Deadly Waters

The Threat of Climate Change
& Rising Sea Levels
to Sea Turtle Nesting Beaches

Turtle Island Restoration Network

Fighting for a Blue-Green Planet

Turtle Island Restoration Network is a leading advocate for the world's oceans and marine wildlife.

Our work is based on science, fueled by people who care, and effective at catalyzing long-lasting positive change that protects the likes of green sea turtles, whale sharks, and coho salmon.

By working with people and communities, we preserve and restore critical habitats like the redwood forested creek banks of California to the full-of-marine-life waters of the Galapagos Islands.

We accomplish our mission through grassroots empowerment, consumer action, strategic litigation, hands-on restoration, environmental education, and by promoting sustainable local, national, and international marine policies.

SeaTurtles.Org

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TURTLE ISLAND RESTORATION NETWORK
FIGHTING FOR A BLUE-GREEN PLANET

Cover photo, contents photo: Shutterstock.

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Sea turtles, inhabiting the world's oceans for 150 million years, have survived natural climate change events including the last Ice Age. But the current pace of climate change will be faster than anything experienced in the last 10,000 years, and therefore is an unprecedented threat to sea turtles whose populations are already vulnerable from human activities.

While climate change may not have led to the current decline of sea turtles, climate change impacts are now being seen, and it is a serious problem that must be addressed to help protect these ancient ocean dwellers from disappearing forever. Sea turtle populations are already vulnerable and the additional impacts from climate change will further hamper the recovery of sea turtle populations to healthy levels.

Climate change will impact sea turtles in the following ways:

- Loss of nesting beaches and coastal habitat through rising sea levels, an increase in storm surges, eroding shorelines, and coastal barrier projects;
- Increased female gender bias in hatchlings;
- Reduced hatching success from high temperatures and increased storm events
- Decreased or shifting food supply; and
- Changing ocean currents impacting migration.

One impact of sea level rise is the loss or diminishment of beaches, including those on which sea turtles nest.

In this report, we examine the impacts of sea level rise on major sea turtle nesting beaches for the seven species of sea turtles. From existing data and sea level rise projections, we have identified two major US nesting beach areas that are at risk from climate change: French Frigate Shoals in Hawaii and Padre Island National Seashore in Texas.

Photo of Kemp's Ridley Sea Turtle by Ron Wooten.

The Endangered Status of Sea Turtles

Sea turtles have swum the world's oceans for more than 150 million years, since before the time of dinosaurs. But now their populations are declining as a result of human activities.

All seven species of sea turtles have been declared endangered, threatened or vulnerable by the US Endangered Species Act, national agencies, or international conservation bodies. For example, the nesting population of Pacific leatherback sea turtles has declined by 95 percent in the last two decades. In 1947, 40,000 Kemp's ridley sea turtles nested at a single beach in Mexico on a single day. Today, the nesting females for this species number only a few thousand.

The threats to sea turtles are numerous including:

- Death by fishing gear in coastal waters and on the high seas;
- Degradation and loss of nesting beaches due to commercial development;
- Pollution including oil spills and plastic trash;
- Ship strikes;
- Commercial exploitation of adult turtles for their shells, skin, and meat;
- Uncontrolled harvesting of eggs at nesting beaches; and
- The impacts of climate change.

Climate Change & Sea Turtles

Sea turtles, inhabiting the world's oceans for 150 million years, have survived natural climate change events including the last Ice Age. But the current pace of climate change will be faster than anything experienced in the last 10,000 years, and therefore is an unprecedented threat to sea turtles whose populations are already vulnerable from human activities.

Over the past century, the average temperature of the Earth has risen by 1.5°F. During the next one hundred years, scientists are projecting another 0.5 to 8.6°F rise in the temperature.[1]

The cause of this temperature change is human activities that have released large amounts of carbon dioxide and other greenhouse gases (such as methane, nitrous oxide, and fluorinated gases) into the atmosphere.[2] The majority of greenhouse gases comes from burning fossil fuels to produce energy.

Results of this global warming include:

- Rising ocean temperatures,
- A more acidic ocean,
- Melting ice caps, and
- Rising sea levels.

Photo of Iceberg near north-eastern coast of Baffin Island by Ansgar Walk. Wikicommons.

The IUCN (International Union for the Conservation of Nature) has predicted that 20-30 percent of plant and animal species are likely to be at increased risk of extinction due to climate change.[3] The species at increased risk include sea turtles.

While climate change may not have led to the current decline of sea turtles, climate change impacts are now being seen, and it is a serious problem that must be addressed to help protect these ancient ocean dwellers from disappearing forever. Sea turtle populations are already vulnerable and the additional impacts from climate change will further hamper the recovery of sea turtle populations to healthy levels.

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Photo of loggerhead hatchling by Shutterstock.

Major Nesting Beaches at Known Risk from Rising Sea Levels

Sea turtles are known to return to their birthplace to lay eggs, breed and nest. Decades after hatching from eggs, most female turtles will return to the beaches where they were born.

Unfortunately this fidelity to natal nesting beaches can pose a threat to sea turtles, especially when nesting beaches begin to disappear as a result of sea level rises and other climatic impacts.

Higher temperatures and the melting of land-based ice warm sea water. When sea water warms, it expands, leading to sea level rises. By 2100, sea levels are projected to rise one to four feet. Recent research suggests that this sea level rise is on the low side and may be as high as 20 feet.[4] In comparison, since 1880, the global sea level has risen by merely 9 inches.[5]

One impact of sea level rise is the loss or diminishment of beaches, including those on which sea turtles nest.

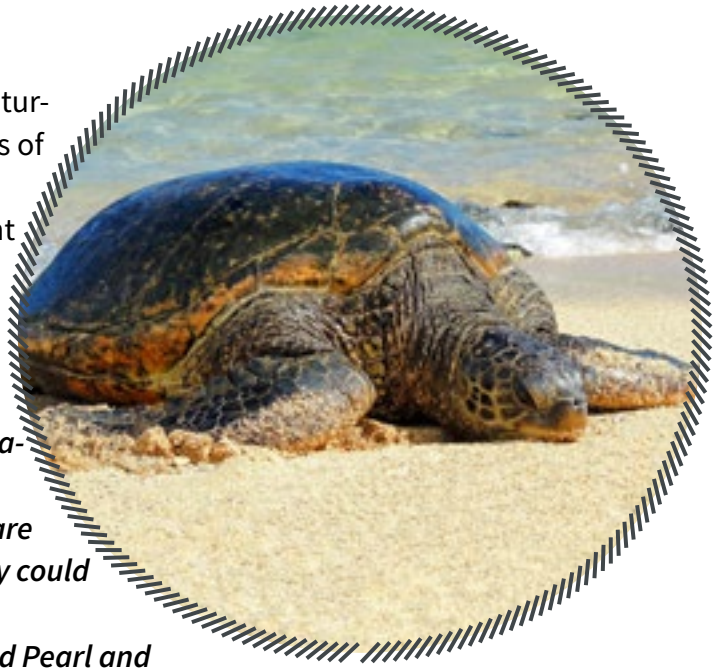
Unfortunately, limited data has been gathered to determine the extent to which rising sea levels will threaten specific sea turtle nesting beaches. The lack of data is especially apparent outside of the United States.

From existing data and sea level rise projections, we have identified two major US nesting beach areas that are at risk from climate change: French Frigate Shoals in Hawaii and Padre Island National Seashore in Texas.

Green Sea Turtles at French Frigate Shoals, Hawaii

The most important nesting site for the Hawaiian green sea turtle subpopulation

Climate change will have a potentially devastating impact on the subpopulation of green sea turtles (Chelonia mydas) that nest in Hawaii. In addition to temperature changes that may impact gender development, scientists have predicted rising sea levels and more intense storm surges will threaten the beaches where Hawaiian green sea turtles nests.



Currently, 90 percent of the Hawaiian green sea turtles (locally known as honu) nest on the beaches of French Frigate Shoals, part of an atoll located in the Northwestern Hawaiian Islands. Fifty percent of those green turtles nest at East Island.

> ***"...scientists are projecting 20 to 60 cm (8 to 24 inches) of sea level rise by the end of this century due to rising global average temperatures. Many of the Northwestern Hawaiian islands have low, flat coastal plains... They are already vulnerable to storm surges, and they could be totally inundated as sea level rises. In particular, French Frigate Shoals and Pearl and Hermes Atoll are currently less than 2 meters (6 feet) above sea level. Rising sea levels reduce the beach area on these islands, and could eventually submerge them."*** [6]

The potential for the loss of a green sea turtle nesting site due to environmental conditions is not hypothetical. It is occurring right now. In the 1960s, Whaleskate Island was the second largest green sea turtle nesting beach for green turtles in Hawaii. By the late 1990s, it had eroded considerably and was completely submerged.

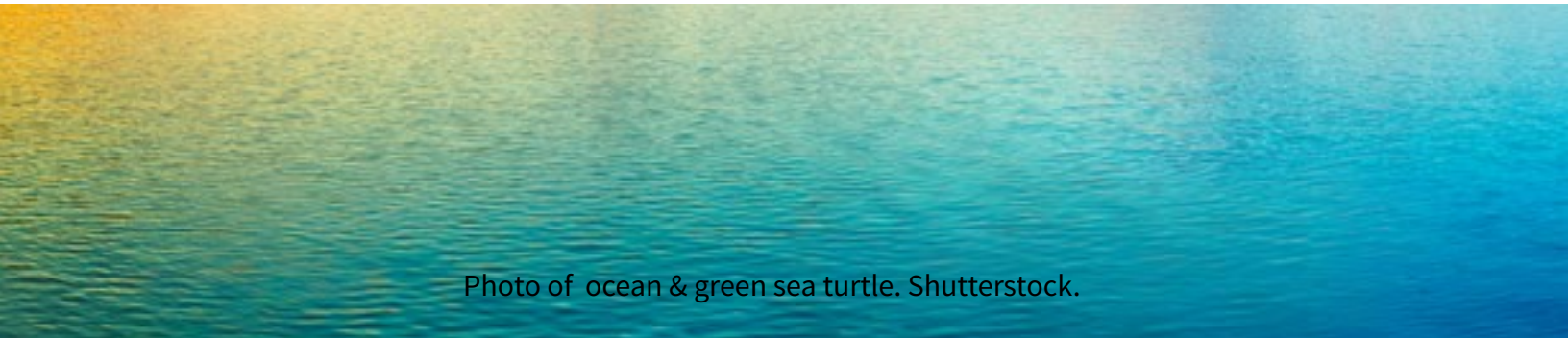


Photo of ocean & green sea turtle. Shutterstock.

Kemp's Ridley at Padre Island, Texas

The second most important nesting site for Kemp's ridleys in the world

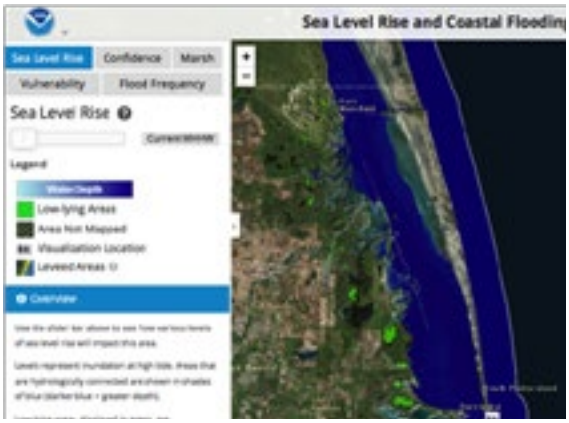
The Kemp's ridley (*Lepidochelys kempii*) is the smallest sea turtle, and also one of the world's most endangered sea turtles.

With the Kemp's geographic range limited to the Gulf of Mexico and the Atlantic Ocean, the most important nesting site for the Kemp's ridley is Tamaulipas, Mexico with about 12,000 nests recorded on three beaches in 2015.[7] Padre Island National Seashore in Texas is the second most important nesting site for the Kemp's ridley sea turtle in the world.[8]

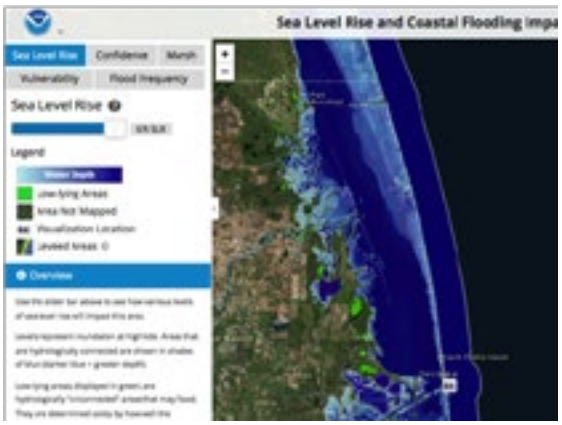
The establishment of the nesting colony at Padre Island is an environmental success story. In the late 1970s, responding to the vulnerability of the Kemp's having a single major nesting area (in Tamaulipas), Mexico and the U.S. joined efforts to save the species from extinction and recover the population. One program that was implemented focused on forming a secondary nesting colony at a protected beach at Padre Island National Seashore.[9] As a result of this program and other efforts to address the impacts of industrial fishing, the nesting population at Padre Island has grown from one observed nest in 1985 to a high of 209 in 2012.[10]

Unfortunately, Padre Island will not be immune to the impacts of climate change including sea level rises and storm surges. Modeling based on NOAA's Sea Level Rise Viewer suggests that a 6-foot sea level rise will completely inundate South Padre Island, thus eliminating critical nesting habitat for the Kemp's ridley.[11]

Padre Island model based on no sea level rise



Padre Island model based on 6-foot sea level rise



Unfortunately, the NOAA modelling information is limited to US waters, and we do not have a projection of the impacts on the major nesting sites in Mexico.

"[Rancho Nuevo's] is formed by low dunes of tidal origin, isolated on the land side by shallow coastal lagoons with several narrow cuts which open during the rainy season forming estuaries or temporary sandbars. The inland sand dunes vary in height from 1 m to 4 m above sea level… The Kemp's ridley usually nests just beyond the high tide mark in front of the first dune."[12]

Given the modeling and suggestions above, a projected 6-foot sea level rise as a result of climate change will potentially wipe out all major historic nesting sites for the Kemp's ridley, putting that species at imminent risk of extinction.

Major Nesting Beaches at Potential Risk from Rising Sea Levels

For many other major nesting beaches, most of which occur outside of the United States, we do not have enough data to predict whether projected sea level rises will threaten these sea turtle nesting colonies.

Data from nesting beaches in the Caribbean suggests sea level rises might have impacts at the major nesting beaches for sea turtles in other regions of the world. "Nesting sites for sea turtles was also explored, with the largest loss of sites in Guyana (50 percent), Belize (44 percent), Haiti (44 percent), St. Kitts and Nevis (35 percent), and The Bahamas (35 percent)."[13]

In the next section, we will review the major nesting beaches for the other five sea turtle species to determine potential risks from rising sea levels.

Photo of hatchlings. Shutterstock.

Olive Ridley Sea Turtle Beaches in Mexico, Costa Rica & India

The Olive Ridley sea turtle (Lepidochelys olivacea) is a sea turtle made famous by its mass nesting behavior, known as an arribada. During this occurrence, between hundreds and thousands of female olive ridley sea turtles come ashore in waves to dig nests and lay eggs. This event is one of the wonders of the natural world.

Worldwide, an estimated 800,000 female olive ridleys nest annually, making it the most abundant species.[14] The two major nesting colonies for the olive ridley sea turtle occur in India and Mexico.

Major Olive Ridley Nesting Populations [15]

Country	Nesting Site	Estimated Annual Nesting Female Subpopulation Size
Mexico	Escobillo	~575,000
Costa Rica	Ostional	~134,000
India	Gahirmatha	150,000 to 200,000

Unfortunately, we have little data about projected sea level rises at these beaches.

However, research from another olive ridley nesting beach in Los Cabos, Mexico suggests that, if topography and conditions are similar, 14% of nests would be inundated with a predicted sea level rise of 0.6 meters over the next 100 years.[16]

Further research needs to be conducted to survey beach profiles and overlay that data with models of projected sea level rises and storm surges to identify the level of risk from climate change at these three major nesting sites.

Hawksbill Sea Turtles in the Caribbean

The hawksbill sea turtle (*Eretmochelys imbricata*) gets its name from its hooded beak which resembles that of a hawk. According to the US Fish and Wildlife Service, more than one million hawksbill turtles have been killed for their beautiful "tortoise shell" scutes since 1970.[17] The shells of these endangered animals have been turned into luxury items such as combs, brushes, cigarette boxes, jewelry, and hair ornaments.

Unlike the mass nesting olive ridley sea turtles, hawksbill are solitary nesters. The largest populations of hawksbills are found in the Caribbean, the Republic of Seychelles, Indonesia, and Australia, where the largest nesting population occurs.[18]

Currently, an estimated 27,000 adult hawksbills live in the Caribbean with the majority of nesting occurring in Mexico and Cuba.[19] In Mexico, about 2,700 hawksbills nest in Campeche, Yucatán, and Quintana Roo each year.[20]

While we do not have extensive research on the impacts of sea level rises specifically on the Mexican beaches, modelling has been conducted to determine potential losses for sea turtles in the broader Caribbean.[21]

More specific to Hawksbills, a study published in 2005 suggested that half of this species' nesting habitat on Bonaire would be lost with a sea level rise of 0.9m.[22]

Further research needs to be conducted to survey beach profiles and overlay that data with models of projected sea level rises and storm surges to identify the level of risk from climate change at the major global nesting areas for Hawksbills.

Photo of hawksbill. ©Tom Doeppner.
http://www.cs.brown.edu/people/twd/home.html

Eastern Pacific Leatherback Sea Turtles in Costa Rica

The leatherback sea turtle (Dermochelys coriacea) is the largest sea turtle and largest living reptile in the world, with adult males and females reaching as much as nine feet in length - head to tail - and weighing up to 2,000 pounds.

Leatherbacks are the most wide-ranging of all sea turtles due to adaptations that allow them to survive in colder water temperatures, and have been sighted from Alaska to Chile. They are the deepest diving turtle and have been recorded diving in excess of 3,900 feet.

The Pacific Leatherback sea turtle is on the verge of extinction due to adult mortality in fishing gear. This population has declined by more than 95 percent.[23]

While a survival strategy for the leatherbacks may be to nest further inland, following the receding beaches, coastal development already is reducing available and future nesting habitat. Therefore, there may not be any available potential habitat given the state of development. Poor planning decisions have not allowed for the creation of a reasonable wildlife buffer zone.

Research at Playa Grande, Costa Rica, one of the most important nesting sites for Eastern Pacific leatherbacks, has suggested that further development of the beach to support a growing tourist industry will degrade the attractiveness and quality of the beach for nesting leatherbacks. As sea levels rise, coastal development may not allow a retreat of nesters further inland.[24]

Further, anecdotal information from Papua New Guinea has also suggested a loss of available nesting beaches for leatherback populations in the Western Pacific as sea levels have risen.[25]

Photo of leatherback hatchlings. Shutterstock.

Loggerhead Sea Turtles in Florida

Loggerhead sea turtles (*Caretta caretta*) were named for their relatively large heads, which support powerful jaws and enable them to feed on hard-shelled prey. A unique characteristic of loggerheads is callus-like traction scales beneath their flippers that allow them to "walk" on the ocean floor.

The most recent reviews of loggerhead nesting show that only two loggerhead nesting beaches have greater than 10,000 females nesting per year: South Florida (U.S.) and Masirah Island (Oman).[26] In 2015, 52,647 loggerhead nests were counted on index beaches in Florida.

Florida will be vulnerable to rising sea levels:

"2120 square miles of land lie less than 3 feet above the high tide line in Florida... Florida has 2,555 miles of road below 3 feet, 35 public schools, one power plant, and 978 EPA-listed sites such as hazardous waste dumps and sewage plants."[27]

Unfortunately, Florida will not be immune to the impacts of sea level rise from climate change.

Researchers are projecting a potential 43% decrease in beach area from 1986 with a half meter sea level rise, predicted by within the next 20 to 50 years. They predict that loggerheads will shift northward in order to nest and beaches will be increasingly crowded.[28]

Further impacts on loggerheads can be seen by research carried out on the island Bonaire. Modeling of sea level rise shows a near total loss of all currently used nesting beach areas. "For the maximum projected scenario projected for the Caribbean by the end of the century (1.6m sea-level rise), 98% of [loggerhead] nests and 98% of beach area would be at risk."[29]

Flatback Sea Turtles of Australia

The Flatback sea turtle (Natator depressus) is only found only in the tropical waters of northern Australia, Papua New Guinea and Irian Jaya, with nesting limited to Australia.

The largest nesting concentration of flatback turtles is in the north-eastern Gulf of Carpentaria and western Torres Strait.

Unfortunately, the flatback is one of most poorly understood species, especially in regards to estimations of population sizes and foraging area and distribution.

According to Australia's Department of Environment:
"Changes in ocean circulation patterns and alteration to marine food webs may both have significant impacts on Flatback Turtles, particularly during their pelagic phase. The long life span and long maturation and reproductive times of Flatback Turtles reduces the ability of these animals to adapt to changes in environmental conditions likely to be associated with climate change."[30]

Photo of flatback by Lyndie Malan. Wikicommons.

Recommendations

1) Ensure Major Nesting Beaches are Climate Resilient

The risk of climate change to current nesting beaches for sea turtles is compounded by poor coastal development policies including climate resiliency projects such as coastal armoring and beach renourishment.

Heavy coastal development removes potential available habitat for sea turtles. When shorelines recede in undeveloped areas, sea turtles can retreat with this changing landscape to nest. But in developed areas, buildings and other structures will reduce available nesting area. For example, according to the Sea Turtle Conservancy, despite 40 percent of Florida's sandy beaches being a "critical erosion" state, builders are allowed to construct homes and condos on the frontal dunes of critically eroding shorelines. A reasonable buffer zone needs to be created to protect retreating shorelines and sea turtle nesting habitat.

Additionally, coastal armoring and barriers such as the construction of seawalls impede the ability of sea turtles to retreat with the eroding shoreline. In response to the risk of destruction of life and property from hurricanes, a number of coastal barrier system projects are currently being developed and discussed in Texas. However, these proposed barrier system projects have the potential to severely degrade the habitat for sea turtles and birds on Galveston Island and along the upper Texas coast. Further, these projects might impede the growth and populations of thousands of fish and crustacean species that reside in the Galveston Bay Area.

One of these proposed barriers is the Ike Dike, which would extend the existing Galveston Seawall along Galveston Island and the Bolivar Peninsula, with a 17ft high revetment near the beach. This would be coupled with barrier gates at San Luis Pass and Bolivar Roads to prevent storm surges from entering Galveston Bay. Estimated costs are $6-10 billion. Multiple environmental issues come to light with the proposed construction of large retractable gates that the Ike Dike would require across Galveston Bay, San Luis Pass and the Intracoastal Waterway. This includes cutting off migratory pathways, altering water flow, and increasing pollutant and contaminant accumulation.

Our recommendations are to:

- Prevent and reverse coastal development that reduces available habitat or interferes with nesting or migration;
- Prevent beach armoring and seawalls as a strategy to manage the impacts of climate change; and
- Ban sand mining from nesting beaches.

2) Establish Second Nesting Colonies at Key Species Nesting Sites

When sea turtles hatch from their eggs, they "imprint" on the beach on which they were born. Decades later, the females return as adults to nest on these very same beaches.

In the late 1970s, one major nesting beach existed for the Kemp's ridley sea turtle: Rancho Nuevo, Mexico in the Gulf of Mexico. To protect against a catastrophic disaster that would wipe out this nesting population, international efforts were undertaken to establish a second nesting colony at Padre Island National Seashore, Texas.

During a 10-year period, "22,507 eggs were collected in Rancho Nuevo, packed in Padre Island sand, and transported to the National Seashore where they were hatched in controlled conditions."[31] By 2012, more than 200 nests were documented on the Texas coast producing more than 20,000 eggs (compared to the 6 nests and 590 eggs documented in 1996).

The work in the Gulf has demonstrated that it is possible to establish a secondary nesting colony to protect the larger sea turtle population. While we believe that it is preferable to invest efforts to protect existing nesting beaches and allow for an unimpeded retreat of nesting locations (by controlling development), in some cases, such as on small islands, retreat may become limited if nesting beaches are completely submerged.

Lanai: A Prime Candidate for a Second Hawaiian Nesting Colony
Historical evidence suggests that Polihua Beach (literally "eggs in a bosom") on the island of Lanai was an important nesting beach for green sea turtles until the late 1900s. In fact, a federal administrative report[32] suggested:

> *Polihua could prove to be one of the best places in Hawaii to do experimental restocking of green turtles aimed at reestablishing a nesting colony.*

Polihua also has the potential to be resilient to sea level rises because of its width. A sea level rise of 6 feet modeled at http://coast.noaa.gov/slr/ does not indicate lose of the beach.

Our concept is to re-establish Polihua Beach on Lanai, Hawaii as a second nesting colony for Hawaiian green sea turtles in order to protect the population from the impacts of climate change and ensure their long-term survival.

We envision the following steps to achieve this second nesting colony:

- Further assessment of the viability of Polihua to support the nesting colony.
- Winning broad support for the concept of the second nesting colony from Lanai stakeholders, federal and state agencies, the sea turtle conservation community, and the funding community.
- Establishment and funding of a formal program to move green sea turtle eggs from French Frigate Shoals to a hatchery facility and then releasing the hatchlings on Polihua Beach so they can imprint.
- Ongoing monitoring and protection of sea turtle nests at Polihua.

Since green sea turtles can take between 20-50 years to reach sexual maturity, we envision this as a "generation" legacy project that will require a long-term commitment of resources and effort.

3) Reduce Other Anthropogenic Threats to Sea Turtles at Priority Nesting Beaches

The ability of sea turtles to be resilient to climate change depends on sea turtles populations being robust and their habitat being protected.

Concurrently, we must also address other major impacts, especially at priority nesting beaches for specific subpopulations. Specifically, we must:

- Reduce sea turtle bycatch in industrial fishing operations such as driftnets, longlines, and shrimp trawls in the areas where sea turtle migrate and forage
- Eliminate illegal egg harvesting on nesting beaches

4) Document Potential Loss of Major Sea Turtle Nesting Beaches Worldwide

Not enough data exists about the potential impacts of projected sea level rises to major sea turtle nesting beaches, especially outside of the United States.

We recommend the following steps:

- Conduct on-site research of projected sea level rise at the major sea turtle nesting colonies for each species. This research should be prioritized based on importance of nesting colony (size), geographic diversity, types of species and where any data is lacking.
- Quantify loss of existing nests and nesting habitat under several sea level rise scenarios.

3. Determine overall condition of nesting colony to determine whether on-beach options such as beach nourishment or managed retreat inland would be viable and affordable.

5) Reduce Climate Change Emissions to Bring Carbon Dioxide Levels Below 350 Parts Per Million

"If humanity wishes to preserve a planet similar to that on which civilization developed and to which life on Earth is adapted, paleoclimate evidence and ongoing climate change suggest that CO2 will need to be reduced from [current levels] to at most 350 ppm." - Dr. James Hansen, one of the world's most respected climatologists

Turtle Island Restoration Network supports the goals of the international climate movement, progressive nations, and many scientists that we must bring down carbon dioxide levels.

Globally, we must reduce carbon dioxide levels in the atmosphere from 400 parts per million to below 350 parts per million. To do so, the United States will need to cut its greenhouse gas emissions to 26 percent or more below 2005 levels by 2025.

We can achieve this through:

- Keeping carbon in the ground;
- Building a new, equitable low-carbon economy;
- Pressuring governments to reduce emissions; and
- Strengthening and expanding natural carbon sinks.

Endnotes

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TURTLE ISLAND RESTORATION NETWORK

FIGHTING FOR A BLUE-GREEN PLANET

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