carry on regardless, because of the high price of farmed turtle meat in the Cayman Islands.

Serious concerns have been raised about the effects of genetic pollution from the head-start program's release of turtles from diverse and unknown genetic stocks. Potentially fatal and contagious illnesses, such as chlamydiosis and gray patch disease, have also been well documented at the farm. Concerns about the risks of introducing diseases and parasites into wild populations contributed to a decision to put the head-start program on hold in 2013.

Both sea turtle conservationists and the Cayman Turtle Farm have recently acknowledged that the scientific data required to back up the farm's conservation credentials are severely lacking. Currently, the true level of Caymanian demand for turtle meat and the proportion actually consumed by tourists is unknown. Similarly, existing data show that only 13 (0.04 percent) of the more than 31,000 farmed green turtles released into the wild have been proved to be nesting on Caymanian beaches. Consequently, the U.K. Department for Environment, Food and Rural Affairs (DEFRA) has provided funding for a three-year study to determine the effectiveness of the farm as a conservation tool by investigating both consumer demand for green turtle meat and the genetics of nesting populations.

In contrast, the animal welfare concerns (referring to an animals' physical and psychological well-being) associated with the farm have been voiced repeatedly by the general public, academics, nongovernmental organizations, and a U.K. Parliamentary Select Committee since 2012. Together, they have documented a range of disturbing animal welfare concerns at the farm. Specific accusations include severe overcrowding (some tanks house up to 999 animals in an area measuring 80 square meters [865 square feet], equating to about 0.08 square meters [0.87 square feet] per turtle), emaciation, disease, injury, and maladaptive behaviors such as frenzied feeding and in some cases even cannibalism. The death of 299 green turtles in one night, which resulted from a burst water pipe in 2012, also raised questions about neglect at the farm.

The economic difficulties associated with sea turtle farming are also apparent. Between 2007 and 2011, the farm received more than CI$44 million (US$53.7 million) in subsidies, a yearly average of CI$9 million (US$11 million). Massive annual subsidies are still being provided and are set to continue despite calls for change from an independent financial review conducted by the global investment company Ernst and Young.

One can reasonably question whether this funding could be more effectively spent on alternative conservation measures that are aimed directly at protecting wild populations. For example, public awareness initiatives and increased resources for enforcement agencies have effectively helped to address the root causes of wild green turtle population declines elsewhere.

Those concerns may be why the farm is the only remaining facility of its kind in operation. Kélonia, the Observatory of Marine Turtles in Réunion Island, has made a gradual yet successful transition away from being a commercial farm to become a much-needed rehabilitation and release facility for sick and injured sea turtles as well as a popular tourist destination. Kélonia's transition has been accompanied by an increase in wild sea turtle populations. This example directly challenges the view held by many farming advocates who believe that a shift away from turtle farming in the Cayman Islands could not be achieved without decimating wild populations.

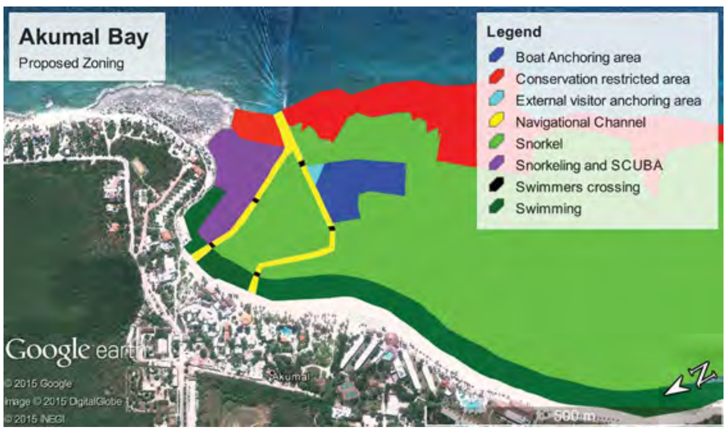
A new study will soon shed light on the conservation credentials of the Cayman Turtle Farm. However, given that other effective ways to conserve green turtles exist (which do not involve animal welfare concerns and exorbitant financial subsidies), we may still find ourselves asking the same underlying question: Does sea turtle farming have a future? ■

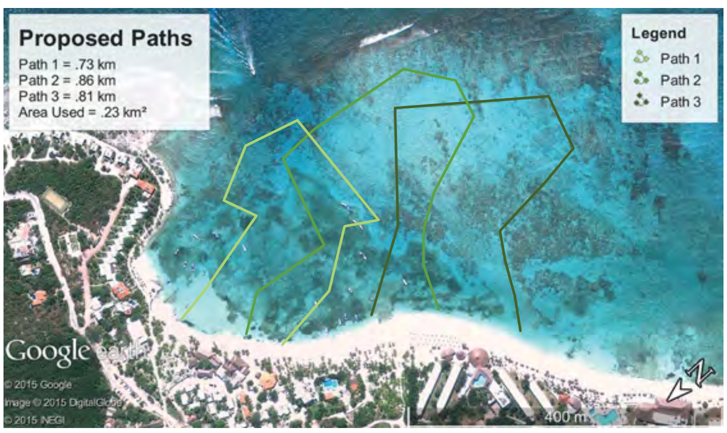
Ancient Mayan "Place of the Turtles" Copes with Modern-Day Tourism

By IVAN PENIÉ, MIGUEL LOZANO, and KATHY SLATER

Akumal is a small town on the eastern coast of Mexico's Yucatan Peninsula in the state of Quintana Roo, about 100 kilometers (62 miles) south of the well-known tourism mecca of Cancún. It was the first tourist destination in Quintana Roo, and the name Akumal means "place of the turtles" in the Mayan language. Akumal lives up to its name, not only as a nesting site for four species of turtles, but also as a foraging ground for a sizable population of juvenile green and loggerhead sea turtles. Akumal has gained fame as one of the few places in Quintana Roo, if not in all of Mexico, where observing sea turtles in their natural habitat is guaranteed. Tourists flock to Akumal by the tens of thousands annually. As a result, local sea turtle populations and marine ecosystems are now threatened by the impacts of too much visitation.

Akumal has a permanent population of only 1,310 people who depend on tourism for their livelihoods. The main in-water tourism attractions are sport fishing, SCUBA diving, and snorkeling. Snorkeling attracts by far the greatest number of tourists and has experienced the greatest growth through the years. Akumal Bay is relatively small—just over 2 hectares (5 acres)—and not only is the presence of 33 small-scale tourism boats causing extensive physical damage to ecosystems critical to the survival of sea turtles, such as coral reefs and seagrass beds, but it also has the potential to cause damage to the turtles themselves through boat strikes and by negatively affecting their natural behaviors.





TOP: A map of the proposed zoning for Akumal Bay that aims to mitigate tourism's impact on turtles. BOTTOM: A map of Akumal Bay showing the three snorkel tour paths proposed as part of new zoning measures. AT RIGHT: A snorkeler observes a green turtle in Akumal Bay. The high volume of snorkel tourists in the Bay is impacting the turtles' natural behaviors. © AKUMAL DIVE SHOP

Concerns about the possible effects on turtles from increased sea turtle tourism and boat traffic in Akumal Bay are not unfounded. Research conducted in the U.S. state of Hawai'i and in Mexico's Bahia de los Angeles in Baja California Sur suggests that turtles in those areas have, in fact, changed their behavior in response to human activities. They now feed at night rather than during the day (documented in both countries) and have changed their movements to avoid snorkelers in Hawai'i.

Concerned about the potential impacts of all this tourism on sea turtles in Akumal Bay, the nonprofit group Operation Wallacea, in collaboration with the Akumal Ecological Center, conducted a study in 2014 to determine the tourism capacity of the bay and to define best practices for sea turtle tourism overall. Researchers conducted daily monitoring over the 12-hour periods during which tourism activities took place, and they evaluated tourist behavior toward sea turtles by documenting crowd size, approaching and touching behaviors, as well as the responses by the turtles to people (evasion, stress, passivity, or feeding). A high incidence of turtle avoidance responses were observed when tourists were within a 5-meter (16.4-foot) radius of the animals, suggesting that the presence and proximity of tourists does indeed affect turtle behavior.

A parallel study carried out by the Akumal Ecological Center, El Colegio de la Frontera Sur (ECOSUR), and the U.S.A.-based organization Teens4Oceans used acoustic transmitters and found that the number of turtles leaving the bay is proportional to the increased presence of tourists. The study also found tourist behaviors such as crowding, approaching, and touching sea turtles to be common daily practices, which is not surprising given that those practices appear in the publicity photos and promotional pamphlets used to promote Akumal Bay as a tourism attraction.

These studies both indicate that the quality of the tour—for example, whether tourists are advised to observe turtles passively, at a safe distance, or are allowed or encouraged to approach and touch them—is likely to be a more important factor influencing the behavior of turtles than simply the number of tourists visiting Akumal Bay. Additional studies are now under way to help to determine the varying impacts of tourist density and tour quality on the health of the ecosystem as a whole.

It is a federal crime in Mexico to disturb the life cycle of sea turtles, yet enforcement is lax at Akumal Bay. As such, the Akumal Ecological Center has proposed a plan for snorkel tourism in the bay that aims to minimize negative environmental impacts while ensuring that local operators can continue to profit from tourism.

Current zoning allows a total area for nonextractive tourism in Akumal Bay of 284,381 square meters (340,117 square yards). Seagrass beds and coral reef formations are scattered throughout this area, and approximately 40 sea turtles inhabit the bay. If the total nonextractive-use zone is used over an eight-hour period, and a mandatory buffer of 5 square meters (6 square yards) is observed around each turtle, a maximum of 59 groups of six people can be in the area every 45 minutes. This limit would result in a total of 354 tourists in the bay at any given time, or more than 4,000 in one day, as was recorded last summer. To limit this substantial number of tourists in the bay and to reduce tourism's impact on the ecosystem, we propose the following measures:

- Each sea turtle should be observed by only one group of tourists at a time and only for a maximum of 2 minutes.
- Each group should contain no more than six tourists, with the guide located at the center of the group.
- Groups should maintain a separation distance of 5 meters (16.4 ft).
- A minimum distance of 3 meters (9.8 ft) should be maintained between a turtle and every member of the group, and the distance between group members should never exceed 1.3 meters (4.3 ft), which will always leave two-thirds of the circumference of the 3-meter radius as a potential escape path for the turtle.
- No more than three paths should be established for snorkel groups to follow (see map p. 28). This measure allows snorkel tours to go out every 30 minutes, with a maximum duration of 55 minutes each. Tours should proceed in opposite directions along these paths to minimize congestion.

When enacted, the measures above will ensure that the total number of tourists in the water at any given time will not exceed 72 and that the daily number of tourist in Akumal Bay will not exceed 540.

To establish these guidelines, a management-and-use plan must be created with the Secretary of the Environment and Natural Resources (SEMARNAT). Once in place, the plan will require all tourism operators to obtain permits. This management-and-use plan, which is currently being designed, calls for many additional actions, including the following:

- The formation of a community monitoring team by the local Federal Attorney for Environmental Protection (PROFEPA). The team will monitor and promptly denounce those in violation of the management plan.
- Ongoing training and certification of all snorkel tour guides and photographers operating in Akumal Bay.
- Obligatory use of certified local guides.
- Establishment of properly marked nautical zoning that will designate turtle observation, boating, and swimming areas.
- Establishment of schedules and strict rules for navigation in the bay, and a plan for gradually decreasing the number of vessels engaged in tourism.

The aim of any measures must be to ensure that tourism activities in Akumal Bay are safe for turtles and fragile habitats, and also assure social development for the local community. With the implementation of an effective and well-informed management-and-use plan, coupled with effective outreach, environmental education, monitoring, and research, we hope to rehabilitate the ecosystem and provide the backdrop for healthy sea turtle populations, while encouraging sustainable development within the Akumal community. ■

Turtle Recovery in Cyprus

THE IMPORTANCE OF LONG-TERM COMMITMENT

By KIMBERLEY STOKES

Local turtle champion Kutlay Keço has been watching green and loggerhead turtles nest on Alagadi Beach in northern Cyprus since the 1970s. Alarmed at the ever-increasing levels of nest predation by stray dogs, he invited two university students, Annette Broderick and Brendan Godley, to collaborate in surveying the population. In 1992, they established the Marine Turtle Conservation Project, documenting a 90 percent nest predation rate, and they set out to turn these unsustainable losses around.

The co-dependency of conservation and research has been a cornerstone of the project since the beginning, and the structure is built on a motivated and well-trained volunteer workforce. Carefully supervised night visits to the otherwise off-limits nesting beach provide the double service of tourist education and fundraising (through donations and a souvenir gift shop) to offset project costs. Keço maintains a deep involvement in the project, housing the volunteers on his land and working with the government to protect nesting

beaches through SPOT, the Society for the Protection of Turtles in North Cyprus.

Each summer, teams of volunteers carry out daily patrols of every nesting beach on the north and west coasts of northern Cyprus for the duration of the breeding season (May–September). The teams record and protect new nests and excavate any that have hatched. At Alagadi Beach, patrols continue throughout the night at sufficient regularity to encounter every single nesting turtle, thus enabling the calculation of reproductive rates such as clutch frequency and remigration interval. By covering a great breadth of nesting sites and implementing in-depth monitoring at one major site, the project is able to observe relatively widescale nesting trends while also collecting individual fecundity metrics to interpret the broader nest count data. The longevity of the data series allows us to see past short-term fluctuations in nesting numbers so we can observe underlying population trends.

Population assessments should be based on data from multiple life stages wherever possible, not just from nests and nesting females. However, the accessibility of nests and females provides logistical opportunity for low-cost, long-term monitoring. Whether assessments come from nesting beach counts or in-water surveys at foraging grounds, monitoring schemes with a core set of simple, robust, and inexpensive measurements often have higher chances of remaining consistent and sustainable in the long term.

Many green turtle research projects estimate the number of nesting females by dividing the number of nests on a beach by a widely accepted average clutch frequency of three nests per female. At Alagadi Beach, where each nest is assigned to a known (tagged) female, green turtle clutch frequency consistently averages three nests per female, thereby validating this widely used method at a regional scale.

In contrast to Cyprus, however, Ascension Island's green turtles are larger, migrate farther, and have a longer season of favorable nesting conditions than do their conspecifics in the Mediterranean. Their average clutch frequency has been shown to be as high as six nests per female per season. Such variations highlight the importance of determining regional reproductive rates, as well as monitoring changes in productivity over time.

Nesting beach research is not limited to adult females and hatchlings; advances in tracking and molecular technologies increasingly extend the scope of insights possible from nest site projects. For example, 12 years of satellite tracking from Alagadi Beach sparked a collaborative tracking project from green turtle nesting sites across four Mediterranean countries. This combined effort has identified shared foraging grounds and migratory corridors with seasonally high concentrations of turtles, thereby revealing an urgent need to investigate fisheries bycatch levels in those key areas.

Moreover, genetic studies at Alagadi using parentage analysis have shown that the green turtle breeding population consists of more males than females, a big surprise considering the heavily female-biased sex ratios of hatchlings that have been recorded there and on surrounding coastlines. This pattern has also been observed in green turtle populations in the southern Great Barrier Reef and in Georgia, U.S.A. Such revelatory findings emphasize the limitations of our understanding of sea turtle biology.

Climate change adds another dimension to the need for long-term data. Long-term monitoring projects from an array of taxa have proved invaluable in demonstrating a clear biological response to recent warming. For sea turtles, some populations are gradually shifting their nesting phenology out of the hottest part of the season, which goes some way toward ameliorating the negative effects of rising sand temperatures on hatchling survival, size, and sex ratio. Major uncertainties remain regarding the resilience and adaptive potential of sea turtle reproduction to modern climate change; conservation and research must go hand in hand in seeking to protect these ancient mariners.

Twenty-three years after the Marine Turtle Conservation Project conducted its first surveys in northern Cyprus, monitoring continues, and in situ nest protection has reduced the once prolific predation rates to less than 5 percent. Green turtle nesting in the region is rising steadily, adding to a growing body of evidence that recovery of vastly reduced sea turtle populations can be achieved, given adequate protection over appropriate timescales. ■

AT LEFT: Researchers tag a nesting green turtle on Alagadi Beach, Cyprus. Long-term research at Alagadi has led to insights into turtle biology that extend well beyond the nesting beach. © OLKAN ERGULER

the true value of sea turtles

By WALLACE J. NICHOLS

Can you recall a time that you glimpsed a sea turtle swimming away from you under water? Or you witnessed the multimillion-year-old ritual of a nesting turtle burying 100 glistening white eggs under the sand and moon? Or the first time you carefully placed a baby sea turtle, hatched minutes prior, on the sand and watched it duck-dive wave after wave as it pushed its way seaward to begin an uncertain decades-long journey?

Of course you can. It's moments like those that led you to the curiosity and exploration you're having now with this volume of *SWOT Report*.

Those experiences transformed us, made us into the turtle warriors we are. Face it, how many of your high school friends are reading about global sea turtle population trends right now? None, that's how many.

So, how did that feeling of awe convert into what may be best described as a life dedicated to turtle-centric altruism?

A typical, oft-repeated, and unquestioned adage is "If you can't measure it, you can't manage it." Those of us who *do* environmental management, who have been involved with successful conservation work and movement building, know that statement is BS. The most important things we manage are not (easily) measurable—from the quality of our new team members to the awe and wonder that's at the root of why we care in the first place. Our greatest successes sometimes occur (a) in spite of government agencies' denials of decades of well-considered science, (b) in the face of barely quantified threats, or (c) alongside massive holes in our understanding of basic sea turtle biology and life history.

The "measure to manage" dogma found its place as militaristic styles expanded into business, and business expanded into our professional relationship with nature in the post–World War II industrial era. The language of targets, tactics, strategies, and enemies now pervades agency- and NGO-speak alike. But when the value of sea turtles to humans is reduced to what's easily measured with our standard metrics and sorely limited resources, we run the risk of getting things dangerously wrong.

Ecology and economics provide a clean, clear, yet wildly incomplete, even cartoon-like framework for analyzing the values of nature. Consider this familiar balance sheet. In one column (A) is the commodified value of sea turtles as resource: eggs, meat, shell, oil. In the next (B) is the value of sea turtles as eco-tourist attractions: hotel rooms, park fees, guides, meals, travel. If the number at the bottom of column B exceeds the value of column A, sea turtles get to live (in theory, at least). The conversation has been expanded in recent years to include a third column called "ecosystem services" that provide public benefits. Those benefits include dune stabilization, sea grass maintenance, and even climate regulation, as provided by the trophic cascades, at the top of which are often found sea turtles and other predators.

Fortunately, the conversation around valuing nature is expanding quickly to include the cognitive, emotional, psychological, and social benefits that we know are real drivers of the human-nature relationship. When neuropsychologists and conservation biologists team up, the results can be revolutionary. Consider a few of the real but rarely described benefits of working with sea turtles.

Awe and Wonder

New research suggests that the feeling of awe is good for our health, boosts empathy and compassion, and helps connect us to the people and places around us.

Feelings of awe are some of the most cherished and transformative experiences in human life and are generated by art, music, architecture, but most often nature. Dr. Paul Piff of the School of Sociology at University of California Irvine defines awe as "the sense of being in the presence of something bigger than oneself that current knowledge structures cannot accommodate and that allows people to rise above stimulus-response patterns and lose themselves in an all-encompassing event."

Scientists have made evolutionary arguments for the universality of awe and how it has likely evolved. Other studies find that awe may enhance our memory of events, play an important role in morality, make people less self-focused and more prosocial, lead to enhanced generosity, increase virtuous behavior, reduce feelings of entitlement, and increase helping. Current studies show that feelings associated with awe can reduce cytokines (proteins important for cell signaling), chemicals associated with disease, and even inflammation.

Yet some people live wonder-free lives. For those who work with sea turtles, awe can be a daily experience. When we share our work, we make the world better. More sea turtle lovers equal more ocean advocates—a virtuous, positive feedback loop.

Solitude and Privacy

Our lives are becoming more and more connected, and time spent truly alone with ourselves and our own thoughts is sadly minimized. A recent study in *Science* demonstrates how uncomfortable solitude feels to college students: two-thirds of men pressed a button to deliver a painful jolt after a mere 15-minute period of solitude. One man—considered an outlier—found quiet thinking to be so disagreeable that he opted for a shock 190 times. In these modern times, our written and spoken words as well as our physical movements are almost constantly monitored by strangers, government agencies, and marketers. And this loss of solitude and privacy adds to the stress of life.

Being near, in, on, or under water can be a refuge or escape, and that relationship can have the same positive benefits mentioned earlier for awe and wonder. A beach or a bay can provide a rare retreat from technology. And those are the settings in which work frequently places us fortunate souls who are turtle professionals.

Creativity and Inspiration

Artists and engineers, musicians and entrepreneurs, writers and scientists rely heavily on their ability to generate creativity—combine old ideas and pieces to make new ones—to think of things that have never been thought of. It's no surprise that great thinkers such as Sir Isaac Newton, Oliver Sacks, and Albert Einstein found inspiration outside under a blue sky or beside flowing waters. Free from walls and overstimulation of modern, urban existence, our brains work differently. That's not to say better, but there's a certain kind of expansive thinking that's facilitated by blue space.

Perhaps there's no better place to experience awe, creativity, inspiration, privacy, solitude, and wonder than on a sea turtle beach. Humans have depicted their appreciation for the ocean and sea turtles through art for millennia. You've had much the same experience as our ancestors on the beach at night, face to face with our beloved chelonians. As a conservation or research professional, student, seasonal volunteer, or wayfaring traveler, being with sea turtles in nature changes us. We become better versions of ourselves.

These are big ideas that are tricky to assign numbers to but important to put into words, with ever-increasing clarity and rigor. Quite literally—as well as poetically—being with sea turtles is good medicine. And here's a prediction: In the not so distant future, medical professionals will prescribe two weeks of volunteering on a turtle beach for what ails their patients. ■

AT LEFT: A boy releases a hatchling green turtle as part of a sea turtle festival in Quintana Roo, Mexico. © PETE OXFORD / ILCP

Up "Grade" Your Volunteer Program with Academic Internships

By KATHERINE COMER SANTOS

The Science Exchange (TSE) creates academic sea turtle research internships for undergraduate and graduate students from around the world. Interns work for about two months at a camp or research lab under the supervision of a professional mentor, for which they can earn up to nine units of credit from San Diego State University or any of a dozen U.S. universities that have participated to date.

TSE has observed over the past 10 years that volunteers and interns at sea turtle projects are personally transformed and report life-changing experiences. Beyond enhancing the lives of the students, academic internships can also boost the success of a volunteer program while benefiting sea turtles and the nonprofits and local communities that work with them. The main reason is that earning credits toward graduation is a major incentive for students and their families, and the drive to get a good grade (or the threat of a low grade) creates strong motivation. One project reported "Claire spent a few hours minimum every day working on her papers, research, presentations, and more, while also helping around the house and performing nightly patrols, morning censuses, and hatchery work."

In our experience, students and universities often rely on the turtle project supervisor (or on TSE, if we are involved) to organize the internship and to evaluate the intern's work. Therefore, we have compiled the following tips for others who are interested in creating a successful academic internship program:

> Academic interns are long-term, invested, and intellectually engaged volunteers who earn college credit while giving back to a turtle project in more ways than just labor and fees.

1. **Research the college's requirements for issuing the credits that the intern needs.** It is best if the credits count toward graduation requirements or completion of the major. TSE frequently negotiates with academic counselors to obtain pre-departure approval for credits to give peace of mind to the student. The most frequent requirement from colleges is assurance that the activities provide a learning experience and are not just manual labor. Schools may also ask for the supervisor's qualifications or education level, proof of a minimum number of hours worked, a paper from the student, a supervisor evaluation, signatures on forms, or an internship plan.

2. **Create a written internship plan.** In addition to the normal volunteer orientation packet (e.g., waivers, insurance, and travel logistics), the intern, supervisor, and school should agree on what will constitute an internship and how performance will be evaluated. Scholarship and loan offices may also require a formal plan. The following are some important plan components:
   - **Internship topics**—The topic of the internship should be relevant to the turtle project and, ideally, benefit the community. Some examples of successful TSE projects include implementing a small section of a larger thesis or ongoing research project, analyzing existing data, performing water quality testing, and piloting new protocols (e.g., SWOT Minimum Data Standards, NOAA marine debris surveys, WWF climate change monitoring). TSE teaches the scientific method, so even our social science and business majors have a research question to answer; they have administered surveys, developed bilingual educational materials, and even created a business plan for a turtle camp. We avoid topics that involve invasive procedures or use captive animals because such studies can require specialized technical experience, permits from the local government, and clearance from universities.
   - **Assignments**—Include a reading list and writing assignments. These key academic components help justify credits, and written products also ensure that the project will have a report to disseminate.
   - **Equipment list**—Use equipment and software that are locally available so that the community can continue the research after the internship ends.
   - **Schedule**—Have interns stay in the field for as long as possible. Students who stay longer are better trained, more adapted to local life, and are able to develop an adequate sample size for statistically significant results. For example, if it is not peak nesting season, or if water quality samples need time to incubate, the schedule should reflect that. To encourage longer stays, create a sliding scale fee system for housing national interns and long-term international interns.
   - **Evaluation criteria**—Include your standards for recommending the work for academic credit. TSE uses a grading rubric in which 75 percent of the credits are based on timely completion of writing assignments. The conditions of our merit-based scholarships are detailed in writing as well.
   - **Intellectual property**—Include expectations for data ownership and publication. TSE shares data with the

ALL: Academic interns assist at various sea turtle research and conservation projects throughout Latin America.

supervisors and offers joint authorship to anyone who helps on the project. Experts note that international collaboration is favored by journals and readers.

- Backup plan—Acknowledge that the plan is subject to field conditions. For example, what if the *arribada* does not arrive? Have a plan B in place that also qualifies for academic credits at their school.

3. Provide supervision at several levels. Often, it is the first time interns have participated in field research. Train them thoroughly and subsequently to observe his or her data collection methods. The intern should also analyze their own data and *will* need help from the supervisor. Schedule regular meetings to review their work.

4. Outline how the community will benefit. Cultural exchanges are just as valuable as scientific exchanges, so include interns in all community outreach efforts. Visiting scholars can generate interest and lend validity to the conservation message. We learn best from teaching, so have the intern make presentations to the local schools. TSE requires our field interns to use Skype to teach low-income K-12 students through our Bridge the Border program. Our interns also must make a final presentation to supervisors and stakeholders in the local community. Interns should not take away a job or internship from a local; on the contrary, the community should see some economic gain from the internship. Consider organizing earning opportunities for locals as part of the internship, such as host family stays; meal preparation; or classes in language, surfing, art, music, or cooking.

5. Ask for and provide feedback. Actively seek feedback from participants. Interns have fresh, outside perspectives that supervisors may have missed from the daily grind in the trenches. Moreover, positive reviews are free marketing material! Offer interns feedback and career advice as well.

6. Follow up. After the interns get back to their university, be prepared to help them petition for credits, if necessary. Although TSE has never had credits denied, we have seen university faculty members change positions and have had to make the case for credits anew. Also, be aware that interns frequently ask for letters of recommendation for jobs even years later.

7. Keep following up! Encourage former interns to disseminate their work. TSE has helped more than half of our 36 interns to date present at conferences or publish. International exposure is important for getting funding and influencing politics surrounding turtle conservation. Finally, the intern–supervisor relationship is often deeper than that of the volunteer–supervisor. Interns can become project promoters, employees, and donors. Don't lose track of them!

Academic interns can require more investment of time compared to regular interns or volunteers, but the return on that investment is also greater. The Science Exchange is growing and looking for more interns and partners in Latin America, specifically Mexico. If your turtle project would like to host an intern, or if you are a student or recent graduate looking for a sea turtle internship, we'd love to hear from you. ■

SWOT team

Acting Globally

SWOT Small Grants 2014

Since 2006, SWOT small grants have helped field-based partners around the world realize their research and conservation goals. To date, we have given 51 grants to partners in 37 countries. SWOT grants are awarded annually to projects in each of SWOT's three areas of focus: networking and capacity building, science, and education and outreach. The following are updates from each of our seven grantees in 2014. Visit **www.SeaTurtleStatus.org** to apply for a 2015 SWOT small grant!

INDONESIA

Alliance for Tompotika Conservation

The Alliance for Tompotika Conservation (AlTo), located in East Central Sulawesi, Indonesia, has worked with local communities since 2006 as it sponsors field-based conservation programs and awareness and outreach programs in local schools that work toward the conservation of the maleo bird and sea turtles. Recognizing the power of the arts as an effective medium for public education and outreach, AlTo will use the 2014 SWOT grant to produce the first traveling Tompotika Sea Turtle and Maleo Festival. This festival builds off a 2014 youth project with local high school students. It addresses a critical need for outreach to adults and members of the Tompotika public who live in rural areas, and it will carry a strong antipoaching and conservation message to their communities.

MEXICO

ProFaunaBaja

ProFaunaBaja is a society for scientists, students, and naturalists who share a common goal: to conserve biodiversity and vulnerable ecosystems in Baja California Sur, Mexico. The 2014 SWOT grant will be used to create a citizen science-monitoring project to facilitate the collection of in-water sea turtle spatial data from the hundreds of foreign boaters that arrive in the area annually. ProFaunaBaja will undertake capacity-building workshops for boaters and will pilot test the I-naturalist integrated mobile phone application for use by citizen science participants. The pilot study will be used to determine the design of a new mobile phone application that boaters can use to share sightings. Boaters will provide the date, species ID, age range, habitat substrate type, depth (using depth finders), approximate abundance, and GPS coordinates.

COLOMBIA

Fundación Tortugas del Mar

Cartagena de Indias, located on Colombia's Caribbean coast, is one of the largest tourist destinations in the Caribbean. The constant influx of both national and foreign tourists feeds a thriving long-term business in illegal tortoiseshell handicrafts. Fundación Tortugas del Mar will use the 2014 SWOT grant to help launch its "Turtle friendly tourism in Cartagena, Colombia" campaign. The campaign will work to raise awareness with both the local communities and tourists about the illegal tortoiseshell trade. The community outreach program will work to introduce conservation concepts through school activities, community briefings, and presentations. The environmental awareness campaign will reach out to tourists with fact sheets, posters, media events, and other promotional materials.

KENYA
Local Ocean Trust—Diani Turtle Watch

Diani, located on the southern Kenyan coast, is a prime nesting area for green turtles. Coastal development poses a serious and imminent threat to the continuity of this rookery. Since 2012, Local Ocean Trust (LOT), which is a sea turtle conservation organization based in Watamu, Kenya, has trained a team of local Kenyan men to monitor and protect nesting females and their nests in Diani. The Diani Turtle Watch is the first satellite program developed by LOT and is based on the team's work in Watamu. The 2014 SWOT grant will be used to provide further training to the Diani Turtle Watch team and to purchase basic equipment to facilitate monitoring and protection activities.

CHILE
University of Antofagasta

The presence of sea turtles in northern Chile has been registered for more than two centuries, but knowledge regarding their ecology is poor. Ricardo Andrés Sarmiento, a doctoral student at the University of Antofagasta in Chile, will use a 2014 SWOT grant to advance research and monitoring in two coastal bays in the Antofagasta region that are heavily influenced by upwelling and other features of the Humboldt Current System. The project will focus on completing abundance estimations and spatial and temporal distribution of turtles, as well as the relationship with some environmental variables. All data will be based on monthly visual surveys from artisanal fishermen. Stable isotope analysis will examine the consumption and proportions of neritic or pelagic foods that contribute to the turtles' diet.

BANGLADESH, INDIA, AND SRI LANKA
Asian University for Women

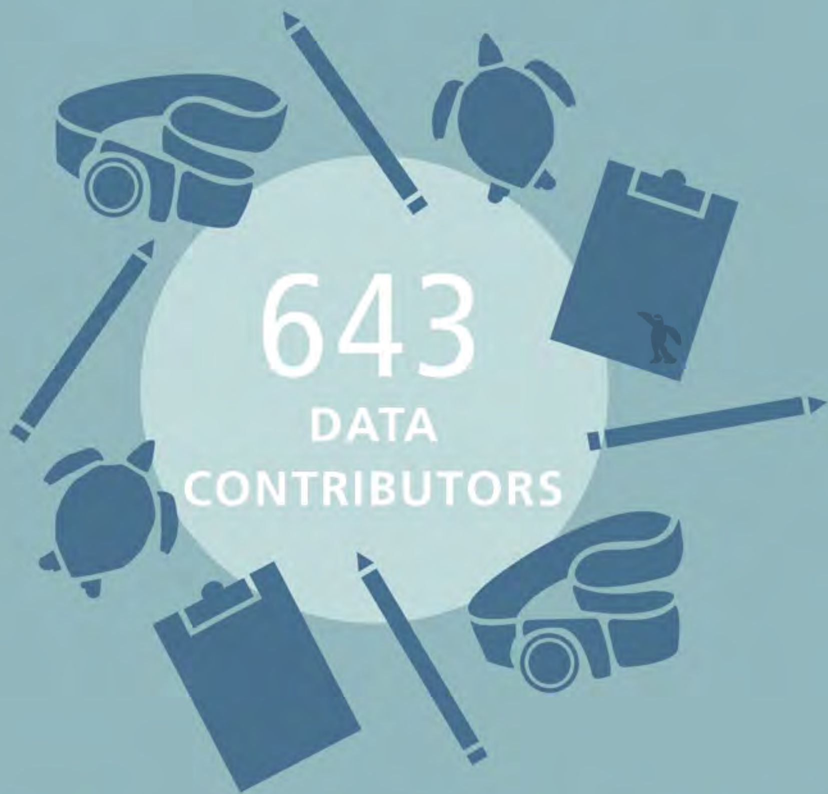
Dr. Andrea Phillott, a professor at the Asian University for Women, is conducting a project to gather data about management practices of sea turtle hatcheries in Bangladesh, India, and Sri Lanka to improve conservation practices. The 2014 SWOT grant will be used to implement on-the-ground research to learn more about hatchery operations. In-country assistants will seek to learn more about hatchery operations through in-person and telephone interviews and questionnaires with hatchery owners and managers. Results will inform the design of targeted awareness workshops and written resources to assist hatcheries in improving their operations with the goal of enhancing hatch success and hatchling productivity.

FRANCE AND WORLDWIDE
Université Paris–Sud

All seven species of sea turtles exhibit temperature-dependent sex determination. Sex ratio depends on sand temperature where eggs are incubated, and sand temperature is itself dependent on many other factors. Dr. Marc Girondot and his team at the Université Paris–Sud will use a 2014 SWOT grant to build a global sand temperature database of all existing—both published and unpublished—records of sand and nest temperatures. This database will be used in a meta-analysis to make a prognosis of sand temperature on a global scale. The goal of the project is to create a model to predict nest temperatures and their effect on sea turtle sex ratios globally on the basis of actual sand temperatures and inferred influences of factors such as air and sea surface temperature and physical properties of beaches.

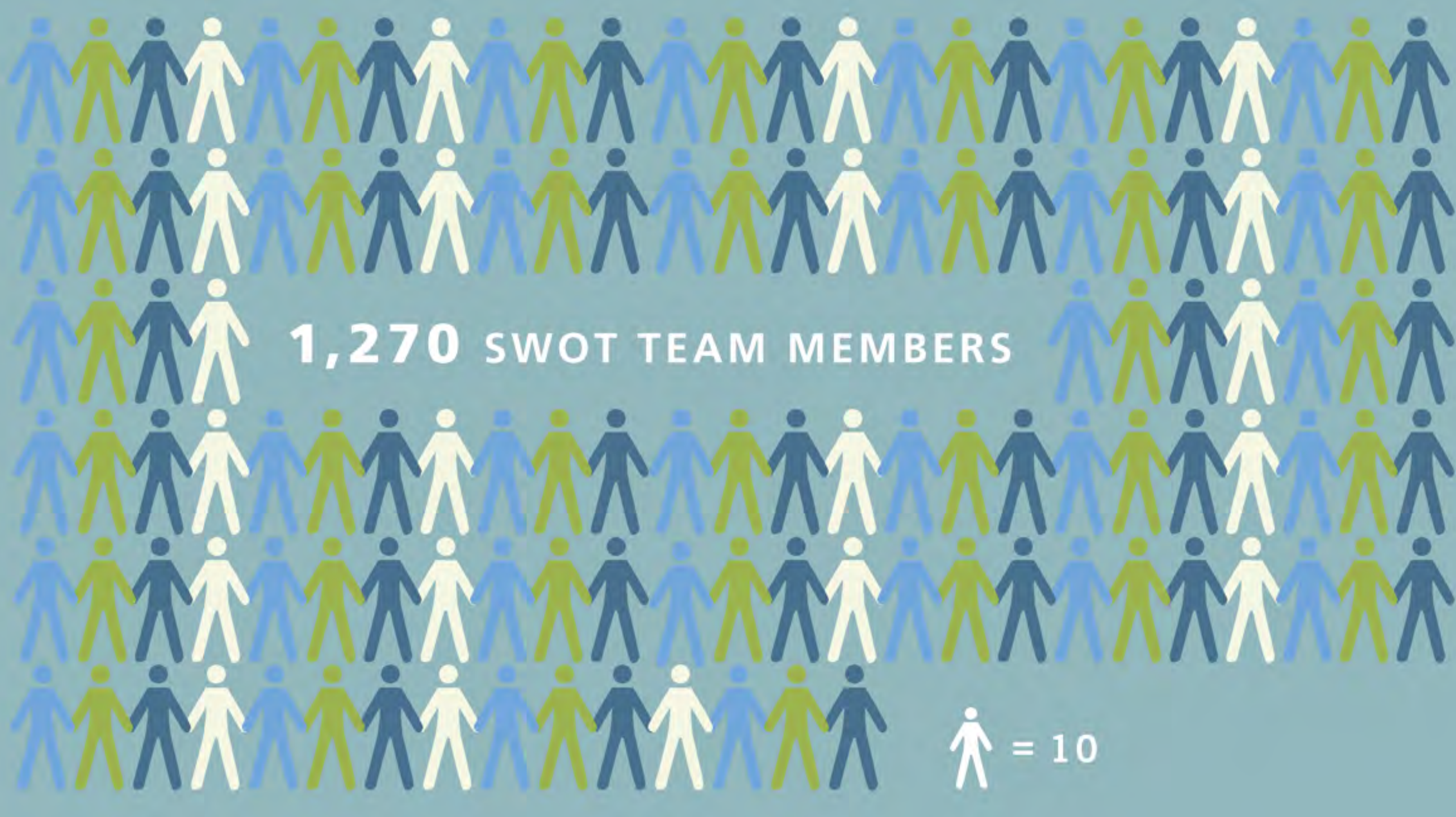
SWOT
BY THE NUMBERS

10
VOLUMES OF SWOT REPORT



643
DATA CONTRIBUTORS

42,000
REPORTS PRODUCED



SEA TURTLE DATA FROM
COUNTRIES & TERRITORIES 130

51 GRANTS GIVEN TO
45 PARTNERS IMPACTING MORE THAN
37 COUNTRIES

201,451
TELEMETRY RECORDS
FROM
525
TAGGED SEA TURTLES

6,899
NESTING RECORDS

3,271
NESTING SITES

A Decade of SWOT Teamwork

Data contributors since 2004

SWOT's global network of volunteer data providers is the lifeblood of the SWOT program. As shown in the infographic on pp. 38–39, SWOT's database now hosts information from 3,271 nesting sites, 525 satellite tracked turtles, and 130 countries and territories. Here we recognize the individuals and institutions who have contributed data to SWOT since 2004.

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Data Citations

Costa Rica Map

DEFINITIONS OF TERMS

Clutches: A count of the number of clutches laid by females during the monitoring period.
Estimated clutches: An estimate of the number of clutches laid in a season. Methods of estimation vary.
Year: The year in which a given nesting season ended (e.g., data collected between late 2005 and early 2006 are listed as year 2006).

GUIDELINES OF DATA USE AND CITATION

The nesting data that follow for Costa Rican sea turtles correspond directly to the map on pages 22–23. Every data record with a point on the map is numbered to correspond with that point. To use data for research or publication, you must obtain permission from the data provider and must cite the original source indicated in the Data Source field of each record.

In the records that follow, nesting data are reported as number of clutches from the most recent available year or nesting season. Beaches for which count data were not available are listed as "unquantified." Additional metadata are available for many of those data records, including information on beach length, monitoring effort, and other comments, and that information may be found online at http://seamap.env.duke.edu/swot. Following the nesting data records, we have included citations for other data sources that were used in creating the map.

DATA RECORD 1

Data Source: Ramírez-Vargas, M. 2014. Reporte final: Anidación de tortugas marinas en playa de Barra de Parismina durante la temporada 2014. Unpublished report. Asociación Salvemos las Tortugas Marinas de Parismina and Ministerio de Ambiente y Energía.
Nesting Beach: Barra de Parismina
Year: 2014 **Species and Counts:** *Dermochelys coriacea*—99 clutches
SWOT Contacts: Marco Ramírez-Vargas and Vicky Taylor

DATA RECORD 2

Data Source: Ramírez-Vargas, M. 2014. Reporte final: Anidación de tortugas marinas en playa de Barra de Parismina durante la temporada 2014. Unpublished report. Asociación Salvemos las Tortugas Marinas de Parismina.
Nesting Beach: Barra de Parismina
Year: 2014 **Species and Counts:** *Chelonia mydas*—19 clutches; *Eretmochelys imbricata*—1 clutch
SWOT Contacts: Marco Ramírez-Vargas and Vicky Taylor

DATA RECORD 3

Data Source: Chacón-Chaverrí, D. 2015. Sea turtle nesting in Barra Norte de Pacuare and Cahuita, Costa Rica: Personal communication. In *SWOT Report—The State of the World's Sea Turtles*, vol. 10 (2015).
Nesting Beaches: Barra Norte de Pacuare and Cahuita
Year: 2014 **Species and Counts:** *Chelonia mydas*—52 and 6 clutches, respectively; *Dermochelys coriacea*—137 and 71 clutches, respectively; *Eretmochelys imbricata*—13 and 81 clutches, respectively
SWOT Contact: Didiher Chacón-Chaverrí

DATA RECORD 4

Data Source: Santidrián Tomillo, P. 2015. Leatherback nesting in Cabuyal, Costa Rica: Personal communication. In *SWOT Report—The State of the World's Sea Turtles*, vol. 10 (2015).
Nesting Beach: Cabuyal
Year: 2013 **Species and Counts:** *Dermochelys coriacea*—10 clutches
SWOT Contact: Pilar Santidrián Tomillo

DATA RECORD 5

Data Source: Beange, M., and R. Arauz. 2015. Sea turtle nesting in Caletas, Corozalito, Costa de Oro, and San Miguel, Costa Rica: Personal communication. In *SWOT Report—The State of the World's Sea Turtles*, vol. 10 (2015).
Nesting Beaches: Caletas, Corozalito, Costa de Oro, and San Miguel
Year: 2014 **Species and Counts:** *Chelonia mydas*—1, 5, 3, and 3 clutches, respectively; *Dermochelys coriacea*—1, 9, 1, and 1 clutches, respectively; *Lepidochelys olivacea*—1,644; 1,931; 378; and 458 clutches, respectively
SWOT Contacts: Randall Arauz and Maddie Beange

DATA RECORD 6

Data Source: Arauz, R. 2009. Personal communication. In *SWOT Report—The State of the World's Sea Turtles*, vol. 10 (2015).
Nesting Beach: Caletas
Year: 2008 **Species and Count:** *Eretmochelys imbricata*—1–25 clutches
Nesting Beach: Camaronal
Year: 2009 **Species and Count:** *Eretmochelys imbricata*—1–25 clutches
Nesting Beach: Punta Banco / Punta Burica
Year: 2008 and 2009 **Species and Count:** *Chelonia mydas*—3 clutches (2008); *Eretmochelys imbricata*—1–25 clutches (2009); *Lepidochelys olivacea*—213 clutches (2008)
Nesting Beach: Sirena and Corcovado
Year: 2008 and 2009 **Species and Counts:** *Chelonia mydas*—13 clutches (2008); *Eretmochelys imbricata*—1–25 clutches (2009); *Lepidochelys olivacea*—137 clutches (2008)
SWOT Contacts: Randall Arauz, Maddie Beange, Didiher Chacón-Chaverrí, Alex Gaos, and Sandra Viejobueno

DATA RECORD 7

Data Source: Saborío-R., G., and M. Sánchez. Unpublished data. Sea Turtle Conservation Project, Osa Conservation, Costa Rica.
Nesting Beaches: Carate and Río Oro
Years: 2011 **Species and Counts:** *Chelonia mydas*—2 and unquantified clutches, respectively; *Lepidochelys olivacea*—274 and unquantified clutches, respectively
Nesting Beaches: Pejeperro and Piro
Years: 2012 **Species and Counts:** *Chelonia mydas*—106 and 21 clutches, respectively; *Lepidochelys olivacea*—24 and 13 clutches, respectively
SWOT Contacts: Hansel Herrera and Guido Saborío

DATA RECORD 8

Data Source: Gaos, A. R., I. L. Yañez, and R. M. Arauz. 2006. Sea turtle conservation and research on the Pacific coast of Costa Rica. Technical report. Programa Restauración de Tortugas Marinas (PRETOMA).
Nesting Beach: Costa de Oro
Year: 2004 **Species and Counts:** *Dermochelys coriacea*—2 clutches
SWOT Contacts: Randall Arauz, Maddie Beange, Alex Gaos, and Ingrid Yañez

DATA RECORD 9

Data Source: Dow, W. E., and K. L. Eckert. 2007. Sea turtle nesting habitat—A spatial database for the wider Caribbean region. *WIDECAST Technical Report*, no. 6, Wider Caribbean Sea Turtle Conservation Network (WIDECAST) and The Nature Conservancy, Beaufort, NC.
Nesting Beach: Erlin
Year: 2005 **Species and Counts:** *Eretmochelys imbricata*—25–100 crawls
SWOT Contact: Didiher Chacón-Chaverrí

DATA RECORD 10

Data Source: Malaver, M., and D. Chacón-Chaverrí. 2009. Anidación de tortugas marinas en la playa de Gandoca, Caribe Sur, Costa Rica. Informe Temporada 2009.
Nesting Beach: Gandoca
Year: 2009 **Species and Counts:** *Dermochelys coriacea*—524 clutches; *Eretmochelys imbricata*—38 clutches
SWOT Contact: Luis G. Fonseca

DATA RECORD 11

Data Source: Chacón-Chaverrí, D. 2008. Hawksbill nesting in Costa Rica: Personal communication. In *SWOT Report—State of the World's Sea Turtles*, vol. III (2008).
Nesting Beaches: Isla Uvita, Manuel Antonio National Park, Platanares, and Punta India to Rayo
Year: 2006 **Species and Counts:** *Eretmochelys imbricata*—1–25 clutches each
SWOT Contact: Didiher Chacón-Chaverrí

DATA RECORD 12

Data Source: Fonseca, L. G. 2015. Green turtle nesting at Isla San José, Costa Rica: Personal communication. In *SWOT Report—The State of the World's Sea Turtles*, vol. 10 (2015).
Nesting Beach: Isla San José
Year: 2014 **Species and Counts:** *Chelonia mydas*—998 clutches
SWOT Contacts: Luis G. Fonseca and Wagner Quirós

DATA RECORD 13

Data Source: Francia, G. 2014. Proyecto de Conservación de Tortugas Marinas de Junquillal (Asociación Vida Verdiazul) 2014.
Nesting Beach: Junquillal (south Guanacaste)
Year: 2013 **Species and Counts:** *Chelonia mydas*—24 clutches; *Dermochelys coriacea*—19 clutches; *Lepidochelys olivacea*—253 clutches
SWOT Contact: Gabriel Francia

DATA RECORD 14

Data Source: Piedra, R. 2008. Hawksbill nesting on Playa Langosta, Costa Rica: Personal communication. In *SWOT Report—The State of the World's Sea Turtles*, vol. 3 (2008).
Nesting Beach: Langosta
Year: 2003 **Species and Counts:** *Eretmochelys imbricata*—2 clutches
SWOT Contact: Rotney Piedra

DATA RECORD 15

Data Source: Piedra, R., and E. Vélez. 2005. Reporte de actividades de investigación y protección de la tortuga baula (*Dermochelys coriacea*), temporada de anidación 2004–2005, Playa Langosta. Proyecto de Conservación en Tortugas Marinas—Tortuga Baula, Parque Nacional Marino Las Baulas, Guanacaste, Costa Rica. Unpublished manuscript.
Nesting Beach: Langosta
Year: 2004 **Species and Counts:** *Dermochelys coriacea*—147 clutches
SWOT Contacts: Rotney Piedra and Elizabeth Vélez

DATA RECORD 16

Data Source: Fonseca, L. G. 2015. Personal communication. In *SWOT Report—The State of the World's Sea Turtles*, vol. 10 (2015).
Nesting Beaches: Bejuco, Blanca, Coloradas, Curú, Esterillos, Esterillos Este, Jacó, Jobo, Junquillal (north Guanacaste), Montezuma, Potrero Grande, and Rajada (unquantified)
Comments: Sea turtle nesting is known to occur on these beaches but no monitoring efforts are in place.
Nesting Beach: Nancite
Year: 2012 and 2014 **Species and Counts:** *Chelonia mydas*—37 clutches (2014); *Dermochelys coriacea*—1 clutch (2012); *Eretmochelys imbricata*—1 clutch (2012); *Lepidochelys olivacea*—68,541 clutches (2014)
Nesting Beach: Naranjo
Year: 2014 **Species and Counts:** *Chelonia mydas*—139 clutches; *Dermochelys coriacea*—1 clutch; *Lepidochelys olivacea*—250 clutches
Nesting Beach: Norte
Year: 2014 **Species and Counts:** *Chelonia mydas*—735 clutches; *Dermochelys coriacea*—66 clutches; *Eretmochelys imbricata*—40 clutches
SWOT Contact: Luis Fonseca

DATA RECORD 17

Data Source: Chacón-Chaverrí, D., and G. McFarlane. 2005. Anidación de la tortuga baula (*Dermochelys coriacea*) en Playa Negra/ Puerto Vargas, Parque Nacional Cahuita, Talamanca, Costa Rica. In *Informe de actividades, temporada* 2005. Asociación ANAI/WIDECAST.
Nesting Beach: Negra
Year: 2005 **Species and Counts:** *Dermochelys coriacea*—196 clutches
SWOT Contact: Didiher Chacón-Chaverrí

DATA RECORD 18

Data Source: Vélez, E., and R. Piedra. 2015. Leatherback nesting at Nombre de Jesus, Guanacaste, Costa Rica: Personal communication. In *SWOT Report—The State of the World's Sea Turtles*, vol. 10 (2015).
Nesting Beach: Nombre de Jesus
Year: 2014 **Species and Counts:** *Dermochelys coriacea*—745 clutches
SWOT Contacts: Rotney Piedra and Elizabeth Vélez

DATA RECORD 19

Data Source: Sarti, L. 2009. Personal communication. In *SWOT Report—State of the World's Sea Turtles*, vol. 5 (2010).
Nesting Beach: Nosara
Year: 2009 **Species and Counts:** *Lepidochelys olivacea*—unquantified

DATA RECORD 20

Data Source: Chaves, G., R. Morera, and J. R. Avilés. 2014. *Seguimiento de la actividad anidatoria de las tortugas marinas (Cheloniidae, Dermochelyidae) en el RNVS Ostional: VI Informe anual.* Escuela de Biología de la Universidad de Costa Rica.
Nesting Beach: Ostional
Year: 2013 **Species and Counts:** *Chelonia mydas*—27 clutches; *Dermochelys coriacea*—23 clutches
SWOT Contacts: Gerardo Chaves, Roldán Valverde, Marta Pesquero, Luis Fonseca, Carlos Mario Orrego, and Wagner Quirós

DATA RECORD 21

Data Source: Fonseca, L. G. 2015. Personal communication. In *SWOT Report—The State of the World's Sea Turtles*, vol. 10 (2015).
Nesting Beach: Ostional
Year: 2014 **Species and Counts:** *Lepidochelys olivacea*—1,192,039 estimated clutches
SWOT Contacts: Gerardo Chaves, Roldán Valverde, Marta Pesquero, Luis Fonseca, Carlos Mario Orrego, and Wagner Quirós

DATA RECORD 22

Data Source: Paladino, F. 2014. Sea turtle nesting at Playa Grande, Costa Rica. Personal communication. In *SWOT Report—The State of the World's Sea Turtles*, vol. 10 (2015).
Nesting Beaches: Playa Grande-Playa Ventanas (4.7 km)
Year: 2013 **Species and Counts:** *Chelonia mydas*—8 nesting females; *Dermochelys coriacea*—28 nesting females; *Lepidochelys olivacea*—46 nesting females
SWOT Contact: Frank Paladino

DATA RECORD 23

Data Source: Francia, G. 2008. Proyecto de Conservación Baulas del Pacífico de Junquillal (World Wildlife Fund) 2008.
Nesting Beaches: Playa Lagarto, Playa Frijolar, Playa Azul, and Playa San Juanillo (combined)
Year: 2007 **Species and Counts:** *Dermochelys coriacea*—8 clutches
SWOT Contact: Gabriel Francia

DATA RECORD 24

Data Source: Brenes Arias, O. 2015. Sea turtle nesting at Playa Tortuga, Costa Rica. Personal communication. In *SWOT Report—The State of the World's Sea Turtles*, vol. 10 (2015).
Nesting Beach: Playa Tortuga
Year: 2014 **Species and Counts:** *Lepidochelys olivacea*—90 clutches
SWOT Contact: Oscar Brenes Arias

DATA RECORD 25

Data Source: Ward, M., and C. Elkins, Sea Turtles Forever. 2015. Sea turtle nesting at Punta Pargos, Costa Rica. Personal communication. In *SWOT Report—The State of the World's Sea Turtles*, vol. 10 (2015).
Nesting Beach: Punta Pargos
Year: 2013 **Species and Counts:** *Chelonia mydas*—171 clutches; *Lepidochelys olivacea*—16 clutches
SWOT Contacts: Chris Elkins and Marc Ward

DATA RECORD 26

Data Source: Venegas-Li, R., R. Valentín-Gamazo, and A. García. 2014. Green turtle nesting at Reserva Pacuare, Limon, Costa Rica. Personal communication. In *SWOT Report—The State of the World's Sea Turtles*, vol. 10 (2015).
Nesting Beach: Reserva Pacuare
Year: 2014 **Species and Counts:** *Chelonia mydas*—26 clutches
SWOT Contacts: Aida García, Rocío Valentín Gamazo, and Ruben Venegas-Li

DATA RECORD 27

Data Source: Venegas-Li, R., R. Valentín-Gamazo, and A. García. 2014. Leatherback turtle nesting at Reserva Pacuare, Limon, Costa Rica. In *SWOT Report—The State of the World's Sea Turtles*, vol. 10 (2015).
Nesting Beach: Reserva Pacuare
Year: 2014 **Species and Counts:** *Dermochelys coriacea*—533 clutches
SWOT Contacts: Aida García, Rocío Valentín Gamazo, and Ruben Venegas-Li

DATA RECORD 28

Data Source: Venegas-Li, R., R. Valentín-Gamazo, and A. García. 2014. Hawksbill turtle nesting at Reserva Pacuare, Limon, Costa Rica. In *SWOT Report—The State of the World's Sea Turtles*, vol. 10 (2015).
Nesting Beach: Reserva Pacuare
Year: 2014 **Species and Counts:** *Eretmochelys imbricata*—6 clutches
SWOT Contacts: Aida García, Rocío Valentín Gamazo, and Ruben Venegas-Li

DATA RECORD 29

Data Source: Harrison, E. 2014. Sea turtle nesting at Tortuguero, Costa Rica. Personal communication. In *SWOT Report—The State of the World's Sea Turtles*, vol. 10 (2015).
Nesting Beach: Tortuguero
Year: 2014 **Species and Counts:** *Chelonia mydas*—10,001–500,000 clutches; *Dermochelys coriacea*—101–250 clutches; *Eretmochelys imbricata*—1–25 clutches
SWOT Contact: Emma Harrison

DATA RECORD 30

Data Source: Solano, R., and ASVO. 2015. Personal communication. In *SWOT Report—The State of the World's Sea Turtles*, vol. 10 (2015).
Nesting Beach: Punta Mala
Year: 2007 **Species and Counts:** *Lepidochelys olivacea*—759 clutches
Nesting Beaches: Guapil, Isla Bolaños, Isla Peladas, and Manzanillo
Year: 2014 **Species and Counts:** Unquantified
SWOT Contact: Roberto Solano

DATA RECORD 31

Data Source: **(1)** Umaña Ramírez, E., ASVO. 2009. *Descripción de la Actividad de Anidación y Manejo de Nidadas de Tortuga Marina en Playa Buenavista, Península de Nicoya, Costa Rica. Informe final, temporada 2008–2009*; **(2)** Umaña Ramírez, E., Pérez Durán, R., and R. Soto Pérez, ASVO. 2009. *Manejo Sostenido de la Colonia Anidadora de Tortugas Marinas en las Playas del Refugio Nacional Vida Silvestre Playa Hermosa–Punta Mala, Pacífico de Costa Rica, Usando Como Base a Funcionarios del MINAE, y Organizaciones Voluntarias: Informe final de temporada.*
Nesting Beaches: Buena Vista and Hermosa
Year: 2008 **Species and Counts:** *Chelonia mydas*—4 and 5 clutches, respectively; *Eretmochelys imbricata*—1 clutch (Buena Vista); *Dermochelys coriacea*—1 clutch (Hermosa); *Lepidochelys olivacea*—332 and 1,185 clutches, respectively
SWOT Contact: Roberto Solano

DATA RECORD 32

Data Source: Santidrián Tomillo, P., S. Roberts, D. Díaz, and P. Aguilar Masís. 2013. *Análisis de la Anidación de Tortugas Marinas en Playa Cabuyal y Golfo de Papagayo Sur.*
Nesting Beach: Cabuyal
Year: 2012 **Species and Counts:** *Chelonia mydas*—173 clutches
SWOT Contacts: Pilar Santidrián Tomillo and The Leatherback Trust

DATA RECORD 33

Data Source: Sánchez, F. A., D. Melero, P. A. Smith, M. Bigler, and B. Díaz. 2007. *Proyecto de Protección, Conservación y Recuperación de Poblaciones de Tortuga Marina en Playa Drake, Península de Osa, Costa Rica: Reporte Técnico Temporada 2006.*
Nesting Beach: Drake
Year: 2006 **Species and Counts:** *Lepidochelys olivacea*—103 clutches
SWOT Contacts: Fabián Sánchez and Fundación Corcovado

DATA RECORD 34

Data Source: Ureña Lopez, R. 2014. Nesting of Pacific green turtle *Chelonia mydas* (Linnaeus 1758) at Playa Matapalo, Guanacaste, Costa Rica. *Marine Turtle Newsletter* 142: 17–18.
Nesting Beach: Matapalo (Guanacaste)
Year: 2011 **Species and Counts:** *Chelonia mydas*—117 clutches
SWOT Contact: Randall Ureña

DATA RECORD 35

Data Source: Conejo Salas, K., and K. Wesenberg. 2008. *Monitoreo de la Dinámica de Anidación y Manejo de Nidadas Tortugas Marinas en Playa Matapalo, Pacífico de Costa Rica: Temporada 2007–2008.*
Nesting Beach: Matapalo (Puntarenas)
Year: 2007 **Species and Counts:** *Lepidochelys olivacea*—212 clutches
SWOT Contact: Roberto Solano

DATA RECORD 36

Data Source: WIDECAST. 2012. *Informe de Actividades de Conservación en Playas (March 31–October 15).*
Nesting Beach: Moín
Year: 2012 **Species and Counts:** *Chelonia mydas*—43 clutches; *Dermochelys coriacea*—1,425 clutches; *Eretmochelys imbricata*—1 clutch
SWOT Contact: Luis Fonseca

DATA RECORD 37

Data Source: Skilros, S., and S. Rodríguez Méndez. 2014. *Programa de Conservación e Investigación Colonia Anidadora de Tortugas Marinas Dermochelys coriacea, Estación Las Tortugas: Informe de Investigación 2014.*
Nesting Beach: Mondonguillo
Year: 2014 **Species and Counts:** *Chelonia mydas*—2 clutches; *Dermochelys coriacea*—308 clutches; *Eretmochelys coriacea*—6 clutches

OTHER CITATIONS

Protected Areas: International Union for Conservation of Nature (IUCN) and United Nations Environment Programme–World Conservation Monitoring Centre (UNEP–WCMC). The World Database on Protected Areas (WDPA). Cambridge, U.K.: UNEP–WCMC. Accessed February 7, 2015, at www.protectedplanet.net.

Regional Management Units: Wallace B. P., A. D. DiMatteo, B. J. Hurley, E. M. Finkbeiner, A. B. Bolten, et al. 2010. Regional Management Units for marine turtles: A novel framework for prioritizing conservation and research across multiple scales. *PLoS ONE* 5(12): e15465. doi:10.1371/journal.pone.0015465.

Nest Data Conversion Factors: (1) Alvarado-Diaz, J., E. Arias-Coyotl, and C. Delgado-Trejo. 2003. Clutch frequency of the Michoacán Green Sea Turtle. *Journal of Herpetology* 37: 183–185. **(2)** Mortimer, J. A., and R. Bresson. 1999. Temporal distribution and periodicity in hawksbill turtles (Eretmochelys imbricata) nesting at Cousin Island, Republic of Seychelles, 1971–1997. *Chelonian Conservation and Biology* 3: 318–325. **(3)** Reina, R. D., P. A. Mayor, J. R. Spotila, R. Piedra, and F. V. Paladino. 2002. Nesting ecology of the leatherback turtle, Dermochelys coriacea, at Parque Nacional Marino Las Baulas, Costa Rica: 1988–1989 to 1999–2000. *Copeia* 2002(3): 653–664. **(4)** Sarti Martínez, L., A. R. Barragán, D. G. Muñoz, N. García, P. Huerta, and F. Vargas. 2007. Conservation and biology of the leatherback turtle in the Mexican Pacific. *Chelonian Conservation and Biology* 6: 70–78. **(5)** Van Buskirk, J., and L. B. Crowder. 1994. Life-history variation in marine turtles. *Copeia* 1994(1): 66–81.

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In Memoriam

© ROBERT P. VAN DAM

Nicholas Mrosovsky (1934–2015). Born in Romania, Nicholas Mrosovsky was educated in England and earned a PhD in psychology from University College London. He joined the faculty at the University of Toronto in 1967, where he remained in the departments of zoology, psychology, and physiology for his entire career. He is recognized internationally for important contributions to sea turtle biology, behavior, and conservation. His work on temperature-dependent sex determination and the role of light in hatchling turtles' sea-finding abilities had an enormous effect on our community. He was co-chair of the IUCN Marine Turtle Specialist Group with Archie Carr, and he worked hard on issues such as the *IUCN Red List* assessment process for sea turtles. He was also founding editor of *Marine Turtle Newsletter* (MTN); he served as managing editor of MTN through the 1980s and remained on the MTN board until his death. His books *Conserving Sea Turtles* (1983) and *Sustainable Use of Hawksbill Turtles* (2000) were groundbreaking and thought provoking. Nicholas was an early champion of sustainable use, and he applied science to all perspectives of species conservation, from biology to sociology, economics, and politics. He was admired for his keen insights and for his willingness to speak his mind and encourage open discussion of contentious issues.

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Loretta Dittrich Spotila (1945–2015). Born in Cleveland, Ohio, Laurie Spotila began her career as a nutritionist in Buffalo, New York. She later earned her doctorate at the State University of New York (SUNY) in Buffalo with research focused on the use of molecular biology to study the mechanisms of disease. After earning her doctorate, she was a research associate at SUNY Buffalo from 1985 to 1988; she later moved to Philadelphia and joined the faculties at Thomas Jefferson University and Drexel University. An expert in molecular biology and genetics, Laurie discovered the origins of replication of the SV 40 virus and yeast and made important discoveries about the genetic basis of osteoporosis and collagen diseases. She also made important molecular discoveries on the basis of temperature-dependent sex determination and paternity of leatherbacks. She co-founded and managed the Leatherback Trust with her husband, Jim Spotila, and with Frank Paladino. She mentored numerous graduate and undergraduate students involved in research and conservation of turtles, particularly leatherbacks at Las Baulas de Guanacaste National Park in Costa Rica. Laurie's keen mind and gentle demeanor were in no small way responsible for the accomplishments of the Spotila lab over the years, and she was a formative influence on many early career scientists and colleagues working on turtle research and conservation. Her sharp sense of right and wrong was a rudder for the actions of the Leatherback Trust for many years.

SWOT report

The State of the World's Sea Turtles

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