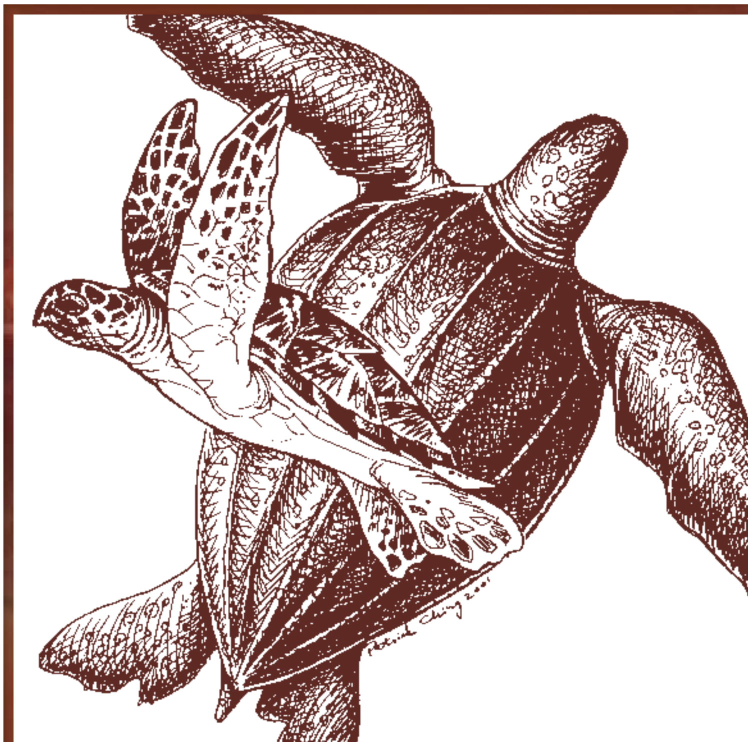

# WESTERN PACIFIC SEA TURTLE

## *Cooperative Research & Management Workshop*

Second Edition, Volume II

## North Pacific Loggerhead Sea Turtles

# PROCEEDINGS OF THE SECOND WESTERN PACIFIC SEA TURTLE

*Cooperative Research & Management Workshop*

## VOLUME II
# North Pacific Loggerhead Sea Turtles

Coordinated & Edited
by Irene Kinan

Sponsored by the
WESTERN PACIFIC
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*To provide a forum to gather and exchange information, promote collaboration, and maintain momentum for research, conservation and management of Pacific sea turtle populations.*

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**Editors' note**
The papers presented at the workshop and contained in these proceedings have been edited and formatted for consistency, with only minor changes to language, syntax, and punctuation. The authors' bibliographic, abbreviation and writing styles, however, have generally been retained. Several presenters did not submit a written paper, or submitted only an abstract to the meeting. In these instances, a summary was produced from transcripts of their presentations. The opinions of the authors do not necessarily reflect those of the Western Pacific Regional Fishery Management Council.

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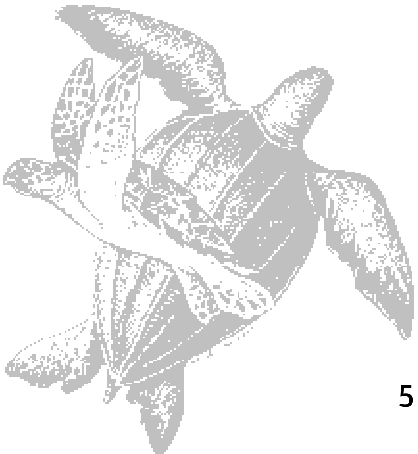

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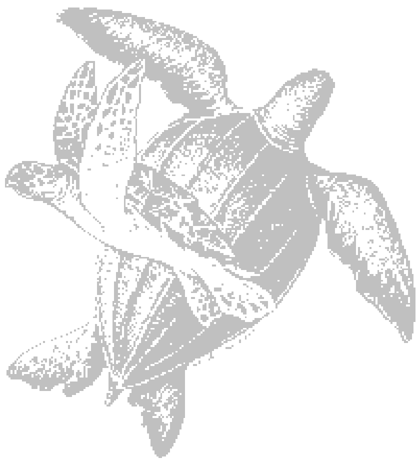

# Preface

This volume of papers is a record of the Second Western Pacific Sea Turtle Cooperative Research and Management Workshop that convened in Honolulu, Hawaii sponsored by the Western Pacific Regional Fishery Management Council (WPRFMC). The focus of these proceedings is on north Pacific loggerhead sea turtles.

Sea turtles migrate vast distances across ocean basins, living complex life histories within pelagic, coastal and beach habitats of numerous Pacific nations. Consequently a collaborative approach among nations, in a manner that considers their entire life history, is essential for effective conservation and management. Recognizing that sea turtle recovery must focus on more than just fishery mitigation, the WPRFMC, the federal authority for fisheries in the U.S. waters of the Pacific Islands region, has expanded its focus of international fishery management to include sea turtle conservation.

In 2002, the WPRFMC convened the first Western Pacific Sea Turtle Cooperative Research and Management Workshop to exchange scientific information, gather an update on the status of population trends, and help build consensus for a regional approach towards research and conservation (Kinan, 2002). Through this dialogue, the WPRFMC focused on the most efficient use of its resources to aid in the recovery of depleted Pacific sea turtle populations. Since 2003, the WPRFMC, in collaboration with NOAA Fisheries and numerous community-based Non-governmental Organizations (NGOs) have helped foster essential research and conservation throughout the Pacific region. To date, the WPRFMC's management program consists of a suite of measures that include sea turtle conservation projects at nesting beaches and coastal foraging habitats, and actions that promote environmentally responsible longline fisheries.

To maintain momentum for continued research, conservation and management, the WPRFMC convened a series of workshops that together comprise the Second Western Pacific Sea Turtle Cooperative Research & Management Workshop. The focus of these workshops were on west Pacific leatherback and southwest Pacific hawksbill sea turtles (May 17-21, 2004: Volume 1; Kinan, 2005), and north Pacific loggerhead sea turtles (March 2-3, 2005: Volume 2).

The 13 papers presented at this workshop comprise current and comprehensive information from key players involved in Pacific loggerhead sea turtle research and conservation. The workshop concluded by the development of a threat matrix for the north Pacific loggerhead stock. Overall, new and encouraging information was offered as well as evidence that population level impacts persist. This meeting reinforced that effective sea turtle conservation must be wide ranging and international in scope, and that multi-cultural projects involving scientists, conservationists, fishermen and communities are necessary to establish effective long-term management solutions.

# Acknowledgments

The Western Pacific Regional Fishery Management Council (WPRFMC) would like to thank the workshop participants for their presentations and papers prepared for the meeting. Without the dedication and enthusiasm of our participants, this meeting would not have been possible. The WPRFMC expresses its sincerest gratitude to its Turtle Advisory Committee: Mr. George Balazs, Dr. Jeff Polovina, Dr. Peter Dutton, Dr. Colin Limpus, Dr. Milani Chaloupka, Dr. Nick Pilcher, Dr. Naoki Kamezaki, and Ms. Laura Sarti for their time, energy, ideas and insights, and whose expertise and leadership we could not do without. We thank NOAA Fisheries for involvement and support of this workshop, of the WPRFMC's turtle program, and for sharing in the vision of cooperative research and integrated sea turtle management.

# Indo-Pacific Marine Turtles

Although revered in culture and customs around the globe, sea turtles have also been exploited for their meat, eggs, shell, leather, and oil for centuries. The negative effects of this unregulated adult and egg harvest, along with impacts from habitat degradation, coastal construction, commercial trade and mortalities through accidental capture in coastal and pelagic fisheries have accelerated the decline of sea turtle populations in the Pacific. Today, all sea turtle populations are listed as either threatened or endangered under the U.S. Endangered Species Act[1].

Leatherback (*Dermochelys coriacea*)

Olive ridley (*Lepidochelys olivacea*)

Hawksbill (*Eretmochelys imbricata*)

Loggerhead (*Caretta caretta*)

Flatback (*Natator depressus*)

Green (*Chelonia mydas*)

Marine turtles of the Indo-Pacific. Not pictured is the subpopulation of the eastern Pacific "black" sea turtle, *Chelonia agassizii* (PHOTO SOURCE: DR. COLIN LIMPUS)

[1] Green (*Chelonia mydas*), and olive ridley (*Lepidochelys olivacea*) sea turtles are listed as threatened, except for breeding colony populations of green turtles in Florida and on the Pacific coast of Mexico and breeding colony populations of olive ridleys on the Pacific coast of Mexico which are listed as endangered.

# Workshop Participants

**GROUP PHOTO:**
*From left to right, top to bottom:* Mr. Jeff Mangel, Dr. Yoshimasa Matsuzawa, Mr. David Maldonado, Ms. Anne Trevor, Ms. Tina Fahy, Ms. Kitty Simonds, Dr. Alonso Aguirre, Dr. Amanda Southwood, Mr. Mizuno Kojiro, Ms. Erika Mori, Mr. George “Keoki” Balazs, Ms. Therese Conant, Dr. Jeffrey Polovina, Ms. Brande Gerkee, Dr. Peter Dutton, Dr. Nicolas Pilcher, Mr. Hoyt Peckman, Dr. Wallace J. Nichols, Dr. Colin Limpus, Dr. Kazuyoshi Ohmuta, Dr. Hiroshi Takeshita, Ms. Cheryl Ryder, Dr. Melissa Snover, Dr. Naoki Kamezaki, Dr. Yonat Swimmer, Ms. Irene Kinan. Not pictured: Dr. Milani Chaloupka.

**Irene Kinan**
*WPRFMC*
*Turtle Program*
*Coordinator*

# Workshop Summary:
# A Collaboration of Partnerships Around the Pacific

The WPRFMC loggerhead sea turtle workshop, March 2-3, 2005, brought together researchers from Japan, Mexico, the United States and Australia involved in the conservation, management and recovery of the Pacific loggerhead sea turtles. Participants from the Sea Turtle Association of Japan (including Yakushima Island), Miyazaki Wildlife Research Group, ProPeninsula's ProCaguama project, Queensland Turtle Research and NOAA Fisheries discussed their results and progress from the 2004 field season and solicited comments from the WPRFMC's Turtle Advisory Committee (TAC) who provided valuable advice and suggestions to strengthen research initiatives.

North Pacific loggerhead sea turtles connect the ecosystems and cultures of the Pacific Rim through their migrations; as juveniles they travel from Japan to Mexico via the Hawaiian archipelago, and at maturity they return to their Japanese nesting beaches to reproduce. These "Pacific Ocean ambassadors" gather for decades at the coast of Baja California Sur (BCS) to feed and mature. Nearby, off Puerto Lopez Mateos, loggerheads, known locally as *caguamas*, forage especially close to shore where artisanal gillnet and longline fishing is intense. In the central north Pacific, pelagic longline fisheries of many nations operate in similar areas utilized by foraging and migrating loggerheads. This unfortunate overlap of fishing and foraging results in severe loggerhead bycatch and a significant source of mortality. Recent research has thus refocused scientific investigation to the open ocean and coastal stage, where turtles are vulnerable to longline fisheries and coastal gillnets.

*ProCaguama*, a community-based campaign of the grassroots conservation network Grupo Tortuguero in Baja California, Mexico, is empowering local communities and fishers to protect endangered sea turtles and the threatened ecosystems they inhabit through partnerships to eliminate bycatch and reduce local harvest pressure. Scientists from *ProCaguama* conducting research in Baja are getting closer to understanding the foraging dynamics of loggerheads, and a number of communities are becoming "turtle safe" from poaching and fishery bycatch. In working with the halibut gillnet fishery, researchers and fishers have acquired a greater understanding of the fishery's dynamics and how the fishery as a unit interacts with its environment, including target and non-target species. With this knowledge, fishers are better able to make informed and effective management decisions.

On the other side of the Pacific, Japanese colleagues from the Sea Turtle Association of Japan and the Miyazaki Wildlife Research Group presented encouraging loggerhead nesting population trend information as well as innovative education and outreach initiatives. International collaborations and exchange of both information and scientists among Japan, the United States and Mexico are connecting communities and cultures across the north Pacific. This trans-Pacific experience is broadening perspectives and increasing capacity for conservation among communities throughout Baja and Japan. Although international collaborations are strengthening, scientific results and data indicate that significant environmental impacts from beach erosion, typhoons, and extreme temperature continue to plague the north Pacific loggerhead nesting stock.

Scientists from the NOAA Fisheries Pacific Islands Fishery Science Center (PIFSC) in Hawaii presented a summary of collaborative pelagic research projects with Japan and Taiwan, results from longline fishery mitigation experiments, and data on sea turtle fishery bycatch studies in Peru. A special guest from The Wildlife Trust, the Director for Conservation Medicine, provided valuable information and insight regarding conservation medicine and sea turtle health studies, with an emphasis on Baja California turtles.

Reports on an international loggerhead study initiated in 2003 between American and Japanese researchers have revealed the importance of the north Pacific, defined by the Kuroshio Extension Current, as an important juvenile forage hotspot for loggerhead sea turtles. Lead scientists call the area "a nursery habitat for sea turtles," noting that satellite telemetry combined with oceanography is providing scientific evidence as to why turtle bycatch in the north Pacific is largely young juvenile turtles. Representing the work of researchers from Hawaii, California, and Japan, the study recommends that conservation efforts focus on identifying and reducing threats to loggerhead survival in this nutrient-rich area that is frequented by fishing vessels from many nations.

Additionally, the results from a pilot study to quantify the nesting demographics of a poorly defined and unstudied south Pacific loggerhead nesting stock in New Caledonia were presented. In the south Pacific, loggerhead turtle breeding is almost entirely restricted to eastern Australia and New Caledonia. Although the eastern Australian population has been extensively monitored and researched, including long term census trends, genetics analysis and demographic studies since 1968, the New Caledonian stock has not been studied in any detail. Preliminary results indicate a modest nesting stock of approximately 60 females. The population has declined, and findings suggest intensive nesting beach impacts from erosion, predation and land development.

In conclusion, long distance migrations through international waters, combined with a slow growth rate, make loggerhead sea turtles extremely vulnerable to both natural and human pressures. Loggerheads literally connect the whole Pacific Ocean and thus conservation efforts have to be international in scope involving scientists, conservationists, fishermen and communities in collaborative, multi-cultural, and multi-lingual projects. Reducing incidental catch of loggerheads in pelagic longline fisheries represents only one aspect of conservation efforts. Direct hunting and illegal trade must be reduced, nesting beaches protected and turtles must be conserved in their foraging grounds from both harvest and incidental catch by coastal fisheries. Most importantly, resource managers must engage a holistic approach to conservation by improving their understanding of the totality of turtle ecosystems, such as that of the far-ranging loggerhead.

Irene Kinan and
Dr. Wallace J. Nichols

# Introduction:
# Research Story of the North Pacific Loggerhead Sea Turtle

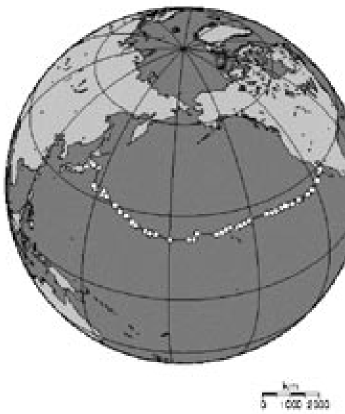

**FIGURE 1.** *Adelita's 1997 track from Baja California, Mexico to Japan.*
SOURCE: J. NICHOLS

Adelita was the name scientists and fishermen gave a loggerhead turtle *(Caretta caretta)* they released nearly a decade ago, on August 10, 1996, just off the town of Santa Rosalita on the Pacific Coast of Baja California, Mexico. Named after the daughter of a Mexican fisherman who helped researchers secure a satellite transmitter on her back, the 223-pound mature female splashed into balmy Mexican coastal waters, made a beeline across the Pacific toward Japan, and crossed into turtle history (Figure 1). "It was a major, major discovery," says Wallace J. Nichols, ProPeninsula and research associate from the California Academy of Sciences. Nichols, then a graduate student at the University of Arizona, was part of the U.S. and Mexican research team that set Adelita on her historic journey.

A lot has happened since then in understanding the far-ranging ecosystem of the highly migratory Pacific loggerhead, a threatened sea turtle species. But back in 1996, although previous research had shown a genetic connection between loggerheads in Japan and Baja, Nichols and his fellow researchers and fishermen friends supplied the first detailed physical proof that these turtles migrated from opposite sides of the Pacific by tracking Adelita's trans-Pacific journey by satellite (Figure 1).

Adelita's journey came at a critical time for the threatened loggerhead sea turtles in the north Pacific. Once abundant along the nesting beaches of Yakushima Island (near the southern tip of Kyushu, Japan's southernmost island), loggerhead turtles have been in rapid decline in recent decades, with the number of nesting females falling from an estimated 5,000 year to only 1,000 females nesting annually by 2002.

On the other side of the Pacific, in the nutrient-rich waters that surround the Baja California Peninsula, a similar tale could be heard. As early as the 1970s, Mexican fishermen reported seeing fewer and fewer turtles, long considered a delicacy at traditional feasts. Even after the Mexican government outlawed the eating of turtles in 1990, as many as 35,000 turtles are still consumed today in the Californias, particularly during holidays such as Easter and Christmas.

Yet little was known about the north Pacific loggerhead. In fact, as late as the early 1990s, it was still unknown where Baja California's loggerhead turtles came from, as there were no loggerhead nesting beaches along the Pacific coast of Mexico. Less than 60 years ago, the first confirmed report of their existence in the area was made in 1947, and confirmation that the species did indeed live in the area came only in the 1960s.

Better knowledge of this species, based on scientifically accurate information, was critically needed to turn the tide for the declining north Pacific loggerhead. Adelita's historic 11-month trek across more than 6,000 miles of Pacific Ocean proved one leg of the trans-Pacific turtle migration hypothesis – the return journey to nesting beaches in Japan.

Nichols and other researchers figured, in turn, that juvenile loggerheads, born in Japan, must be crossing the Pacific to feed and mature off the coast of Baja. It would explain why the loggerheads being caught by Baja fishermen were mature turtles and older juveniles. And it would further explain why U.S. and international fishing fleets in the north Pacific were interacting with young juvenile loggerheads as bycatch in longline fishing operations.

Then in 1999, another piece of puzzle fell into place. A Mexican fisherman came forth with a flipper tag he had removed from a loggerhead he had caught off the Baja California coast and stuck on his keychain for five years. Initially afraid to report his capture of a threatened species, the fisherman revealed his find after working with and trusting turtle researchers.

The tag was from a turtle hatched on Yakushima Island, where a third of Japan's loggerheads nest. Raised for one year at Okinawa Aquarium by Drs. Teruya and Uchida, it was tagged with the small metal tag #572 and released in 1988. In 1994 (two years before Adelita began her epic journey), it was captured in San Carlos, Baja California Sur, Mexico, by the fisherman who finally revealed his find in 1999.

"This was such a great find, considering the paucity of tag returns common in turtle research," says Nichols. "The small turtle, which began its journey as a 6-inch, hand-sized juvenile, made the 6,000-plus mile trip in the time it took me to get my Ph.D. – six years!"

"This opened exciting, new working opportunities among scientists, fishermen and conservationists in Japan, Hawaii, California, and Mexico," explains Nichols of the growth in international collaborations of the Pacific loggerhead. "The turtle has become a cultural ambassador for countries all working to protect this species, an icon for the connectedness of the ocean," he adds.

These international research collaborations over the last decade have yielded new data that have transformed what we know about the turtle called the "Pacific Ocean ambassador," as well as the Pacific Ocean itself. New scientific data, improved technologies, and expanded international cooperation have resulted in major discoveries in understanding the life cycle, migrations, feeding ecology and pelagic behaviors of this species. New scientific tools range from aerial surveys, satellite telemetry combined with oceanography to new fishing methods, including educational outreach and community workshops and festivals.

Bringing together scientific research and creative education, fishermen and community leaders have launched a diverse community-based outreach initiative in Baja that ranges from tagging turtles to presenting plays about turtles to school children. This innovative, community networking approach appears to be gaining momentum for both sea turtle conservation and marine resource management as a whole.

Today, the work proceeds on many fronts, guided by holistic recovery strategies that attempt to address threats to the entire life cycle of these ancient and long-lived creatures; by multilateral and cooperative conservation efforts among nations, and by institutional strengthening through an expanding conservation framework that combines biological, socio-economic, political and conservation measures on both sides of the Pacific Ocean. The papers in this document not only profile the challenges ahead to protect north Pacific loggerheads, but also the lessons learned and scientific achievements made over the last few years of conservation.

**Dr. Yoshimasa Matsuzawa**
*The Sea Turtle Association of Japan*

# Nesting Beach Management of Eggs and Pre-emergent Hatchlings of North Pacific Loggerhead Sea Turtles in Japan[1]

## INTRODUCTION

The loggerhead sea turtle, *Caretta caretta*, is a highly migratory species. Hatchlings leave their nesting area in Japan for developmental and foraging habitats in the eastern Pacific (Uchida and Teruya 1988; Bowen et al. 1995). After spending years in the offshore waters along the Pacific coast of California, USA and Baja California, Mexico, loggerhead turtles return to Japanese waters for reproduction (Resendiz et al. 1998; Nichols et al. 2000).

As a result of the dedication and hard work of an extensive network involving many independent field teams in Japan, annual census data are available from most nesting beaches. These data indicate that there has been a substantial decline (50-90%) in the size of the annual loggerhead nesting population in Japan during the last half of the 20th century and that the current population level is considerably lower than the population levels of the other ocean basins, although it starts on a gradual recovery trend (Kamezaki et al. 2003). For example, in 1998, 1999, 2000, 2001, 2002, 2003 and 2004 seasons, a total of 2,447, 2,255, 2,589, 3,122, 4,035, 4,519 and 4,854 loggerhead nests, respectively, were recorded on Japanese beaches.

In contrast to dedicated nesting survey, hatching success and number of emergence for clutches *in situ* are hardly examined systematically in many rookeries. However, owing to various factors such as beach use by tourist, predation, inundation, erosion, and excessive heat (Matsuzawa et al. 2002), mortality of eggs and pre-emergent hatchlings seem to be unusually high in Japanese rookeries. For example, hatching success in the Minabe-Senri beach were 24% (1996), 50% (1997), 53% (1998), 48% (1999), 62% (2000), 41% (2001), 34% (2002) (Matsuzawa unpublished data). It should be noticed that these figures do not include many clutches that were washed out and were not examined.

The greatest rookeries in Japan occur at Yakushima Island. These beaches were included in the list of the important wetlands of Ramsar Convention in November 2004. The Inakahama Beach suffers environmental disruption including beach erosion and light pollution. Nesting females and hatchlings are disturbed by headlight of cars passing on the road behind the beach, which used to be screened off by pine trees. Whenever a typhoon passes by the island, many nests are washed out or inundated. Moreover, last few years it was found that egg and pre-emergent mortality were relatively high mainly due to stomping by tourists that has been increasing year by year (Kudo et al. 2004).

Considering the current status of this nesting population, some aggressive actions at nesting beaches are required to address environmental and anthropogenic threats. The purpose of this project is to reduce the mortality rate of loggerhead turtles' eggs and pre-emergent hatchlings from stomping, beach erosion, and extreme temperatures at loggerhead-nesting beaches in Japan to bolster hatchling production.

In 2004 and 2005, the Sea Turtle Association of Japan acquired funding assistance from the Western Pacific Regional Fishery Management Council to assist with management activities to address the above mentioned threats to loggerhead nesting beaches. In 2004, four beaches were included in the project: Inakahama, Maehama, Minabe-Senri, and Hii-Horikiri. In 2005, a fifth project site was added at Myojinyama-Oida beach.

[1] Final Report to the Western Pacific Regional Fishery Management Council, Contract No. 04-WPC-011. NOAA award #: NA03NMF4110017 and NA03NMF4110164. Due to the delay in producing these proceedings, results from both the 2004 and 2005 nesting season are consolidated into this one report.


FIGURE 1. *Loggerhead turtle nesting beach locations in of this project.*

## METHODS

### Yakushima Island

Inakahama Beach is located in Kamiyaku-town, Yakushima Island, Kagoshima prefecture (Figure 1). This 1.2 km long beach is the greatest rookery in Japan. Maehama Beach is next to Inakahama Beach across a river. This 1.6 km long beach is the second greatest rookery in Japan. Daily and nightly patrols were conducted on these two beaches during nesting season and following incubation season from April to October. When a new nest was found below the high tide mark or on slopes beside streams, it was immediately relocated to a safer area.

Nesting densities in these beaches were relatively high. Therefore, the best method identified to mark individual nests is by use of underground coils. A proportion of the clutches were marked with underground-coil markers. To protect eggs and hatchlings from visitors walking on nests, areas of high nesting density were surrounded with rope from July 15$^{th}$ through the end of the nesting season (Figure 2). Short sticks were put in the sand adjacent to nests when the first hatchling emergence events or hatchlings tracks for the nests were observed. Nest marked with coil markers were excavated about 10 days after first hatchlings emergence, or expected date of emergence, to evaluate and estimate hatching success. Sand temperatures at the depth of 40 cm were measured using data loggers.

### Minabe, Atsumi and Miyazaki

Minabe-Senri beach, Minabe town, Wakayama prefecture is one of most important loggerhead rookeries on the main island of Japan. In some seasons, loggerhead clutches nested in this beach exhibit very low hatching success (less than 10%) due to heat and inundation. Sand temperatures at the depth of 40 cm were measured using data loggers. All-night beach patrol was conducted throughout the nesting season, turtle nests were marked with sticks, and turtle eggs close to drift line were relocated to an area of elevation within a few hours of oviposition (Figure 3). In order to protect eggs and pre-emergent hatchlings from the heat, the nests were sprinkled with water[2] when sand temperature at nest depth exceeds the threshold in the post-rainy season (Figure 4). Safety nets were set on expected egg chambers to protect pre-emergent hatchlings from predation (Figure 5).

Hii-Horikiri Beach, Atsumi town, Aichi prefecture is located at the tip of the Atsumi peninsula. This 3.6 km long beach has suffered serious beach erosion due to upstream dams and jetties of ports. Then the beach was armored with ranges of tetrapods

FIGURE 2. *Fences to protect nests from human activities.*

FIGURE 3. *Staff relocating nests laid in erosion prone areas to safer location.*

FIGURE 4. *Watering of nests to reduce extreme temperatures.*

FIGURE 5. *Protective measure to protect nests and hatchlings from predation.*

FIGURE 6. *Beached armored with concrete blocks that prevent loggerheads from nesting in preferred habitat, close to the vegetation.*

[2] The Council's Turtle Advisory Committee discussed the benefits of watering nests to reduce extreme (lethal) temperatures and concluded that this is a viable solution and encouraged the project implement this management measure.

(concrete blocks) between the shoreline and the vegetation line (Figure 6). These blocks obstruct loggerhead females from proceeding close to vegetation line. As a result, females are forced to nest close to shoreline at this beach, and almost all eggs are eventually washed out or drowned. All eggs at this beach were relocated to an open hatchery located in safety zone.

Myojinyama-Oida Beach, is located north of Miyazaki city, where constructions of a big port and an airport caused serious beach erosion. This 6 km long beach accommodates many nesting females that come ashore to nest in the southern eroded beaches. However, this area also suffered serious beach erosion when many typhoons approached this area successively last autumn. Consequently, there are few safe areas for turtles to nest. This area was included in the project for the 2005 season.

Table 1. Number of emergence tracks and nests at Yakushima Island, 2004.

| | Inakahama Beach | | | Maehama Beach | | |
|---|---|---|---|---|---|---|
| Month | #Emergence (tracks) | # Nests | Nesting success | #Emergence (tracks) | # Nests | Nesting success |
| April | 20 | 11 | 0.55 | 17 | 6 | 0.35 |
| May | 640 | 353 | 0.55 | 695 | 248 | 0.36 |
| June | 970 | 563 | 0.58 | 939 | 290 | 0.31 |
| July | 613 | 312 | 0.51 | 701 | 221 | 0.32 |
| August | 12 | 6 | 0.50 | 11 | 4 | 0.36 |
| Total | 2,255 | 1,245 | 0.55 | 2,363 | 769 | 0.33 |

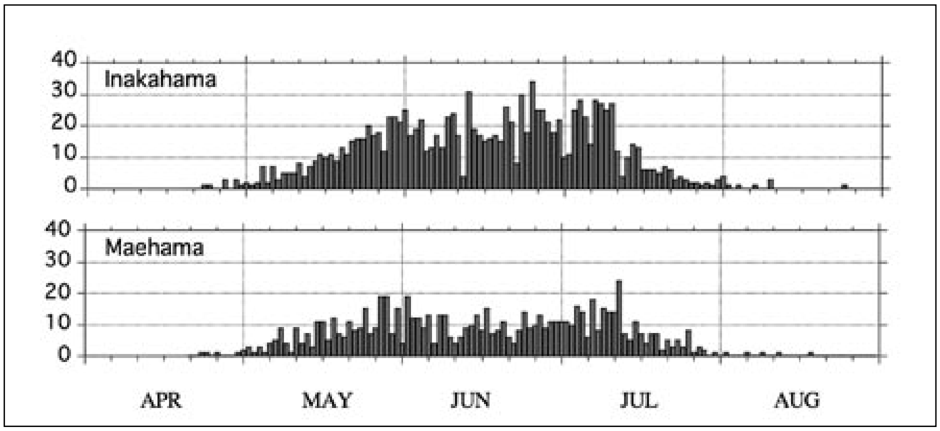


**FIGURE 7.** *The number of clutches laid on Inakahama Beach and Maehama Beach throughout the 2004 nesting season.*

## RESULTS

### Landing and nesting

The nesting season for both the 2004 and 2005 season started on April 21st. This date is the earliest ever recorded for loggerhead nesting in Japan. Although, in some other southern islands the nesting season started much earlier.

#### 2004 Season

At the Inakahama and Maehama Beaches, a total of 2,014 clutches were laid during the 2004 nesting season (Table 1 and Figure 7). This total is about 1.24 times that of last season (in 2003). One remarkable development of this season was the low nesting success. Only 43.6 % of landing turtles completed egg chambers in 2004 compared to 60 to 70% nesting success in previous seasons. This may be a consequence of dry sand, which causes easy corruptions of egg chambers. Additionally, many uncontrolled eco-tourists seemed to disturb females on the beach.

At the Minabe-Senri Beach, the nesting season started on April 21 and ended on August 6. It was also the earliest ever recorded. A total of 92 clutches were laid during the 2004 season. The total number of nests in this season is about 1.23 times that of last season. The nesting success was also the lowest ever recorded (only 32.2%).

At the Hii-Horikiri Beach, the number of nests decreased compared to last season. In 2004, only 14 clutches were laid compared to 29 during the 2003 season. This might be related to the Kuroshio Current and a cold water-mass off shore of this rookery; other adjacent rookeries also had lower nesting this season.

#### 2005 Season

During the 2005 nesting season, a total of 1,758 clutches were laid at Inakahama and Maehama Beaches (Table 2 and Figure 8). The total number of nests during the 2005 season was about 0.87 times that of the 2004 season. One remarkable development of this season was that the northeast half of the Maehama beach that eroded in 2004 could not be used by nesting females until the beach was nourished artificially in May of 2005. The lower nesting success in April and May of 2005 may thus be related to this matter.
At the Minabe-Senri Beach, the nesting season started on May 22nd and ended on August 20th. A total of 121 clutches were laid (Table 3). The total number of nests in this season is about 1.3 times that of last season. The nesting success was 52.4%. At the Horikiri Beach, the number of nests increased. In 2005, 29 clutches

Table 2. Number of emergence tracks and nests at Yakushima Island, 2005.

| | Inakahama Beach | | | Maehama Beach | | |
|---|---|---|---|---|---|---|
| Month | #Emergence (tracks) | # Nests | Nesting success | #Emergence (tracks) | # Nests | Nesting success |
| April | 10 | 7 | 0.70 | 12 | 4 | 0.33 |
| May | 402 | 260 | 0.65 | 528 | 186 | 0.36 |
| June | 715 | 470 | 0.66 | 799 | 385 | 0.48 |
| July | 365 | 202 | 0.55 | 456 | 240 | 0.53 |
| August | 5 | 2 | 0.40 | 5 | 2 | 0.40 |
| Total | 1,497 | 941 | 0.63 | 2,363 | 817 | 0.45 |

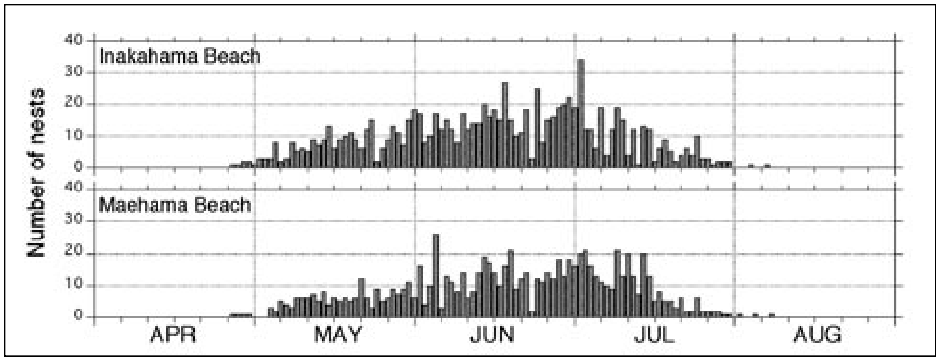


**FIGURE 8.** *The number of clutches laid on Inakahama Beach and Maehama Beach throughout the 2005 nesting season.*

Table 3. Number of emergence tracks and nests at Miyazaki and Minabe, 2005.

| | Myojinyama-Oida Beach | | | Minabe-Senri Beach | | |
|---|---|---|---|---|---|---|
| Month | #Emergence (tracks) | # Nests | Nesting success | #Emergence (tracks) | # Nests | Nesting success |
| May | 33 | 27 | 0.82 | 4 | 2 | 0.50 |
| June | 112 | 83 | 0.74 | 76 | 40 | 0.53 |
| July | 97 | 65 | 0.67 | 113 | 60 | 0.53 |
| August | 12 | 8 | 0.67 | 38 | 19 | 0.50 |
| Total | 1,497 | 183 | 0.72 | 2,363 | 817 | 0.52 |

Table 4. Number of relocated nests, 2004.

| Month | Inakahama | Maehama | Minabe-Senri | Hii-Horikiri |
|---|---|---|---|---|
| April | 3 | 3 | 1 | 0 |
| May | 74 | 28 | 4 | 0 |
| June | 48 | 25 | 8 | 4 |
| July | 15 | 9 | 6 | 6 |
| August | 0 | 0 | 0 | 4 |
| Total | 140 | 65 | 19 | 14 |

Table 5. Number of marked nests at Yakushima Isl., 2004.

| | Inakahama | | Maehama | |
|---|---|---|---|---|
| Month | *in situ* | relocated | *in situ* | relocated |
| May | 17 | 18 | 18 | 9 |
| June | 108 | 25 | 65 | 18 |
| July | 53 | 14 | 30 | 6 |
| August | 0 | 0 | 0 | 0 |
| Total | 178 | 57 | 113 | 33 |

were laid compared to 14 last season. The nesting success was 51.8%. At the Myojinyama-Oida Beach, a total of 183 clutches were laid during this season (Table 3). The nesting success was 72.0%.

## RELOCATION AND MARKING OF NESTS

### 2004 Season

To save eggs from erosion prone areas, we conducted nightly patrols and relocated 16,511 eggs from 140 clutches on Inakahama Beach, 7,476 eggs from 65 clutches on Maehama Beach, 1,153 eggs from 14 clutches on Hii-Horikiri Beach, and 19 clutches on Minabe-Senri Beach during the 2004 nesting season (Table 4). Ninety relocated nests and 291 *in situ* nests were marked with underground-coil markers in the two beaches of Yakushima Island to assist in quantifying the hatch success of relocated nests (Table 5).

### 2005 Season

During the 2005 nesting season, we conducted nightly patrols and relocated 123 clutches on the Inakahama Beach, 171 clutches on the Maehama Beach, 3,473 eggs from 33 clutches on the Minabe-Senri Beach, and 2,493 eggs from 29 clutches on the Hii-Horikiri Beach, and 114 clutches on the Myojinyama-Oida Beach to save nests from erosion prone areas (Table 6). At the Inakahama Beach and the Maehama Beach, 260 and 96 clutches were marked with underground-coil markers to quantify hatch success of *in situ* versus relocated nests. Mean clutch size in Yakushima was 111.7.

## Weather conditions

During the 2004 nesting season, there was relatively little rain during the rainy season, but beaches suffered a record number of typhoons (Figure 9). In the middle of June, unseasonal typhoons struck the Japan archipelago one after the other; Typhoon NO.4 approached closest to Yakushima Island on June 10 and hit Minabe and Atsumi on June 11, and Typhoon No.6 on June 20 and 21. After Typhoon No. 10 hit Minabe at the end of July, the project sites suffered other typhoons without a break until the end of incubation season. Among them, Typhoon No. 16 at the end of August caused immense harm to Yakushima and a half stretch of Maehama Beach was washed away. In all project sites, a few nests were drowned and/or washed out with data loggers and post-emergent nests accordingly. In Minabe, sand temperatures remained higher than 31.6 in July and August excepting temporal drops on typhoon approached. On the other hand, sand temperatures in the Yakushima beaches did not exceed this threshold considerably (Fig. 10)

During the 2005 nesting season, three typhoons landed on the main islands of Japan. Both the Typhoon No. 7 coming in July and Typhoon No. 11 in August hitting Atsumi were relatively small and weak. But Typhoon No. 14 in September was very powerful. It hit the project sites in the Yakushima Island with full force on September 5th and 6th. And to make things worse, it coincided with the fall spring tide. A half stretch of the Maehama Beach, which had been artificially nourished in May, was washed away and collapsed again. Even the ropes and sticks fencing the high-nesting density areas in the higher elevation of the two beaches were also washed away.

Because Typhoon No. 14 approached from the south of the main islands of Japan and hit the western Japan, other three project sites also suffered huge surge and concentrated heavy

Table 6. Number of relocated nests, 2005.

| Month | Inakahama | Maehama | Minabe-Senri | Hii-Horikiri | Myojinyama-Oida |
|---|---|---|---|---|---|
| April | 4 | 3 | 0 | 0 | 0 |
| May | 63 | 97 | 1 | 1 | 0 |
| June | 25 | 33 | 13 | 8 | 47 |
| July | 30 | 38 | 14 | 11 | 67 |
| August | 1 | 0 | 5 | 9 | 0 |
| Total | 123 | 171 | 33 | 29 | 114 |

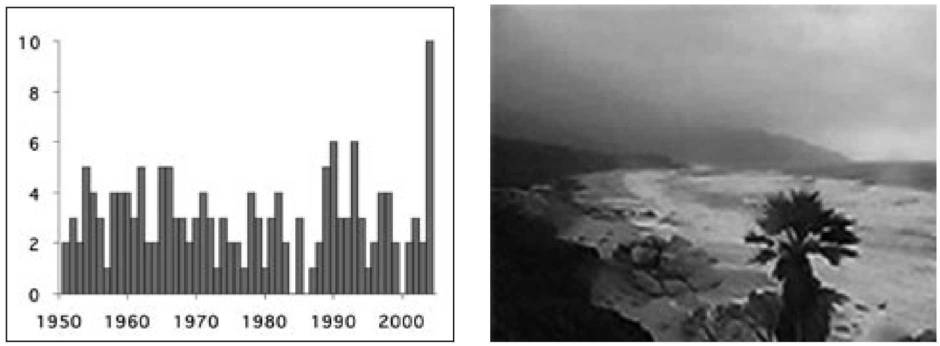


**FIGURE 9.** *Annual number of Typhoons landing on Japan between 1950 and 2004.*

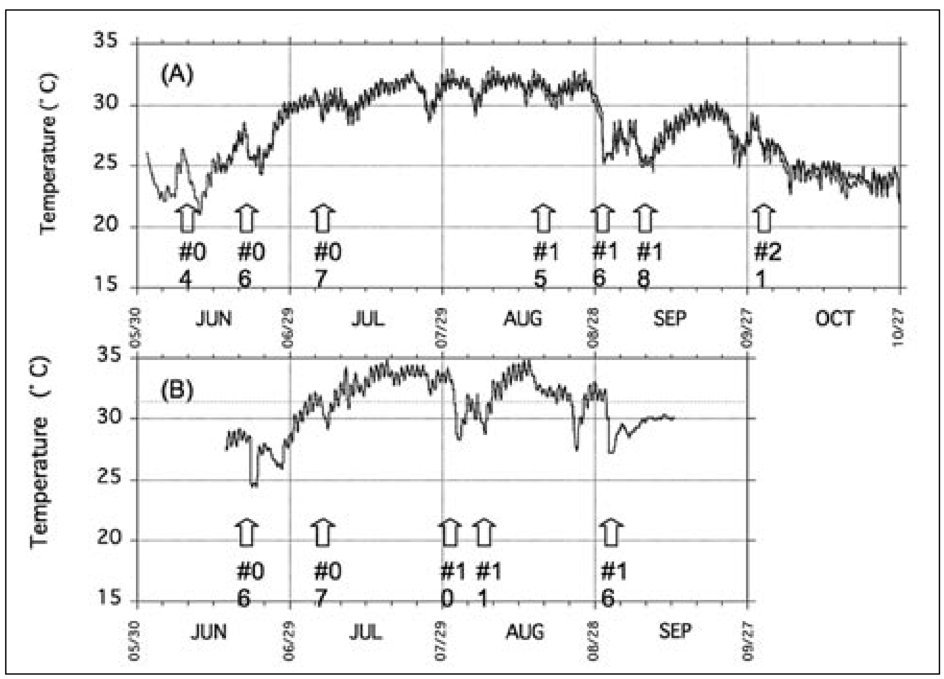


**FIGURE 10.** *Sand temperatures at Inakahama (A) and Maehama (B) beaches. Arrows indicate typhoons affecting beaches. The temperature data were measured in the vegetation.*

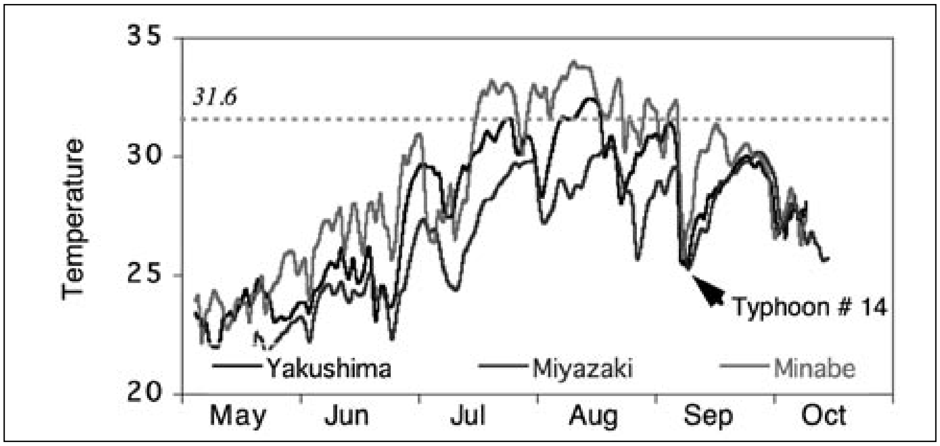


**FIGURE 11.** *Sand temperatures at Yakushima, Miyazaki and Minabe beaches during the 2005 nesting season.*

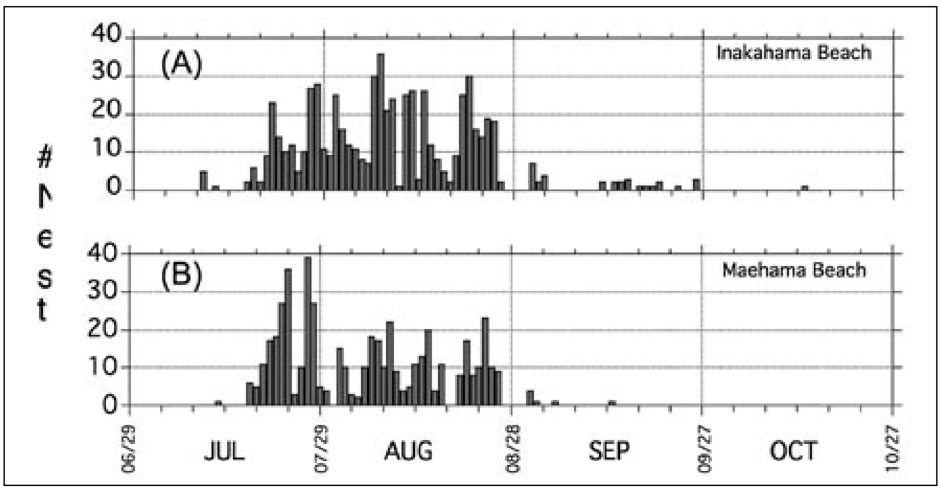


**FIGURE 11.** *Daily number of nests from which the first hatchlings emergent was observed in 2004 at Inakahama (A) and Maehama (B) Beaches.*

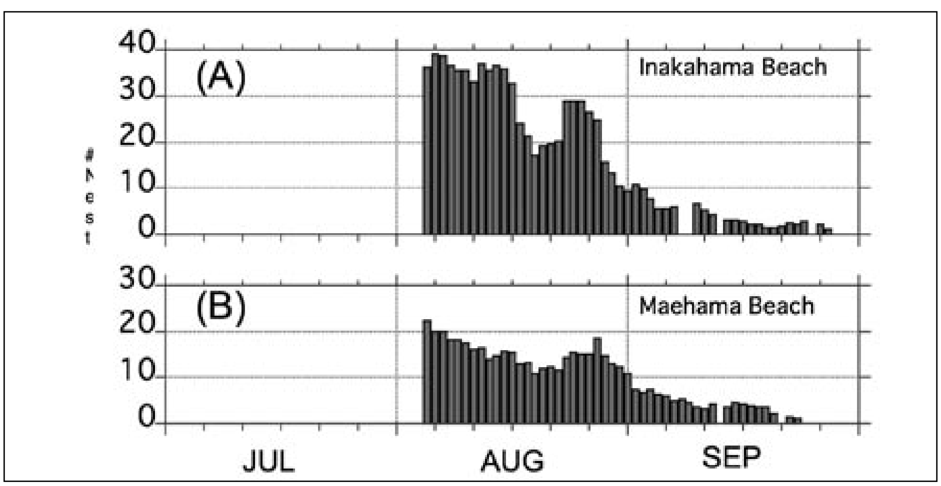


**FIGURE 12.** *Number of due nests in Inakahama (A) and Maehama (B) Beaches in 2004. Data have been smoothed with a 5 days running mean. Number of due nests were calculated from daily number of nests and expected incubation periods based on the following equation (Matsuzawa et al. 2002): Incubation period = 639.8 x 1 mean sand temperature - 17.6)-1.*

rain, hence serious beach erosion occurred. In all project sites, some eggs were drowned and/or washed out with data loggers and post-emergent nests accordingly. The surge reached the vegetation line at the Minabe-Senri Beach on September 4th. We therefore relocated 6 ***in situ*** clutches that were in danger of inundation to safer, higher elevation.

Additionally, the 2005 season also witnessed record heat. At Minabe, sand temperatures were kept higher than 31.6 in the post rainy season excepting temporal drops on typhoon approached (Figure 11). We therefore sprinkled nests with water almost everyday. On the other hand, sand temperatures in the beaches in Yakushima and Miyazaki did not exceed this threshold considerably.

## INCUBATION AND EMERGENCE

### 2004 Season

The first emergence of hatchlings occurred on June 30, 2004 in Maehama Beach and on July 10, 2004 in Inakahama Beach. After this date, hatchlings emerged from at least 637 clutches on Inakahama Beach, and from at least 485 clutches on Maehama Beach (Figure 11). Very few emergences were found in September and October.

Based on the equation provided by Matsuzawa et al. (2002), the expected due date for the clutch nested on May 31, 2004, was July 31, 2004. After this date, the number of daily nests due (smoothed with a 5 days running mean) was calculated from the daily number of nests and expected incubation period (Figure 12). These results also indicated that less clutches are due in September. The ratios of smoothed number of daily due nests to smoothed number of nests from which hatchling emergences observed was 54.4 % in Inakahama Beach and 60.0 % in Maehama Beach during the period between July 31 and August 26, 2004 (Fig. 7).

### 2005 Season

During the 2005 nesting season, the first emergence of hatchlings occurred on July 19, 2005 in the Maehama Beach and on July 18, 2005 in the Inakahama Beach. After then, hatchlings emerged from at least 839 clutches from Inakahama Beach, and from at least 603 clutches from Maehama Beach, including clutches without exact data of first emergence. Most of emergences occurred in August (Figure 13). As for clutches marked with underground-coil markers, hatchlings emerged from 241 of 260 (92.7%) nests at Inakahama Beach and 77 of 96 (80.2%) from the Maehama Beach. Other nests were washed out or did not produce any hatchlings.

Base on the equation given by Matsuzawa et al. (2002), the expected due date for the clutch nested on May 4, 2005, was July 23, 2005. After this date, the number of daily nests due (smoothed with a 5 days running mean) were calculated from daily number of nests and expected incubation period (Figure 14). Sixteen clutches and seven clutches nested before May 4 in the two beaches were not included in the figure. This result also indicated that not as many nests were expected to hatch in September. Only 46 clutches (4.6%) in the Inakahama and 37 clutches (4.5%) in the Maehama were estimated to be due after the Typhoon 14 hit the sites.

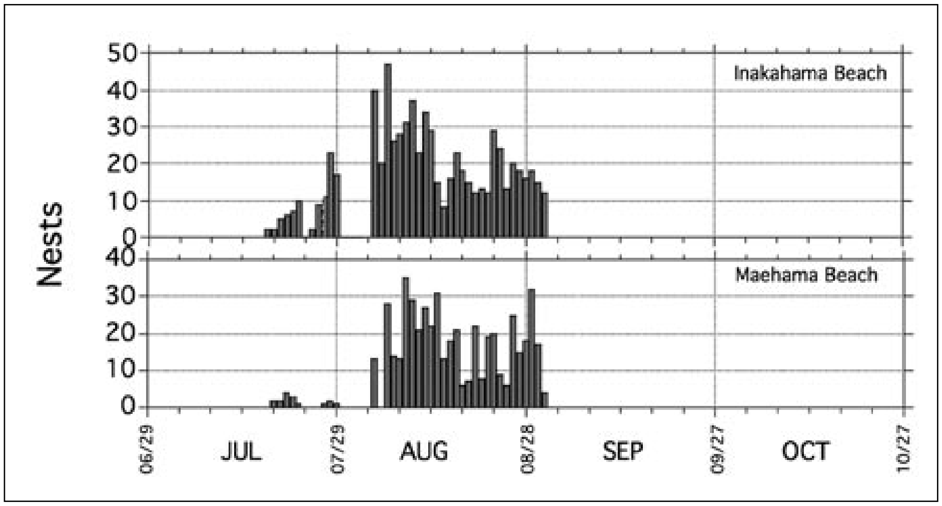


**FIGURE 13.** *Daily number of nests from which hatchlings emerged in Inakahama and Maehama Beaches in 2005.*

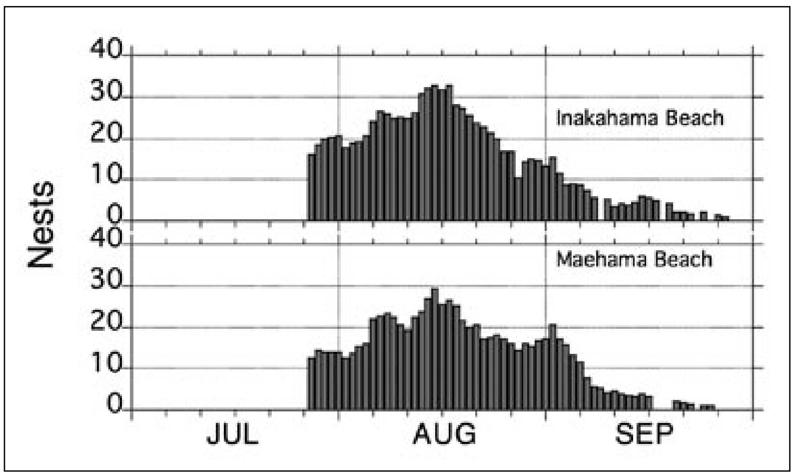


**FIGURE 14.** *Number of due nests in Inakahama and Maehama Beaches in 2005. Data have been smoothed with a 5 days running mean.*

## Hatching success

### 2004 Season

At Inakahama Beach, 331 of 1,245 clutches laid were examined. Luckily, most hatchlings had emerged before the big Typhoon No. 16 struck. The mean overall hatching success was 78.2% (28,566 of 36,525 eggs). Of the 331 clutches examined, 286 were *in situ* and 45 were relocated (see Table 3). The hatching success of *in situ* compared to relocated clutches at Inakahama Beach was 80.5 and 63.3%, respectively. In Maehama Beach, 150 of 769 clutches were excavated. The mean overall hatching success was 70.1% (11,799 of 16,834 eggs). Of the 150 clutches examined, 140 were *in situ* and 10 were relocated. The hatching success of *in situ* compared to relocated clutches at Maehama Beach was 70.4 and 65.8%, respectively. Supposing that all other unexamined clutches were washed out when the Typhoon No. 16 approached on August 27, we can apply the same hatching success and clutch size to the 819 and 540 unexamined clutches nested by July 11. In this estimation, 99,239 and 54,281 total hatchlings were produced in Inakahama Beach and Maehama Beach, respectively (Table 7).

Among 92 clutches in Minabe-Senri Beach, thirty-three (35.9%) clutches including 13 post-emergent clutches were washed out. Hatching success for 17 relocated clutches was 30.2%

Table 7. The number of nests laid and relocated, and total estimated number of hatchlings produced at four project sites in 2004.

| Beach | No. of nests laid | No. of nests relocated | No. Hatchlings produced |
|---|---|---|---|
| Inakahama | 1,245 | 140 | 99,239 |
| Maehama | 769 | 65 | 54,281 |
| Minabe-Senri | 92 | 19 | 3,276 |
| Hii-Horikiri | 29 | 14 | 171 |
| Total | 2,135 | 238 | 156,967 |

Table 8. The number of estimated hatchlings produced from *in-situ* and relocated nests at five project sites in 2005.

| Beach | *In-situ* | Relocated | Total hatchlings |
|---|---|---|---|
| Inakahama | 70,640 | 8,941 | 79,581 |
| Maehama | 43,172 | 10,417 | 53,589 |
| Minabe-Senri | 3,641 | 1,426 | 5,067 |
| Hii-Horikiri | 0 | 1,414 | 1,414 |
| Myojinyama-Oida | 3,710 | 6,117 | 9,827 |
| Total | 121,163 | 28,315 | 149,478 |

(590 of 1,952 eggs), whereas hatching success for 42 *in situ* clutches was 44.8% (2,062 of 4,599 eggs). Applying these clutch size and hatching success to one relocated clutch and 12 *in situ* clutches from which hatchlings emerged before they were washed out, then we would have expected 35 hatchlings and 1,314 hatchlings from these unexamined clutches. Therefore, it is estimated that 3,276 total hatchlings were produced in this beach.

Although the hatchery in Hii-Horikiri Beach was located in the vegetation area, it was inundated frequently. Consequently, two clutches and a data logger were washed out, and many embryos died during incubation. From 1,153 eggs of 12 clutches, 171 hatchlings were produced; the mean hatching success was 14.8 %.

**2005 Season**

At Inakahama Beach, mean hatching success of 312 *in situ* nests and 86 relocated nests were 83.4% and 70.2%, respectively. At the Maehama Beach, mean hatching success of 246 *in situ* nests and 28 relocated nests were 74.6% and 68.0%, respectively. Piecing together these hatchling successes with mean clutch size of 111.7 and percentage of clutches from which any hatchlings emerged, it is expected that 70,640 hatchlings from *in situ* nests and 8,941 hatchlings from relocated nests were produced from Inakahama Beach and 43,172 hatchlings from *in situ* nests and 10,417 hatchlings from relocated nests were produced from Maehama Beach (Table 8).

Among 121 clutches in the Minabe-Senri Beach, nine (7.4%) clutches including 4 post-emergent clutches were washed out and 8 clutches were predated. Hatching success for the 33 relocated clutches was 41% (1,426 of 3,473 eggs), whereas hatching success for 71 *in situ* clutches was 48.9% (3,641 of 7,446 eggs). These hatch success rates are better than those during last season. Applying mean clutch size of 105 and mean hatching success of 48.9% to the 4 *in situ* clutches from which hatchlings were emerged before they were washed out, then we can expect 205 more hatchlings from these unexamined clutches. Therefore, it was estimated that totally, 5,272 hatchlings were produced in this beach. This number is about 1.6 times the estimation of last season.

Although the hatchery in the Hii-Horikiri Beach was located in the vegetation area, it was inundated. Consequently, data loggers were washed out before they could be recovered. From 2,493 eggs of 29 clutches, 1,414 hatchlings were produced; the mean hatching success was 56.7%.

At Myojinyama-Oida Beach, 183 total clutches were laid and 114 were relocated. Of the relocated clutches, 35 (30.7%) were washed out or predated. Hatching success for the other 79 relocated clutches was 74.6% (6,117 of 8,205 eggs). Assuming that clutch size, hatching success, and ratio of damage by wave and predation were the same between relocated clutches and *in situ* clutches, it is estimated that 3,710 hatchlings were produced from 69 *in situ* clutches.

## CONCLUSION

The most critical component of understanding the functioning of a nesting beach is to understand its productivity. This project supported nightly beach patrols to monitor and management activities to reduce impacts and maximize hatchling production through the successful relocation of nests laid in erosion prone areas. Additionally, researchers identified new sources of environmental threats (i.e., high beach temperatures and extreme erosion due to weather and beach armoring) that have the potential to significantly impact the productivity of nesting beaches of Japan. The project has plans to mitigate these impacts during the upcoming 2005 nesting season.

In 2004, the Sea Turtle Association of Japan acquired funding assistance from the Western Pacific Regional Fishery Management Council[3] (Council) to assist with management activities to reduce the mortality rate of loggerhead turtles' eggs and pre-emergent hatchlings from stomping (beach use), beach erosion, and extreme temperatures at four Japanese loggerhead-nesting beaches at Inakahama, Maehama, Minabe-Senri, and Hii-Horikiri. In 2005, the project was expanded to include Myojinyama-Oida Beach.

In 2004, management activities were supported to maximize hatchling production and save nests laid in erosion prone areas. In total, 240 nests were relocated from certain destruction, and restrictions (such as fences) were placed at high density nesting areas to reduce anthropogenic impacts from foot traffic and beach use. Approximately 157,000 total hatchlings were released from the four study sites (Table 7), and the hatching success rate ranged from 70.4 to 80.5% for ***in situ*** nests and 63.3 to 65.8% for relocated nests at Inakahama and Maehama Beaches.

In March 2005, the Council's Turtle Advisory Committee (TAC) reviewed this project and encouraged management actions and experimental research to further reduce environmental impacts. To reduce impacts from extreme weather, namely erosion (due to typhoons and other beach conditions associated with beach armoring), the TAC strongly encouraged additional relocation of clutches (within the constraints of project logistics), since it is evident that the project is producing more hatchlings from the beach by management efforts to relocate clutches [if eggs are not relocated, zero percent hatchling production results]. The project leaders recognize that other kinds of effects due to relocation are unknown, but any level of hatch success (even 10%) is better than zero percent. If one wants to think in terms of adults, a beach needs to produce a lot of hatchlings to produce an adult some decades later. The TAC thus encouraged the project to move hundreds of clutches to maximize hatchling production to have those extra adults in the future. The TAC further supported that the project experiment with watering of nests in effort to reduce extreme temperatures at project sites.

Based on the advice from the TAC, and after acquiring greater understanding regarding the goals and objectives of the Council, the project was able to refine the project's results to calculate the number of hatchlings released due to management intervention. During the 2005 nesting season, 470 nests were relocated (Table 8). It is estimated that these relocated nests resulted in the release of approximately 28,315 hatchlings that would have otherwise been lost to erosion or other environmental impacts. In total, 149,478 hatchlings were produced at the five project sites (Table 8). The hatching success rate ranged from 74.6 to 83.4% for *in situ* nests and 56.7 to 70.2% for relocated nests at Inakahama and Maehama Beaches. Of total hatchlings produced, approximately 19% were a result of management activities to relocate eggs laid in erosion prone areas.

## REFERENCES


Bowen, B.W., F.A. Abreu-Grobois, G.H. Balazs, N. Kamezaki, C.J. Limpus and R.J. Ferl. 1995. Trans-Pacific migration of the loggerhead turtle (*Caretta caretta*) demonstrated with mitochondrial DNA markers. *Proc. Natl Acad. Sci.* 92: 3731-3734.

Kamezaki, N., Y. Matsuzawa, O. Abe, H. Asakawa, T. Fujii, K. Goto, S. Hagino, M. Hayami, M. Ishii, T. Iwamoto, T. Kamata, H. Kato, J. Kodama, Y. Kondo, I. Miyawaki, K. Mizobuchi, Y. Nakamura, Y. Nakashima, H. Naruse, K. Omuta, M. Samejima, H. Suganuma, H. Takeshita, T. Tanaka, T. Toji, M. Uematsu, A. Yamamoto, T. Yamato, and I. Wakabayashi. 2003. Loggerhead Turtles Nesting in Japan. In: *Loggerhead Sea Turtles*. Edited by A.B. Bolten and B.E. Witherington. Smithsonian Institution. P.p. 210-217.

Kudo, H. Murakami, A. Watanabe, S. 2003. Effects of sand hardness and human beach use on emergence success of loggerhead sea turtles on Yakushima Island, Japan. *Chelonian Conservation and Biology,* 4*(3)*: 695-696.

Matsuzawa, Y. Sato, K. Sakamoto, W. Bjorndal, K. A. 2002. Seasonal fluctuations in sand temperature: effects on the incubation period and mortality of loggerhead sea turtle (*Caretta caretta*) pre-emergent hatchlings in Minabe, Japan. *Marine Biology,* 140(3):639-646.


[3] Interactions with threatened loggerhead sea turtles have the potential to compromise the long-term continuity of U.S. pelagic longline fisheries. The Western Pacific Regional Fishery Management Council (Council), the federal management authority of fisheries operating in the Pacific Islands Region, has therefore implemented an integrated approach to sea turtle conservation to address anthropogenic and environmental threats to turtles in various phases of their life history. In 2004, the Council began supporting nesting beach management actions in Japan, because 100% of the loggerhead turtle/fishery interactions by the Hawaii-based longline fishery occur with the north Pacific loggerhead turtle nesting stock.

Nichols, W.J., A. Resendiz and C. Mayoral-Russeau. 2000. Biology and conservation of loggerhead turtles (*Caretta caretta*) in Baja California, Mexico. In: Proceedings of the 19th Annual Symposium on Sea Turtle Conservation and Biology. NOAA Tech-Memo NMFS-SEFSC-443. Pp. 169-171.

Resendiz, A., B. Resendiz, J. Nichols, J. Seminoff, N. Kamezaki. 1998. First confirmed east west transpacific movement of a loggerhead sea turtle, *Caretta caretta*, released in Baja California, Mexico. *Pacific Science* 52: 151-153.

Uchida, S. Teruya, H. 1988. Transpacific Migration of a Tagged Loggerhead, *Caretta caretta* and Tag- Return Results of Loggerheads Released From Okinawa Island, Japan. In: Uchida, I. ed., Proceedings of International Symposium on Sea Turtles in 1988 in Japan. Himeji City Aquarium, Himeji City, Japan. p69-182.

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# The Sea Turtle Situation of Yakushima Island

## INTRODUCTION

The circumference of Yakushima Island, Kagoshima prefecture in southern Japan is approximately 130 kilometers, surrounded by the East China Sea and the Pacific Ocean. The three primary sea turtle nesting beaches, Maehama, Inakahama and Yotsusehama, are on the northern side of the island associated with Nagata, Kamiyaku-town (Figure 1). Together, these beaches comprise approximately 40% of all loggerhead nesting in Japan (Kamezaki et al., 2003). The Sea Turtle Museum, Umigame Kong, is also located at Inakahama Beach.

Inakahama Beach, is about one kilometer long, but the shore line changes as the season change. In May and June, there is more sand, but sand erodes during the nesting season and the beach becomes quite rocky. Maehama Beach is about 600 meters long and is protected with concrete berms, and Yotsusehama Beach is approximately 240 meters long. Unfortunately, sand erosion is very serious problem at Maehama (Figure 2). During the winter, typhoon season, the sand is drastically removed.

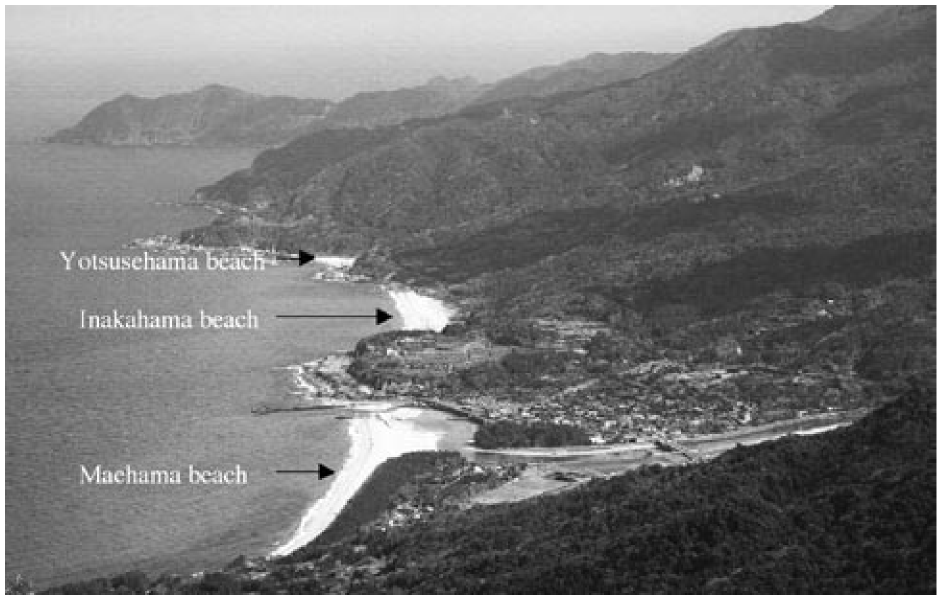



**FIGURE 1.** *Bird's eye view of the three primary nesting beaches of beaches Yakushima Island: Maehama, Inakahama and Yotsusehama beaches.*

**FIGURE 2.** *Maehama beach sand erosion following a typhoon.*

**FIGURE 3.** *Volunteers and staff at the sea turtle museum (Mr. Omuta, center).*

## CONSERVATION RESEARCH

About 500 loggerhead turtles come to lay eggs at the three beaches of Yakushima Island. There are also green turtles, but the greatest percentage are loggerhead turtles. Research is undertaken from May to September and work is conducted by about 40 to 50 volunteers. Thanks to the volunteer program, research has flourished (Figure 3). There is a dormitory for volunteers that houses a maximum of six volunteers at one time.

We estimate that the program tags about 99% of turtles that nesting at Yakushima Island (Figure 4). In addition to tagging and measuring, however, our project transplants eggs that are laid in erosion prone areas to safer locations, and undertakes studies on hatchling success to gather information on the reproductive success of turtles, as well as understand the hatch success of relocated nests.

We also have a project to tag hatchlings with Passive Integrated Transponders (PIT) tags. Between 1988 and 2004, the project has PIT tagged 1,450 hatchlings (Figure 5). There are two main purposes for this study, one is to see how long it will take the turtles to become sexually mature, and the other is to see if they will return to the home beach. We estimate that loggerhead turtles from Yakushima grow into mature females in about 29 years. Hopefully, this will be confirmed with the PIT tags. I'm assuming that these turtles will go to Baja, so please take care of them.

Based on research and beach monitoring surveys, Figure 6 is a graph of the number of female turtles landing (top line), and nesting (bottom line). As you can see the number of both landing and nesting individuals were increasing until about 1991, then gradually decreasing until 2002, and then increasing through 2004 (Figure 6).

## MANAGEMENT MEASURES

In 1973, laws were enacted to prohibit people from eating sea turtle eggs. The law was limited first to Yakushima Island, but in 1988, a similar law was enacted for the entire Kagoshima Prefecture. Additionally, up until 1999, there were many kinds of fishing operations near the coast of Yakushima, but fish catch rates

**FIGURE 4.** *Measuring a loggerhead turtle nesting at Yakushima Island.*

**FIGURE 5.** *Researcher PIT tagging a loggerhead hatchling.*

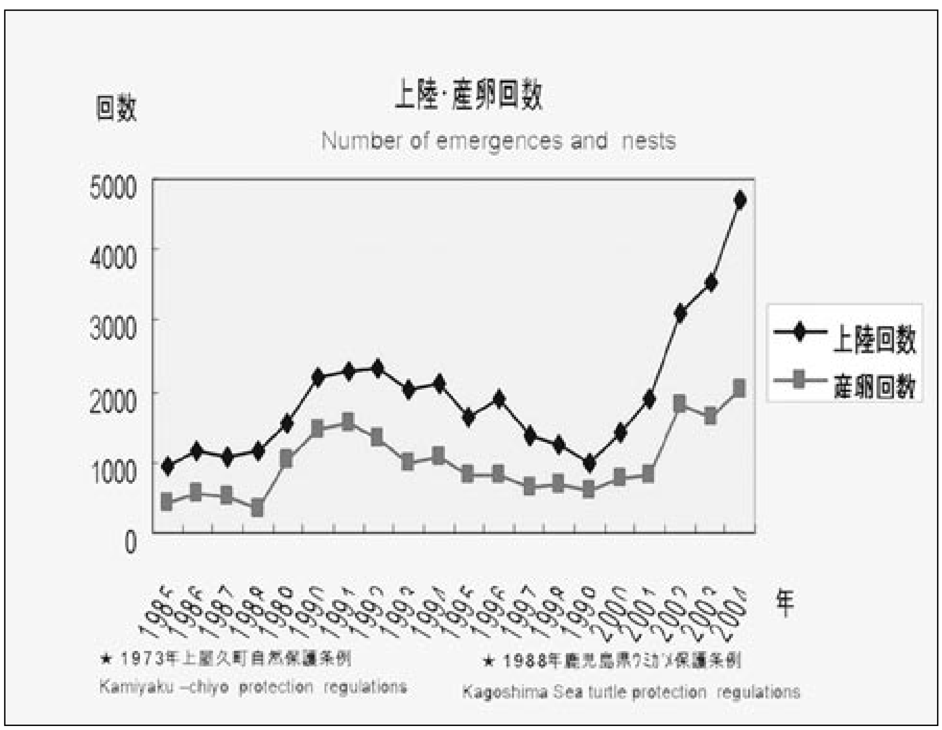



**FIGURE 6.** *Number of female loggerhead turtles emerging (top line) and nesting (bottom line) at Yakushima Island between 1985 and 2004.*

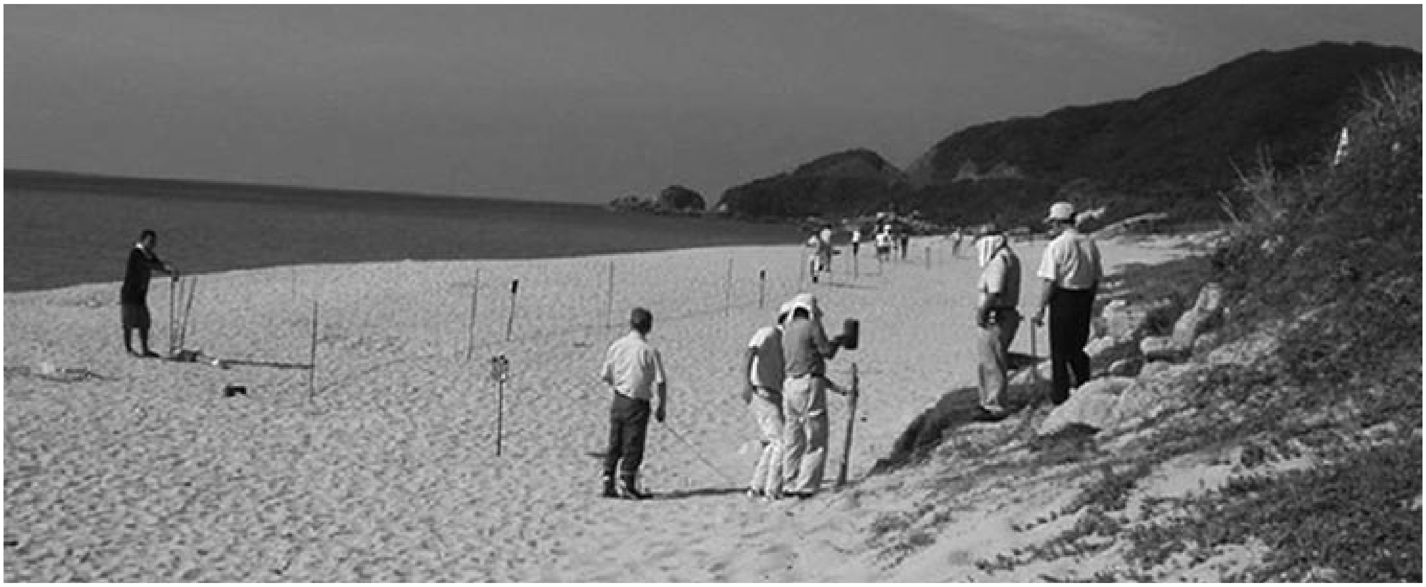


**FIGURE 7.** *Fence placed around highest density nesting areas for conservation.*

**FIGURE 8.** *The public listening to a sea turtle presentation.*

**FIGURE 9.** *School kids learning what is like to be a turtle and dig a "nest."*

decreased and poundnet and gillnet fishing stopped. Since 1999, fishing pressure near Yakushima Island has no longer been a problem.

In Figure 6, the nesting numbers decrease from 1991 to 1999. However, nesting numbers have increased since 1999. In 2002, the nesting numbers have doubled and continued to increase. It is my estimation that the reason for the drastic increase of nesting females from 2001 to 2004 is due to the law enactment in 1973. People are no longer eating sea turtle eggs. So those eggs (hatchlings) are now coming back as nesting females.

Hatching success rates are influenced by typhoons (as discussed in Matsuzawa's paper of these proceedings) and beach use by people or tourists at Yakushima Island. To reduce foot traffic and protect nests from stomping, we mark areas to keep people away, or off of nests (Figure 7). For the sake of sea turtles, we would like to put a fence all around the beach, but that is not possible, so we place fences where the highest density of nests are laid.

We would like to begin restricting beach access at Inakahama Beach in July, but cannot because this is when we have the most tourists and so we need to focus on education. Fences are placed in August. We know that the fences increase hatchling success, because data suggests a 10 percent increase in August compared to July. In comparison, at Maehama Beach where tourism was less during summer (2004), there was a 14 percent increase in hatchling success versus Inakahama.

## EDUCATION AND OUTREACH

Sea turtles have become popular for ecotourism at Yakushima, and the number of visitors coming to see turtles has increased over the past few years. At Inakahama Beach, we have therefore begun a project to show local tourist nesting sea turtles (Figure 8). We give talks about turtles, and elementary school students come to learn about sea turtles (Figure 9). Public education and outreach are big parts of our program to conserve loggerhead turtles at Yakushima Island.

## QUESTIONS

**Mr. Limpus:** Could you explain just a little bit more about the pit tag of the hatchlings? How many pit tags, how many tags on each turtle and what sort of tags are they?

**Mr. Dutton:** As a related question, I'm particularly interested in the brand.

**Mr. Ohmuta:** Troban. One per turtle.

**Mr. Dutton:** Size? Are they just standard 14 or 12 millimeter.

**Mr. Ohmuta:** 11 millimeters.

**Mr. Limpus:** How many years has he been doing the pit tagging on the hatchlings.

**Mr. Ohmuta:** Four years.

**Mr. Pilcher:** Have any of the hatchlings being kept in captivity after being pit-tagged to check for whether there is any impact on survival of the hatchling from using the pit tag?

**Mr. Ohmuta:** There is an aquarium that has done it at Minamichi, and their study indicates that it doesn't affect the survival of hatchlings.

**Mr. Balazs:** Are they inserted into the body cavity or where exactly are they inserted?

**Mr. Ohmuta:** In the cavity.

**Mr. Aguirre:** Have you recovered any of those tags?

**Mr. Ohmuta:** None.

**Mr. Dutton:** An issue for further discussion is the chances of detecting those, if they are surviving, you are more likely -- there are opportunities where observers are catching turtles in fisheries, in high seas fisheries, and on the foraging grounds. But they are only going to detect the pit tags if they are using scanners. So perhaps I would be interested to have further discussion of the various people that are catching juvenile turtles on foraging grounds. If no one is looking for those pit tags with the right equipment, we're missing on opportunity.

**Mr. Ohmuta:** I'm looking forward to further discussion about this issue. Thank you.

**Mr. Peckham:** Mizuno has been coming over to Baja and has been using a scanner on the small juveniles, as well as dead ones the beach. Over the last two summers, he's probably looked at 200 or 250 or so, and has not found any tags. But the turtles might be too large, were not sure.

**Ms. Kinan:** Does he have plans to continue pit tagging?

**Mr. Ohmuta:** I would like to put more pit tags on turtles, but since it's expensive equipment, I need to discuss with people on how to go about this.

**Dr. Limpus:** I commend you for the innovative approach to tagging hatchlings. I do have a question that I would like to get an answer, not now, but with collectively perhaps from the group, if you could give us an answer. You are using an extremely sharp needle to inject an object into the body cavity of a hatchling. I would like to know that there has been a veterinary examination to establish that you are not seriously injuring the digestive tract because where you inject is right next to the stomach of the turtles. And I would like to be satisfied from a veterinary perspective, not just a question of how the little turtles survive for awhile in the aquarium and that might require internal examination by a veterinarian. But so not an answer right now, but if someone could give me an answer please.

**Mr. Dutton:** While we were on the subject of pit-tagging, one of my favorite subjects, you mentioned you have been looking for effective ways of tagging the adults with external flipper tags. I would also urge you that if you get funding to do more pit-tagging that you also consider pit-tagging the adults to allow you to evaluate tag retention and also more effective long-term tagging of your turtles.

**Mr. Ohmuta:** We're going to put 500 pit tags on adult sea turtles this year.

Hiroshi Takeshita
*Miyazaki Wildlife Research Group*

# The Current Status of Loggerhead Sea Turtle Rookeries in Miyazaki, Japan

## INTRODUCTION

This presentation is about the research and conservation activities occurring at loggerhead sea turtle rookeries of Miyazaki, Japan (Figure 1). Miyazaki Prefecture is located on the eastern Kyushu Island of Japan. The coast facing the Pacific stretches 400 kilometers. It has deeply indented coast lines with many vast sand beaches in the central region. Loggerhead turtles land and nest on these beaches (Figure 2).

I first encountered loggerhead turtles when I came to Miyazaki in 1971. At the time, I recognized that about 85 percent of them were taken by people to sell at market. I decided to try to protect them, but the authorities were indifferent about sea turtles in those days. I then began walking along the beach to count and make a record of turtle tracks. In 1973, some members joined my survey, and this was the beginning of the Miyazaki Wildlife Research Group.

## RESEARCH AND CONSERVATION ACTIVITIES

In the early days, we observed a loggerhead's behavior from landing until the end of egg-laying. Following nesting, we measured and tagged the turtle with a handmade number plate (see Figure 4). After the turtle returned to sea, we erased the footprints (tracks) so people wouldn't realize the landing and presence of eggs (to reduce poaching). Today our research group surveys nine main nesting beaches, gathered in the center of the prefecture (Figure 3). The beaches are bordered by rivers, harbors and an airport.

Beach surveys start May 20th and end August 10th every year. Between 1973 to 1979, the southern six sites (16km) were surveyed, however, since 1980 all nine sites have been surveyed (total 26km). In the first few years, surveys were done by foot, but in 1977, we began using cars. In 2001, we resumed walking, because cars were prohibited on the beach.

Beaches are walked in the early in the morning to count and record the footprints (turtle tracks) and nesting plots during the daytime survey.
In the night survey, the beach is walked from 9:00 p.m. to midnight to check for turtles and nests. If a turtle is encountered, we observe their behavior and record the nesting location and take measurements (the length of the shell, head and flippers). We began tagging turtles in 1977 with hand made number plates attached to the shell (Figure 4). However, we now tag turtles in the flipper with metal tags supplied by the Sea Turtle Association of Japan.

In 1978, one year after tagging in 1977, a loggerhead turtle was recaptured in the East China Sea. By 1984, 13 loggerheads with our tags were recaptured in this area (Figure 5). To date, we have tagged

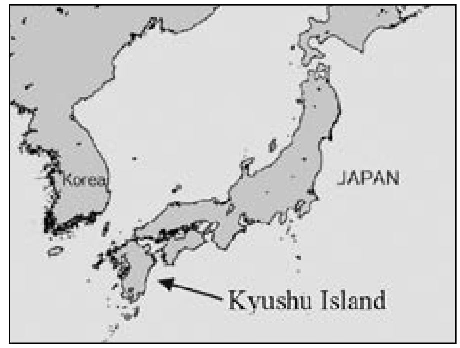



**FIGURE 1.** *Kyushu Island is the largest southern island of Japan.*


**FIGURE 2.** *The primary loggerhead rookeries on Miyazaki Island.*

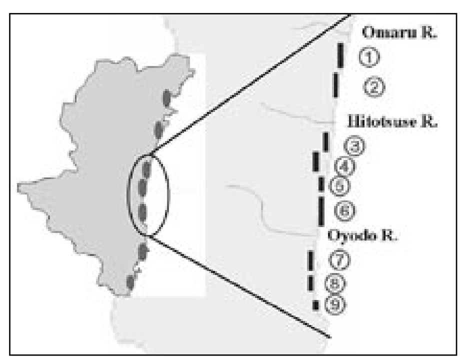



**FIGURE 3.** *Nine sites within the 26 km research area in the center of the Miyazaki Prefecture.*

FIGURE 4. *Handmade tag and tag location used in Miyazaki research in 1977.*


FIGURE 5. *Turtle recapture locations in the East China Sea (shaded area) between 1978 and 1984.*

1,460 loggerheads, and among these, 197 have been recaptured in the East China Sea.

When our survey started in 1973, our activities focused mainly on identifying nesting locations and on how to prevent egg collection. In 1976, there were 200 to 300 total landings per year. This increased in the mid-1980's, and by 1991, there were 1,274 landings. We thought this increase was the result of our protection efforts, but the number started to decrease thereafter. In 1997, there were only 400 landings with less that 300 turtles nesting (the difference between the landing and nesting number indicates loggerheads returning to the sea without laying eggs). Since 2000, however, the landing number has started to increase, and the count exceeded 1,200 in 2004 (Figure 6).

## NESTING BEACH IMPACTS

The Miyazaki Wildlife Research Group has worked to reduce the poaching of nest and harvest of eggs to be sold at market. Some superstitions suggest that turtle eggs promote longevity or are revitalizers (i.e., aphrodisiacs). Therefore, we analyzed the nutrition content of turtle eggs (Yamaguchi et al. 1984). Our study revealed that turtle eggs are no more nutritious than chicken eggs, and this information was provided to the public through newspapers. As a result, egg harvest was dramatically reduced. Next, we proposed the local government to authorize Miyazaki a national treasure, and advertised our survey and protection efforts to the public to gain support. This reduced poaching activities even more and egg harvest has not been a problem since 1985. This protection has prevailed also in other areas of Miyazaki.

Erosion, however, continues to be a serious problem at Miyazaki. The beaches of Miyazaki used to be 20 to 100 meters wide, with mild slope, and bordered with natural vegetation. It stretched 16 kilometers from the south to north, and was one of the main loggerhead rookeries in Japan. In 1981, construction started for a large port in Miyazaki City to harbor ships as large as 20,000 tons. To protect the port from waves, a groin of one kilometer was also constructed from the coast out into the sea. There is now a yacht harbor with breakwaters and artificial beach. Also, in 1982, construction began to expand the airport out into the sea. This combined construction has caused dramatic changes in the water and ocean current conditions that have lead to erosion of beaches on both sides of the construction zone (Figure 7).

To control this erosion problem, the local government constructed detached breakwaters offshore of Sumiyoshi Beach. However, this is also not good for sea turtle nesting activities. Erosion has seriously degraded the beach, and the excellent breeding habitat for loggerheads is now threatened (Figure 8). It is even dangerous for people to walk along the beach.

Unfortunately, human-induced impacts are not the only threats. In 2004, the beach suffered from three severe typhoons and many turtle eggs were lost. Currently, the Miyazaki Wildlife Research Group, along with the Sea Turtle Association of Japan are investigating options to protect sea turtles, such as transplanting eggs to safer beaches to protect them from erosion and typhoons, and making arrangements to use artificial beaches in hopes of imprinting hatchlings to new, hopefully more stable, nesting beaches.

## REFERENCES

Yamaguchi, K.,H. Takeshita, T. Deguchi, C. Haan, S. Haga, and T. Ohashi (1984) Some Chemical Compositions of Turtle Eggs (Carreta caretta). Bulletin of the Faculty of Agriculture, Univ., 31(2):155-159.

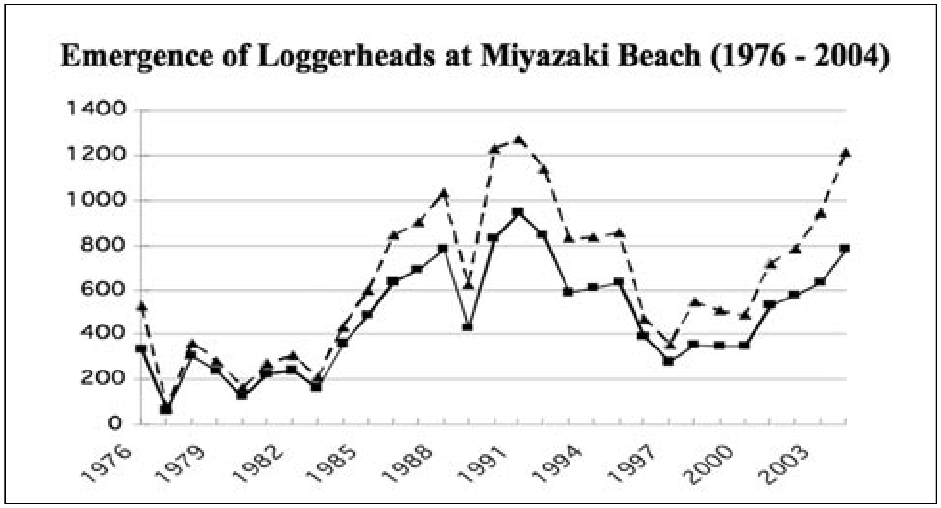
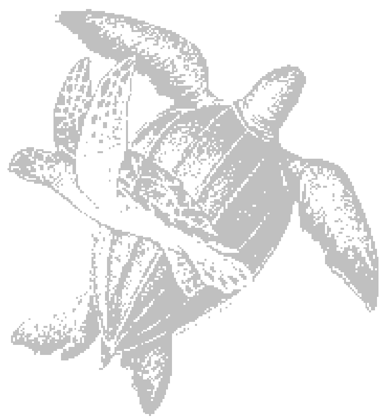



**FIGURE 6.** *Numbers of loggerhead landings (dashed line) and nests (solid line) in Miyazaki Beach. The research area has not been changed since 1985.*

**FIGURE 7.** *Beach erosion at Miyazaki Beach. The picture on the left was taken in 1973 and the picture on the right in 2003.*

**FIGURE 8.** *Breakwater and beach construction impeding nesting activities.*



**George Balazs**
*NOAA Fisheries,*
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# Pelagic Research of Pacific Loggerhead Sea Turtles
## in Partnership with Japan and Taiwan

## INTRODUCTION

The following is a joint presentation by Dr. Jeffrey Polovina and I covering important pelagic loggerhead sea turtle research that we have undertaken over the past five years in collaboration with our Asian colleagues, Dr. Naoki Kamezaki of the Sea Turtle Association of Japan and Dr. I-Jium Cheng of the National Taiwan Ocean University. I would like to emphasize the point of partnership that built the foundation for the research results to be presented by Dr. Polovina. Without partnerships, little can be accomplished with a species that spans such vast areas of the North Pacific – nations and cultures.

## COASTAL POND NETS OF JAPAN

In July 2004, I traveled to Muroto Point, Japan in the company of Dr. Kamezaki to learn more about the coastal pond net fishery in which loggerheads are sometimes taken as bycatch. Pond nets are a non-entangling type of fishery and are common along the coast of Japan. For years, I've been trying to understand what a pond net is and how it works since this type of fishing gear (also known as trap nets) is very common throughout coastal Asia. Dr. Cheng in Taiwan calls them, in his publication, "set nets". To me, a set net is something that fish and turtles swim into and become entangled. Nothing could be farther from the truth for a pond net; it's just a matter of translation from Chinese into English that has resulted in some confusion.

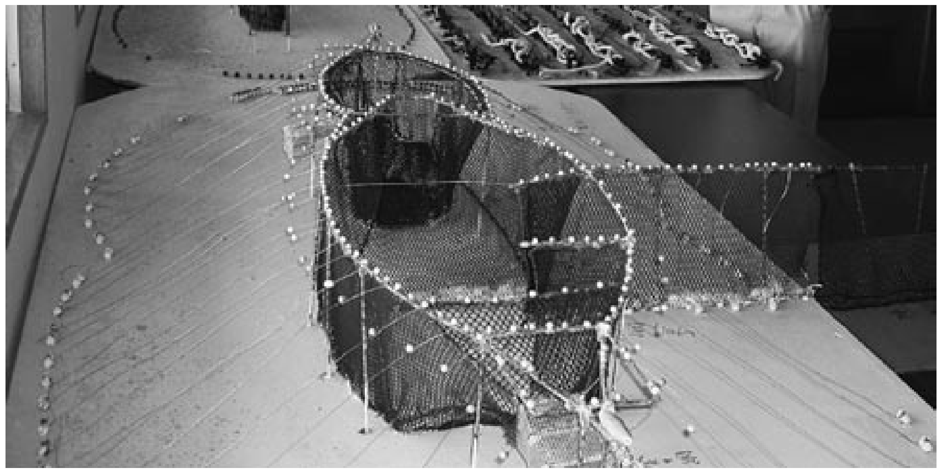


**FIGURE 1.** *Miniature model of a pond net. In reality, each sand bag which anchors the net weighs about two tons.*

A pond net is something like the "pound nets" used in Chesapeake Bay, USA. But a pond net is set out over very deep water, and can be very large. The pond net fishery I visited at Muroto Point is a huge operation that sometimes entraps a turtle, but rarely entangles and drowns the turtle. We have been fortunate in our collaborations to have satellite tags put on these accidentally caught turtles. I was impressed with the immensity of the operation, the amount of net and the amount of gear and finances necessary for construction and maintenance. These nets are used primarily to collect pelagic fish. This is a massive operation and very efficient fish catchers.

**FIGURE 2.** *Top view of miniature pond net. Dr. Kamezaki is "caught" in the entrance to the net, in the deep end which is set in about 90 meters of water.*

In a pond net (as depicted in Figure 2), fish enter in the deep end and swim progressively towards the other end of the net in a step-wise fashion that brings them up shallower and shallower. At the end there's a guide where the fish collect themselves, but are incapable of swimming out. For perspective, each one of the sandbag anchors shown in Figure 2 weighs two tons.


**FIGURE 3.** *The process of collecting fish out of a pond net (A to D).*

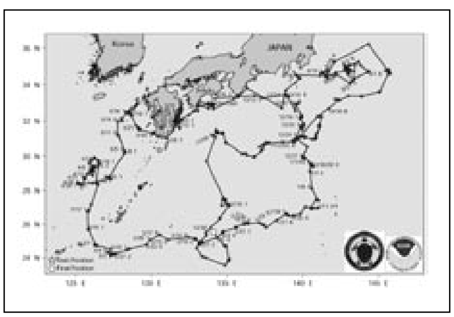



**FIGURE 4.** *Movement of coastal pond net by-catch male loggerhead turtle (#22168) in 2002-2003, at liberty 386 days, traveling a distance of 11,333 km.*

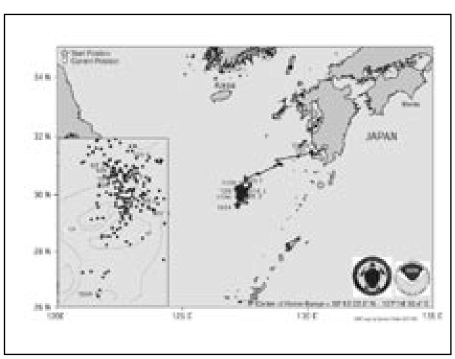



**FIGURE 5.** *Post-nesting tracking of loggerhead turtle (#4805) in 2004-2005, at liberty 219 days.*

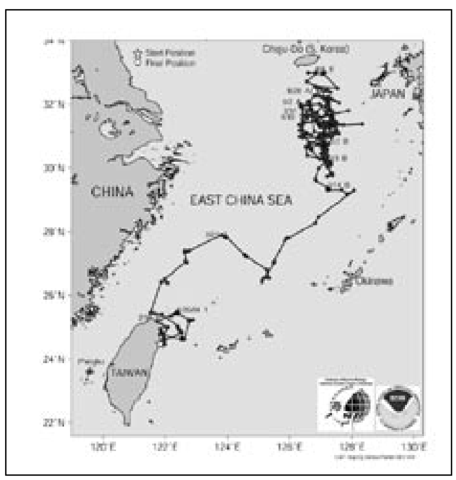



**FIGURE 6.** *Movement of coastal pond net bycatch loggerhead #19599 in 2004, at liberty 225 days traveling 4,456 km.*

Fish are captured by up to ten small boats involving 30 to 35 men that collect the fish by progressively bringing the trap section of the net closer together (Figure 3). The netting does not normally entangle the fish or turtles, and fish are thus scooped out of the pond net (or trap). Any non-target species can easily be released unharmed. Pond nets are set out all the time, day and night. When the typhoons come, they simply take the floats off and sink the net, and then raise it again after the typhoon passes.

## SATELLITE TELEMETRY RESEARCH – JAPAN

From these pond nets come many of our live loggerhead turtle subjects for satellite telemetry research. A turtle that is caught in a pond net is brought ashore, given a scrubbing, fitted with satellite tag, and then released. It is important to note that turtle #22168 (Figure 4) has bounced in and out from coastal habitat, but spent the greatest portion of its time in pelagic habitat, as do many other satellite-tracked turtles in our study.

The map of Figure 5 represents an interesting result of our collaboration, also with the Sea Turtle Association of Japan. I had the honor of visiting a loggerhead nesting beach at Fukiage Beach in Kagoshima, Japan. A satellite tag was put on a loggerhead turtle after she finished her nesting and swam into an offshore ocean area. In Hawaii we say, “where there’s one, there’s two or many more.” The turtle has told us, I believe, that this is an offshore “hotspot” that is important for post-nesting turtles. Further investigation at this site is recommended.

## SATELLITE TELEMETRY RESEARCH – TAIWAN

To understand the migratory movements of North Pacific loggerheads, we work in collaboration with Dr. Cheng on the Pacific coast of Taiwan. In our project, all data are shared, and partnerships are acknowledged. As it turns out, the Taiwanese have similar pond nets, only smaller and closer

**FIGURE 7.** *George Balazs with juvenile loggerhead turtles.*

**FIGURE 8.** *Juvenile loggerheads eager to be released.*

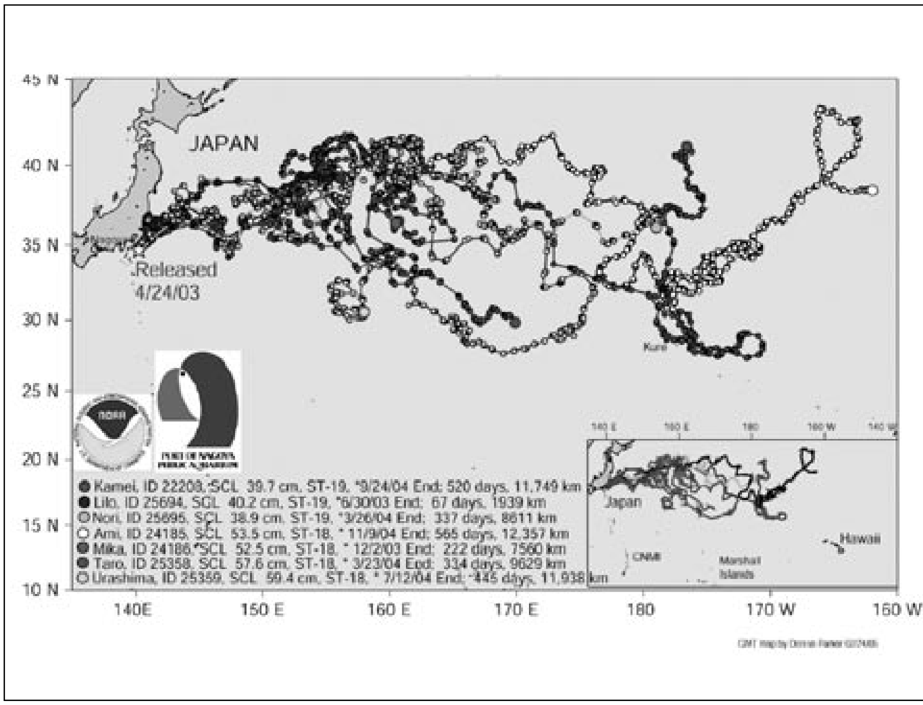



**FIGURE 9.** *Satellite tracks of seven juvenile loggerheads released at sea from the M/V Kitakami off Tokyo, Japan.*

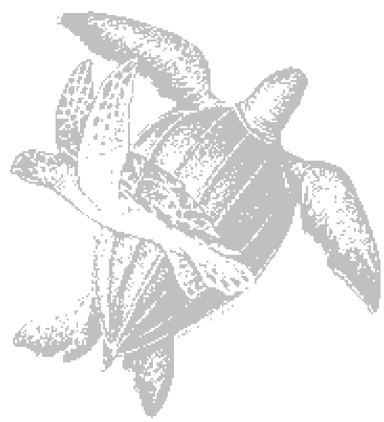
to shore compared to Muroto Point, Japan. From these nets, loggerheads are also captured for satellite telemetry studies (Figure 6). Again, many of these turtles are showing us an important pelagic habitat in the East China Sea.

## SATELLITE TELEMETRY RESEARCH – PELAGIC RELEASE

Another collaborative project that has proven to be very valuable is in Japan in association with the Port of Nagoya Public Aquarium. In this project, captive-reared loggerhead turtles are released from a passenger ship about 40 kilometers off Tokyo in the Kuroshio Extension Current. These turtles are raised up to one, two and three years of age and fitted with satellite transmitters to help our research team better understand the pelagic habitats used by juvenile loggerheads (Figure 7). A cargo company that sails from Nagoya to Sendai to Hokkaido has been extremely cooperative in assisting this project. Two 300-meter vessels that carry 200 passengers and all sorts of cargo are used to release turtles at sea.

The release point is the Kuroshio Current, and it can be a very exciting event. Turtles are put in baskets a few at a time and the baskets are lowered over the ship's side (Figure 8). A meter above the surface of the water, each basket is flipped and into the ocean the turtles go. These juveniles swim towards the International Date Line and the vicinity north of the Hawaiian Islands (Figure 9).

This presentation is followed by Dr. Polovina who will describe some of the oceanographic research results associated with the migratory and foraging movements of these juvenile loggerheads in pelagic habitats in the North Pacific.



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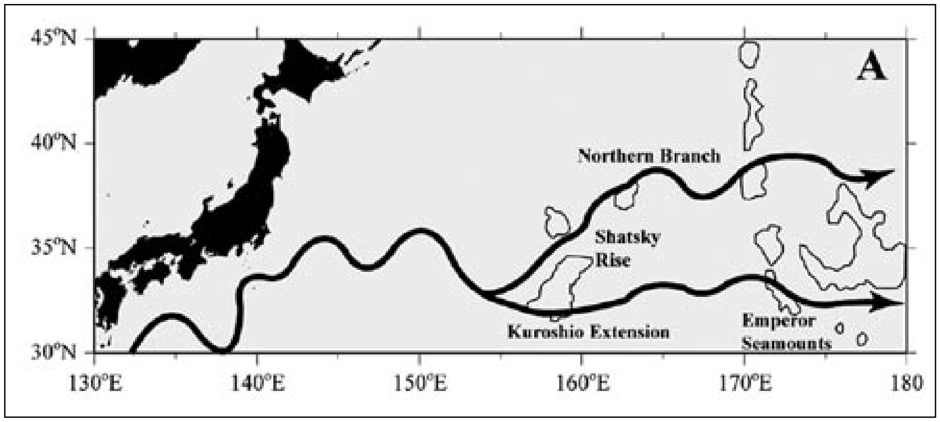
# The Kuroshio Extension Current Bifurcation Region: A Pelagic Hotspot for Juvenile Loggerhead Sea Turtles




*Schematic of the Kuroshio Extension Bifurcation Region (KECBR).*

This presentation summarizes the release of 43 juvenile loggerhead sea turtles (*Caretta caretta*) in the western North Pacific off of Japan together with satellite-remotely sensed oceanographic data identified the Kuroshio Extension Current Bifurcation Region (KECBR) as a forage hotspot for these turtles.

The loggerhead turtle is a threatened and declining species in the North Pacific where its ecology and life history are not well known. Juvenile loggerheads are known to use pelagic habitat, and some members of the population make trans-Pacific migrations from the Japanese nesting beaches to coastal habitat off Baja, Mexico. In previous studies, satellite telemetry of 26 loggerheads in the central North Pacific has shown that juvenile loggerheads caught and released from longline fishing gear appear to be long-term residents in the oceanic North Pacific. They often travel westward from the central North Pacific toward the dateline, and travel seasonally north and south between 28º and 40º N latitude, and they forage almost exclusively in the top 50 m (Polovina et al., 2004; Polovina et al., 2003). Their most common prey are *Janthina* spp., *Carinara cithara*, *Vella vella*, *Lepas* spp., *Planes* spp., and *pyrosomas* (Parker et al., 2005).

One feature in the central North Pacific that appears to represent an important loggerhead forage and migration habitat is the Transition Zone Chlorophyll Front (TZCF) (Polovina et al., 2004). The TZCF is identified from satellite-remotely sensed surface chlorophyll data as a basin-wide surface chlorophyll front. This front represents a boundary between vertically stratified warm, low-chlorophyll subtropical waters on the south and vertically mixed, cool high chlorophyll waters on the north (Polovina et al., 2004; Polovina et al., 2001).

Previous satellite telemetry work with loggerheads has focused on describing juvenile loggerhead forage and migration habitat primarily to the east of the international date line in the central North Pacific. However, the Kuroshio Extension Current (KEC) lies west of the date line and is the dominant physical and biological habitat in the North Pacific, recognized for its high eddy kinetic energy and high phytoplankton and zooplankton productivity (Komatsu et al., 2002; Kimura et al., 2000; Qiu, 2001).

In this study, one group of turtles were composed of 37, 1-3-year-old loggerheads reared at the Port of Nagoya Public Aquarium and released off the coast of Japan on three dates: April 2003, November 2003, and April 2004. The second group was composed of six juvenile loggerheads, caught and released between 2000 and 2003 from longline gear in the central North Pacific. All 43 turtles traveled west of the dateline into the KEC region. Satellite oceanographic data was used, especially sea surface height (SSH) from altimetry, and surface chlorophyll from ocean color data to describe the mesoscale habitats the turtles used.

Results indicated that in the KECBR, juvenile loggerheads resided in Kuroshio Extension Current (KEC) meanders and the associated anti-cyclonic (warm core) and cyclonic (cold core) eddies during the fall, winter, and spring when the KEC water contained high surface chlorophyll. Turtles often remained at a specific feature for several months. However, in the summer when the KEC waters became vertically stratified and surface chlorophyll levels were low, the turtles moved north up to 600 km from the main axis of KEC to the Transition Zone Chlorophyll Front (TZCF).

In some instances, the loggerheads swam against geostrophic currents, and seasonally all turtles moved north and south across the strong zonal flow. Loggerhead turtles traveling westward in the KECBR had their directed westward movement reduced 50% by the opposing current, while those traveling eastward exhibited an increase in directed zonal movement. It appears, therefore, that these relatively weak-swimming juvenile loggerheads are not passive drifters in a major ocean current, but are able to move east, west, north, and south through this very energetic and complex habitat.

It has long been assumed that juvenile loggerheads use the North Pacific oceanic regions largely as a pathway to reach coastal nursery habitat off Baja, Mexico. These research results showed that the KEBR is an important habitat for juvenile loggerheads migrating both from Japan and from oceanic habitat in the central and eastern North Pacific. Furthermore, juvenile loggerheads do not just transit through pelagic habitat, but spend years inhabiting the open ocean and in particular the KEBR. It may be that a significant number of juvenile loggerheads use pelagic habitat and particularly the KEBR for their entire juvenile phase and never travel to the coast of the eastern North Pacific. On the other hand, transmitted turtles from Baja don't show a lot of movement out of Baja. That habitat appears to have very different dynamics. However, since the juvenile phase in loggerheads lasts a decade or more, answering this question is beyond the scope of present satellite telemetry techniques.

It is well known that the KEBR is an important pelagic fishing ground for fleets from many nations. However, interactions between fishing gear and loggerheads in the KEBR are not well documented. Given newly discovered importance of this region for loggerheads, the documenting of interactions between loggerheads and fishing gear in this area is an important conservation priority. Further, interannual and decadal changes in productivity of the dynamic KEBR are likely substantial and may be important to the population dynamics of this species.

In summary, these results indicate that oceanic regions, specifically the KECBR, represent an important juvenile forage habitat for this threatened species. Interannual and decadal changes in productivity of the KECBR may have a big impact on growth and survival of juvenile loggerheads and their population dynamics. Further, conservation efforts should focus on identifying and reducing threats to the survival of loggerhead turtles in the KECBR. In the future, we have plans to develop a spatial movement model that we can drive with remotely sensed data to try to capture all of the dynamics across the North Pacific to try to describe the whole juvenile loggerhead population movement.

## REFERENCES


Komatsu, T, T.Sugimoto, K.Isida, P. Mishra, and T.Miura. 2002. Importance of the Shasky Rise area in the Kuroshio Extension as an offshore nursery ground for Japanese anchovy (*Engraulis japonicus*) and sardine (*Sardinops melanostictus*). *Fisheries Oceanography 11*(6): 354-360.

Kimura, S., H. Nakata, and Y. Okazaki. 2000. Biological production in meso-scale eddies caused by frontal disturbances of the Kuroshio Extension. *ICES Journal of Marine Science 57*:133-142.

Parker, D. M., W. J. Cooke, G. H. Balazs. 2005. Diet of oceanic loggerhead sea turtles (*Caretta caretta*) in the central North Pacific. *Fishery Bulletin 103*: 142-152.

Polovina, J. J., G. H. Balazs, E. A Howell, D. M. Parker, M. P. Seki, and P. H. Dutton. 2004. Forage and migration habitat of loggerhead (*Caretta caretta*) and olive ridley (*Lepidochelys olivacea*) sea turtles in the central North Pacific Ocean. *Fisheries Oceanography* 13*(*1*)*: 36-51.

Polovina, J. J, E. A Howell, D. M. Parker, and G. H. Balazs. 2003. Dive-depth distribution of loggerhead (*Carretta carretta*) and olive ridley (*Lepidochelys olivacea*) sea turtles in the central North Pacific Ocean: Might deep longline sets catch fewer turtles? *Fishery Bulletin* 101*(*1*)*:189-193.

Polovina, J.J., E. Howell, D.R.Kobayashi, and M.P.Seki. 2001. The Transition Zone chlorophyll front, a dynamic global feature defining migration and forage habitat for marine resources. *Progress in Oceanography (*49*)*1-4:469-483.

Qiu, B. 2001. Kuroshio and Oyashio Currents. In: Encyclopedia of Ocean Science, Academic Press. pp. 1413-1425.

## QUESTIONS

**Dr. Swimmer:** I'm curious as to what the target species is in the pound net fisheries.

**Mr. Balazs:** Many species.

**Ms. Fahy:** I think it's pretty amazing that we have so few tracks that go from the Northern Pacific down to Baja; yet we have a lot of information on the size of those animals. Do you have any idea, comparing the size of turtles taken in the longline fisheries and those seen in Baja, when they would start to move down to Baja, and why perhaps we haven't been able to track them? Where are they, and when are they going down to Baja, or what age?

**Dr. Polovina:** That's a great question. We have looked at sizes, but maybe Hoyt or George wants to respond.

**Mr. Peckham:** All the collections that Jay made over the past ten years of turtles stranded and carcasses found in dumps, and captured turtles, the size of these almost completely overlap. The averages of the turtles caught in the North Pacific longline fishery is around 61 or 62 centimeters. And off Baja, the average is about the same, but actually getting higher, which is a point of concern.

**Dr. Nichols:** I just have a quick question for both of you, or anybody who has any ideas may answer. Thinking back to the map, there are some areas we don't know much about, the Kurishio extension, and then some other areas that we know more about. Can you speculate as to disbursal of hatchlings?

**Mr. Balazs:** In the one case, one, two and three years old, the smallest we could get the new tags on is about 28 centimeters, and that's the ones we showed.

**Dr. Nichols:** So I'm thinking, the time between hatching and 28 centimeters is probably a couple of years. Something is happening in there. And maybe Jeff could speculate on, where are those animals being pushed to?

**Dr. Polovina:** Yes. I think, if they do get out to the Kurishio extension, the system would start to carry them out there even earlier.

**Dr. Nichols:** And, then, over the course of two years, assuming a hatchling is completely subject to the current, rather than these older turtles that are apparently able to do their own thing, for the most part, where would a hatchling end up after two years of riding the current?

**Dr. Polovina:** Well, if it were just a passive particle, this is the perfect region for it to end up. That is a region, where, for example, when there's large populations of sardines or anchovies, the juveniles get advected. The larvae of sardines and anchovy are out in this region. This is a very -- really dynamic sort of habitat for a lot of organisms, albacore tuna, blue fin tuna. The amazing thing is that you get these small animals, the ones that George and his colleagues released were one-year-olds to three-year-olds. So those seem to be able to move actively through this region, north and south. They weren't just swept through this region. So even as a one-year-old, they are actively swimming, actively migrating, it seems.

**Mr. Balazs:** And it's entirely possible – we bought this paradigm for years; that hatchlings are just passive drifters. But I would question that. I would say that if the 25-centimeter ones can be moving around like that, on their own scale, that those hatchlings or post hatchlings, six months old, or whatever, could be negotiating similar habitat. There may be some threshold there or gradation of it. The other thing that I wanted to point out, although we didn't present that data here, we have put SDR satellite dive recorders on some of those animals that were captive-reared. And it's astonishing to see within the first day after release, dives down to 80, 90 meters, even though they had never been in water over 2 meters deep in their life. The thesis that captive-reared animals are somehow messed up does not seem to bear any reality to the loggerhead turtles from Japan.

**Dr. Limpus:** I urge you to go back and reread Ken Loman's papers on the behavior of post hatchling loggerheads, or small loggerheads, in the experimental situation of being exposed to magnetic fields in the North Atlantic. He certainly demonstrated these animals are not just inert things out there; they are actually directing their swimming in response to where they are in the jar. And, I guess, I'd respond to your initial question that, while the current may take them in one direction and there may be eddies that perhaps would tend to hold them in an area, Ken's work would say to me, if they have a target that is part of their inherited biology, they can direct their swimming to go in that direction. So go back and look at Ken's stuff, and see if it has some bearing here to what you are trying to resolve.

**Mr. Balazs:** I'll just summarize so that nobody misunderstands. There's no denying that Baja is important habitat for the North Pacific loggerhead. I think what we're beginning to feel from this data, or see from this data, that there are other places that may even be more important, but there's no denying that the loggerheads get all the way over to Baja. We all know that from the genetics, they proved that some years ago. It's a question of where is the major nursery growing area for these animals. And it certainly looks like in this case they're going back and forth out there in the middle of no man's land, but an important fishery area to fisherman. So, again, elevating a conservation concern generated by a collaboration of partnerships around the Pacific.

Dr. Yonat Swimmer and
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# Sea Turtle Bycatch Reduction: An Update on Sensory Experiments and Field Trials

## INTRODUCTION

The following presentation is about the work the National Marine Fisheries Service (NMFS) is doing in regards to loggerhead sea turtle bycatch reduction in longline fisheries. This is an update of the sensory experiments using captive animals and the field trials testing mitigation methods in various locations. This is all a collaborative and very much an international group effort. It is my belief that this is the surest way to arrive at practical solutions that can be applied to fisheries worldwide.

Our work focuses on three general areas: 1) track turtles using satellite telemetry after their release from fishing gear to better understand mortality due to longline fisheries interactions, 2) conduct and coordinate sensory and mechanical experiments to reduce hooking of turtles in longline gear, and 3) conduct field trials to test possible mitigation measures in actual fisheries.

## SATELLITE TELEMETRY RESEARCH

We have selected to work with pop-up satellite archival tags to determine survivorship after their release from fishing gear (Figure 1). This is the best tag to use when specifically addressing post-release survivorship/mortality. It also

**FIGURE 1.** *Turtle outfitted with popup satellite archival tag.*

has the potential to provide highly valuable information such as turtles' geolocations, which will help identify potential migratory corridors, turtles' dive depths, as well as the water temperature occupied by the turtle. Primarily the tag is designed to determine if the turtle does indeed die after being released from the gear. Tags are deployed by fishery observers in Hawaii as well as in the California-based swordfish fishery. All are fishing in the cold waters of the North Pacific Ocean.

To date, tagging efforts have been hampered by a number of different legal reasons, but, in general, we have been up and running and trying to get turtles tagged since 2002. The Hawaii swordfish fishery was shut down for a couple years which reduced tagging opportunities. The swordfish fishery is now open, with a requirement of 100-percent observer coverage, and therefore the opportunity exists to tag every single turtle that is encountered. Thus far (at the time of the workshop March 2005), observers have tagged eight within the last month encountered in the swordfish fishery and 13 from the California-based fishery. Most of the turtles have been tagged by California-based observers that were on boat fishing in the same general area these past couple of years. A preliminary look at the data indicates that the tags are lasting an average of almost five months. These are animals that were deeply hooked whereby they had actually swallowed the hooks. There were a few duds, meaning tags we never heard from after their deployment. However, based on the design of the tag, we believe these are not suggestive of mortality.

Of the 13 tags, there has been one observed mortality six months after the initial interaction. There could have been subsequent interactions or a number of other factors that could have led to its mortality, or maybe simply a natural mortality. However, based on just a handful of tags, at this point, our data suggests that there is high survivorship within the first six months after their release from fishing gear (Table 1).

In terms of turtles' movements, all turtles headed due west post-release. Our data show the same information that Jeff has found; that, indeed, they are staying within this nutrient rich boundary layer, the same, very shallow, cold water.

| Table 1. Summary of PSAT Tagging Efforts from 2002 to Current (i.e., hundreds of trips observed) | |
|---|---|
| Hawaii Swordfish fishery | 8 tags deployed within Feb/March |
| California Swordfish fishery | 13 tags deployed |
| Results | • Mouth-Hooked: avg # days tracked = 136 (n=8)<br>• Flipper Hooked: avg # days tracked= 55 (n=1)<br>• 1 observed mortality 6 months post-release |

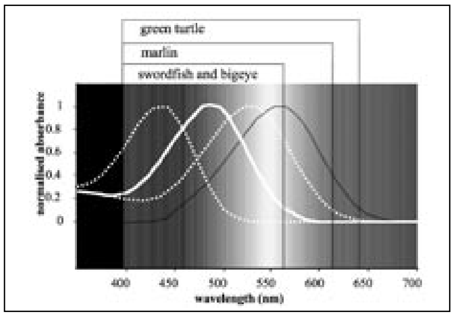


**FIGURE 2.** *Profile of color sensitivities of pelagic fish and green turtle (source: Levonson and Eckert, 2006; Fritsches et al., 2005).*

## SENSORY RESEARCH

### Visual Sensory Mechanisms

The other aspect that we're working on is to understand the sensory mechanisms that marine animals use that attract them to fishing gear. A few years ago, my colleague and mentor Rich Brill and I set about to identify research needs in the field of sensory biology that would provide information on how pelagic fish and sea turtles sense their environment. Specifically, we were interested to identifying cues that were responsible for attracting them to fishing gear - was it visual, acoustic? The idea here is to understand what attracts turtles, and if there are differences to how fish and turtles are attracted to gear, then such information could be applied to designing a modification that would allow fishers to catch fish and not turtles.

A suite of laboratory studies were conducted primarily with captive turtles in Galveston, Texas to test behavioral and physiological responses to various sensory stimuli, and similar studies were conducted with pelagic fish. The aim of these studies was to generate field-testable ideas that we could then try in the open ocean. The ultimate goal of these first two steps would be to provide information to fisheries managers so that after extensive testing, effective mitigation measures could be implemented into the proper regulations.

Our first experiments focused on understanding the visual capabilities in sea turtles. Scott Eckert and Dave Levonson (2006) looked at color vision in green, loggerhead and leatherback turtles, while Karen Fritsches (2005) investigated color vision in pelagic fish. The graph in Figure 2 represents a theoretical profile on the color sensitivities of a number of species interacting with fishing gear. While tuna and swordfish have rather limited vision – only shades of blue/green, marlin and green turtles can see across the visible spectrum, well into the red. Given this greater color sensitivity in turtles, a visual repellent would have to incorporate more than just color, such as differences in the speed of vision between fish and turtles.

Abilities and limits of detecting colors were another focus of our research. Based on the visual pigment of fish and green turtles, limits of vision can be estimated: turtles will see further that any of the fish into the red. However, red is not a good color in water since it gets absorbed quickly. Colors and light intensities vary drastically in different depth, whereby water acts as a color filter with red and yellow being filtered out first, then green until only blue, violet and some UV remain. Water also dims the light and, even in clear ocean water on a sunny day, the light levels at 600m are equivalent to starlight. In terms of anatomical differences, the team compared the eye design of fish and sea turtles to investigate their ability to detect light. Compared to fish, sea turtles have a small lens (=small aperture) and relatively long focal length which means the eye is much more insensitive to light than that of a tuna and other fish (ie. needs more light to operate properly). A way of quantifying their ability to detect light is to calculate their optical sensitivity. What was discovered was that fish are more sensitive to light than turtles while turtles are more sensitive than humans (when considering their optics and eye design).

In general, fish and turtle species that occupy different parts of the water column prove to be highly adapted to live in their own niches in the open water. Not just having different vertical partitioning, some remaining shallow during the day, such as turtles and some fish, and bigeye and swordfish are deeper at night. They also have clear anatomical differences. The sea turtle eye is not well adapted to life in dim light - it has a very lengthy focal length and a very small lens, therefore it takes a lot of light to get back into the back of the eye. Bigeye, as an example, is a fish that is able to capture even the most remote light available. And it needs that because it's staying much deeper. The team also looked at their visual resolution in time - an indication for example of how good they are to detect fast movements. There was good correlation with diving depth and temporal resolution, with deep divers being slow and shallow divers being fast. The turtle was relatively fast (i.e., has good ability for motion detection). Resolution in time is dependent on the brightness of light available in the animal's habitat, so deep divers living in dim light need slow temporal resolution (e.g., slow shutter speed) to see anything at all.

## Chemosensory Capabilities

Another area of investigation is turtles' chemosensory capabilities. The easiest mitigation method to try to regulate would be an olfactory deterrent. The idea here is that if there is some repellant, or innate repellant, that would cause sea turtles to flee, this could be incorporated into the bait. Amanda Southwood has taken the lead in understanding behavioral responses to olfactory cues, especially as it relates to the fishery issue. Do turtles smell an approaching tiger shark and do they have a flight response? Amanda and Ben Higgins set up a behavioral choice tank and confirmed that indeed turtles smell, but are still working on an effective repellent to test in the field (Southwood et al., in press).

Lastly, our collaborators in Brazil have worked to set up floating pens to house turtles that have been brought in after their capture from fishing gear. In addition to monitoring their long-term health post-interaction, they have also been able to test turtles' feeding response to foods marinated in various chemicals with the aim of identifying repellent compounds.

Some really exciting work has been done by Kristen Fritsches at the University of Queensland and Ken Lohmann at the University of North Carolina where they are working to link turtles' physiological capacities with their behavioral responses. Dr. Fritsches has investigated the critical flicker fusion frequency, which is the point at which you no longer see a flickering light, but it becomes continuous (Fritsches et al., 2005). The results suggest that the green turtle and a few fish species they studied had different critical flicker fusion frequencies, suggesting that a blinking light could appear as such to a turtle, but not to a fish, which would see a continuous light. The idea behind some of the sensory work that's currently been in development is the development of a flickering LED light stick that would attract fish and not turtles.

Dr. Lohmann has done behavioral studies with captive juvenile loggerheads monitoring their orientation to activated and unactivated light sticks. His work has shown that turtles are attracted to light sticks of any color once they have become activated, it doesn't matter what color, they are all attractive to a turtle. But when you use an over-the-counter flashing blue LED, the turtles are not significantly oriented towards it. The idea is to find out what is a frequency profile that would attract fish and potentially not be of interest to turtles. Ken Loman's work also looked at the potential to use shaded light sticks. This is part of the idea that turtles, while remaining very shallow, are above the fishing gear. This suggests that shading the light sticks could make then invisible and thus less attractive from above.

What I've just discussed are examples of the type of research that's currently ongoing on how we're generating field testable experiments in the lab. Some of these ideas have already been taken into the field, and for the rest of the talk I'll discuss work that we've done with our colleagues in Costa Rica and Brazil to test sensory techniques as well as gear modifications, such as differences in hook type. Much of the groundwork for the gear modification studies was laid by John Watson and others in the Pascagoula and Miami Labs of the NMFS[1].

## FISHERY EXPERIMENTS IN COSTA RICA AND BRAZIL

In Costa Rica (CR) and Brazil, we have investigated rates of turtle capture between blue dyed and untreated bait, and in Costa Rica, we have investigated the effects of a 10 degree offset circle hook, and in Brazil, we have investigated the relationship between J vs. Circle hooks with regard to turtle capture.

Work for testing a turtle bycatch mitigation method in CR was conducted in collaboration with PRETOMA and our fisheries agency. CR was an ideal location to conduct such a study due to the unfortunate (for turtles), but fortunate (for statistical purposes) fact that turtle Catch Per Unit Effort (CPUE) is eight, meaning that eight turtles are generally caught per 1,000 hooks set. Nearly all of these turtles are olive ridleys (few greens) and nearly all are released alive.

The first experiments were conducted with blue-dyed bait vs. untreated bait in the mahi mahi fishery during December 2003. In an effort to reduce the number of confounding variables, the test was conducted such that two boats were fishing in the same general area at the same time. Eleven sets were conducted for each boat, and the treatment days were randomly alternated. In an effort to make sure that baits on a set were not

[1] Web site to access experimental results: http://www.sefsc.noaa.gov/seaturtlecontractreports.jsp

contaminated by a treatment, the bait types were not mixed on a set. Rather, squid baits were either all dyed blue or untreated along an entire set. The hook used was the circle 13/0, which is the most commonly used hook in this fishery.

A quick analysis of the data revealed no effect of blue bait on turtle bycatch, nor were there differences between the two boats in the experiment. Similar findings were found in the NED (Watson et al., 2002) and in a study in Japan and reported by Nakano et al. (2004). The results from this blue-dyed bait study has just been accepted for publication in Marine Ecology Progress Series, so you can read more about the details in our methodology and results in the coming months.

A second experiment in this fishery was completed last week [February 2005] where we evaluated the impact of a 10 deg offset on 14/0 circle hooks with regard to turtle capture rates. Only 9 sets were conducted before they had to come in due to an unusually large volume of fish caught. From what I've heard from the field, 20 turtles were caught, 9 on one hook type, 11 on the other, suggesting no apparent effect of this slight offset. Additionally, the lack of an offset did not negatively impact capture of mahi mahi.

## COLLABORATIONS IN BRAZIL

Last winter, researchers with Projeto TAMAR worked closely with the federal fisheries agency to rig their boat to enable longline fishing on board their research vessel. Only 4 sets of 300 hooks/set were made due to unusually rough seas. During this time, one leatherback was foul-hooked and later released. However, based on the previous work with blue-dyed bait showing no effect on turtle capture rates, we do not believe it's worthwhile to pursue this experiment further.

More recently, Brazil has experimented with comparing turtle and fish CPUE between their traditional 9/0 J hook vs. a large 18/0 circle hook. 17 sets were conducted off the southeast coast of Brazil where incidental capture of both loggerhead and leatherback is known to be high. Capture rate of turtles was clearly higher on J vs. circle hooks, however, due to the relatively small sample size, it's too early to conclude with more statistical scrutiny that the effect was due only to the hook type. More research will be conducted to explore the effectiveness of large circle hooks on turtle capture rates in this area in the near future.

## CONCLUSION

To date, the only sensory idea that we've taken out into the field is the blue bait. However, many new ideas are being generated in the lab. The lab experiments are not only generating applied technology to protect these animals in the longline fishery, but have supplied essential information about how animal are functioning in their environment. What we've gleaned thus far has been critical in improving our knowledge on the basic biology of a number of sea turtle and pelagic fish species, as well as shedding light on the development of critical conservation measures.

Ideas that are closest to testing include a blinking light stick, changes in float color, as well as more basic gear modifications of hook dimensions and shape. Lastly, I'd like to emphasize that the collaborative approach has been very fruitful for us and we are likely to continue on this road.

## REFERENCES

Fritsches K. A., Richard W. Brill, and Eric J. Warrant. 2005. Warm Eyes Provide Superior Vision in Swordfishes. Current Biology, Vol. 15: 55–58.

Levonson, D and S. Eckert. 2006. Spectral sensitivities of leatherback sea turtles. In: Swimmer, Y. and R. Brill, eds. Sea Turtle and Pelagic Fish Sensory Biology: Developing Techniques to Reduce Sea Turtle Bycatch in Longline Fisheries. NOAA Technical Memorandum NMFS-PIFSC-6. April 2006. 121 p.

Nakano et al. (2004). Research on the Mitigation and Conservation of Sea Turtles by the Fisheries Research Agency. National Research Inst. Of Far Seas Fisheries, Japan. Japan Fishery Research Agency . Shimizu, Shizuoka, Japan. Presented at the 2nd Western Pacific Sea Turtle Cooperative Research and Management Workshop. 17-21 May 2004. Western Pacific Regional Fishery Management Council, Honolulu, HI USA.

Southwood, A.L., Higgins, B., Brill, R.W., Vogt, R., and J.Y. Swimmer. In press. Aquatic chemoreception in loggerhead sea turtles: behavioral responses to food and a novel chemical. Chemical Senses.

Watson, J. W, Daniel G. Foster, Sheryan Epperly, and Arvind Shah. 2002. Experiments in the Western Atlantic Northeast Distant Waters to evaluate Sea Turtle mitigation measures in the Pelagic Longline Fishery. Unpublished report. NOAA Fisheries, Southeast Fisheries Science Center.

## COMMENTS

**Dr. Limpus:** For the last 20 years, we have been using flashing lights to mark walking tracks of the public access to and from the nesting beach. These lights have had no impact whatsoever on hatchling disbursal from the beach or the arrival/departure of nesting turtles.

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# Loggerhead Turtle Bycatch in Peru

## ABSTRACT

As sea turtle nesting beaches have become increasingly protected, one of the greatest conservation priorities is addressing bycatch in fisheries. Worldwide assessments of turtle bycatch in longlines have been limited due to gaps of information on turtles catch per unit effort (CPUE) in some regions, including the Southeast Pacific. Through a shore-based observer program in 2001-2003, we estimated 2,025 turtles captured at eight ports sampled in Peru. However, due to the clandestine nature of the use of captured turtles, an accurate estimate of turtle CPUE was difficult to achieve. Therefore, in 2003 we established an onboard observer program based in Ilo, home to the largest artisanal longline fleet in Peru, targeting mahi mahi and sharks. During the first 10 months of the program, 10 greens, 1 hawksbill, 16 olive ridleys, 2 leatherbacks and 108 loggerheads were recorded. Of these, 72% were entangled in the line while 23% were hooked.

Fisheries are the second largest economic sector of Peru. However, endangered marine fauna are being affected by fishing practices. Sea turtles in Peru are legally protected, but due to poor socio-economic conditions in the country, political instability and insufficient resources, enforcement of this legislation is very limited. In the case of longline fisheries in Peru, we recommend the implementation of mitigation measures (i.e. de-hookers, circle hooks) together with the improved basic education in coastal communities.

## INTRODUCTION

Increasing protection of sea turtles nesting beaches has improved sea turtle conservation over the last decade. However, bycatch still remains as a major threat to sea turtles. In Peru, gillnets have been identified as the main threat for sea turtles.

During the late 90's, gillnet bycatch of turtles represented about 76.5% of the turtle capture, followed by artisanal longlines. The main species affected by the longline fleet in southern Peru are the loggerhead turtle (Caretta caretta), leatherbacks (Dermochelys coriacea), greens (Chelonia mydas agassizii), olive ridley (Lepidochelys olivacea) and hawksbill turtles (Eretmochelys imbricate).

Over the last few years, longline fisheries have increase rapidly. It is estimated that from 587 to 1,357 vessels are operating with longline gear in Peru in winter and summer, respectively. With this increase in fishing effort, turtle bycatch rate may have changed.

Fisheries as an industry is the second largest economic activity in Peru. Approximately 110,000 persons work directly or indirectly in this activity. However, the informality of artisanal fisheries makes it difficult to monitor catch per unit effort and bycatch rates. Here we summarize the information for the first year of our observer program in Peruvian longlines which was established to assess sea turtle bycatch CPUE.

## METHODS

For an accurate assessment of bycatch, we placed onboard observers from September 2003 to November 2004 in the port of Ilo. Ilo is home to the largest year-round artisanal longline fleet. The fleet uses surface longlines. There are two seasons: the mahi mahi and the shark season (see Table 1, Figure 1 and Figure 2).

## RESULTS

During 14 months, 588 sets were observed during 60 trips. A total of 154 turtles were bycaught. Of all turtles caught, 72% of them were entangled and 23% were hooked. Species composition was as follow: 73.4% loggerheads, 18.2% greens, 2.6% leatherbacks, and 3.8% olive ridley turtles. Of all leatherback turtles caught, 75% were entangled in the line, while 68% of the loggerhead turtles were entangled and 32% were hooked. For trips observed 0.597 turtles/1000 hooks were caught during the mahi mahi season while 0.356 turtles/1000 hooks were caught during the shark season.

| Table 1: Characteristics of the mahi mahi and shark longline fisheries | | |
|---|---|---|
| Fishery | Mahi Mahi | Sharks |
| Hook Type | J#2 | J#0 1/0 |
| # Hooks | 400-800 | 800-1500 |
| Trip Length | Up to 6 days | Up to 20 days |
| Sets/Day | 2 | 1 |
| Distance | 20-70 nm | 250-500 nm |
| Bait | Flying fish, squid, mackerel | Mackerel, squid, mullet |
| Season | December - March | April – November |
| Target Species | Mahi mahi | Mako, Blue |

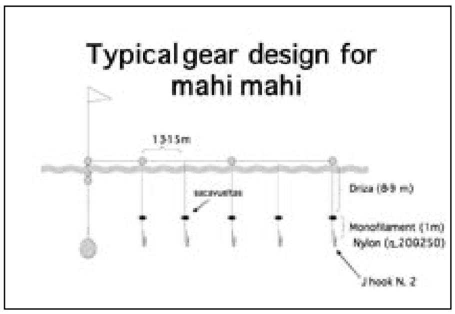


**FIGURE 1.** *Fishing gear design to catch mahi mahi.*

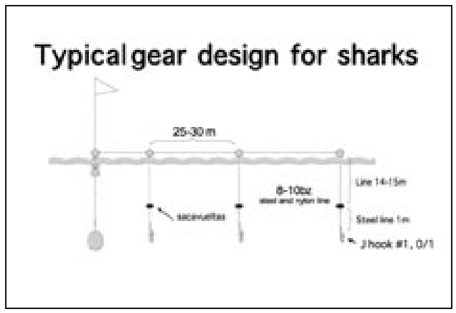


**FIGURE 2.** *Fishing gear design to catch sharks.*

Three turtles were recaptured, two of them after 21 and 13 days respectively. During the sampled period, no seabird bycatch was registered. Only one small cetacean (Delphinus sp.) was hooked. As part of a pilot shark project carried out during some trips we also determine that approximately 82% of the sharks captured were below the legal size minimums.

## CONCLUSIONS

Sea turtle bycatch was higher during the mahi mahi season than the shark season. This seasonality may be linked to changes in oceanographic conditions. Entanglement in the line (rather than hooking) was the major cause of turtle capture. We recommend an assessment of the use of mitigation measures to reduce turtle bycatch such as the use of circle hooks and dehookers, especially during the mahi mahi season.

Encouragement of fishermen to participate in sea turtle conservation would support efforts for long term turtle conservation. Further studies using telemetry are necessary to estimate the post release mortality rate.

## ACKNOWLEDGEMENTS

We warmly thank the fishermen for their generous collaboration during the project. To the crew of ‘Milagritos’, ‘Jesusito’, ‘Lucio IV’, ‘Lucio V’, ‘Aletita II’, ‘Rebecca III’ and ‘Juan de Dios’. Observers conducted an excellent work and provided a great amount of support to improve this study.

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# The Conservation Mosaic:
## Networks, Knowledge and Communication for Loggerhead Turtle Conservation at Baja California Foraging Grounds[1]

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## INTRODUCTION

Five species of sea turtle are known to inhabit the coastal waters of Mexico. The two most common species to frequent the waters within and adjacent to Bahía Magdalena are the eastern Pacific green, or black, turtle (*Chelonia mydas*) and the Pacific loggerhead turtle (*Caretta caretta*). Other species include the olive ridley (*Lepidochelys olivacea*), leatherback (*Dermochelys coriacea*) and hawksbill (*Eretmochelys imbricata*) turtles. Sea turtles are an important part of the cultural history of northwestern Mexico. While overuse was largely responsible for their decline (Cliffton et al. 1982), it is the cultural connection to the animals that may in fact lead to their recovery. As in many fishing communities in the region, the multitude of uses of sea turtles by families living near Bahía Magdalena (a large mangrove estuarine complex on the Pacific side of the Baja California peninsula; Figure 1) have been an important part of coastal living. Green and loggerhead turtles are the species that were most commonly caught by the fishers of Puerto San Carlos, Puerto Magdalena and Lopez Mateos, the three largest communities on the shores of Bahía Magdalena.


**FIGURE 1.** *Study site: Bahia Magdalena, Baja California, Mexico.*

Turtle use originated as subsistence harvest, but over time this use broadened into a directed fishery (Caldwell 1963). In addition to the food, medicinal uses and products provided to an individual fisher's household, there were economic benefits associated with the sale of turtle meat to the market. For many years, the taking of turtles was largely unregulated, and the turtles seemed inexhaustibly abundant (Caldwell & Caldwell 1962) and as many as 375,000 turtles were harvested between 1966 and 1970. As populations began to decline, size limits and closed seasons were enacted. However, by the mid-1970's and early 1980's, it became increasingly obvious that such large-scale harvest was not sustainable and that management schemes were ineffective (Cliffton et al. 1982). Broad legal protection of sea turtles in Mexico came with an Executive Order issued in 1990 by the Mexican Ministry of Fisheries and the Ministry of Urban Development and Ecology (now SEMARNAP). The legislation states that the Mexican Federal Government strictly prohibits the pursuit, capture, and extraction of any species of sea turtle on any beaches or in any federal waters.

A major goal of community-based sea turtle conservation efforts is to develop population and habitat protection practices that are also compatible with the socio-economics and cultural ecology of local resource-dependent communities (Bird and Nichols 2000; Tambiah 2000). Community-based strategies are not new to sea turtle conservation: such approaches take a variety of forms including community monitoring of lighting practices on nesting beaches, community-based stranding networks and beach patrols, self-enforcement by fishing communities, formal sharing of traditional knowledge (Nabhan et al. 1999) and the systematic consideration of interviews with fishers (Tambiah 1999). While such practices are increasing, community-based efforts are still not widely accepted as valid conservation tools (Frazier 1999; Tambiah 2000).

In general, however, many of the "community-based conservation" cases documented in the literature have been those in which external researchers have initiated conservation projects and in the process have integrated local community participation (Govan 1998; Hackel

[1] With excerpts from the published papers: 1) Bird, K.E., Nichols, W.J. and C. R. Tambiah. 2003. The Value of Local Knowledge in Sea Turtle Conservation: A Case From Baja California, Mexico. Putting Fishers' Knowledge to Work: Conference Proceedings, Page 178-183; and 2) Nichols, W.J., K.E. Bird, and S. Garcia. 2000. Community-based research and its application to sea turtle conservation in Bahia Magdalena, BCS, Mexico. *Marine turtle newsletter* 89:4-7.

*Fisherman and son releasing an accidentally caught sea turtle, and thereby participating in conservation while transferring knowledge to the younger generation.*

1999; Tambiah 1995). Few of these case studies have actually integrated local science into the project. In many places around the world, external researchers only have the time and resources to make a snapshot assessment. The typical approach of a research project is to "get in and get out" - gathering as much data as possible as efficiently as possible. Once the data are collected researchers may never return. They may enter the host community with complete autonomy, for instance, with their own boat, equipment and food. Alternatively, a special connection can be made through a certain dependence on the host community - for food, equipment, labor and guidance - which fosters trust and builds partnerships.

## THE CONSERVATION MOSAIC

While there have been great advancements in our understanding of sea turtle biology and behavior, and the science of conservation is continually developing new tools, "science" does not always translate into "conservation" on the ground. As researchers become increasingly aware of the cultural motivations involved in sea turtle exploitation, it becomes critical to shift conservation efforts to *actively* include local communities, particularly to the fishers often in the position to make choices directly impacting the fate of turtles. While

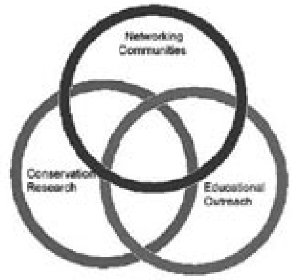



**FIGURE 2.** *The schematic of the Conservation Mosaic.*

the ways that fishers have negatively impacted sea turtle populations have been documented, what is often overlooked is how these same individuals can contribute to their conservation.

A major goal of community-based efforts in sea turtle conservation is to develop practices which will protect sea turtle populations and habitats that are also compatible with the socioeconomic system and cultural ecology of local resource-dependent communities. Within a conservation mosaic, the incorporation of both biological and social research methods and communication are critical. Analysis sea turtle recovery efforts within Baja California, Mexico indicates that community-based research can result in locals actively participating in conservation and providing the knowledge and information necessary to create successful long-term conservation plans. Formation of partnerships through local education, informal conversations, and community meetings are also a fundamental part of sea turtle conservation.

The *conservation mosaic* approach seeks to utilize local knowledge and to foster partnerships, which facilitate the exchange of information and active community participation (Figure 2). The following stepwise approach, outlining general research considerations for the integration of local science into conservation initiatives, is suggested:

1. The first step involves getting to know the community, while allowing them to know you as more than just an outside researcher: build trust through friendships and partnerships within the local community and show respect in interactions will all individuals.
2. After introductions to the community, learn about community issues, cultural norms and beliefs. Show consideration towards personal, local, and regional politics, and work within the existing socioeconomic framework.
3. While it is acceptable to share knowledge with local fishers, (particularly when it is specifically requested), do not do all the talking: spend an equal amount of time asking questions and engaging in participant observation. Both "outsiders" and "insiders" have something to share and learn from each other.
4. Integrate local knowledge and information with 'outside' science into an action plan, and implemented the plan with the support, knowledge and active participation of the local population.
5. Lastly, monitor progress and maintain flexibility, following adaptive management strategies.

The three components of the Conservation Mosaic, networks, knowledge and communication, function together to achieve a set of conservation targets. These targets may include specific policy actions, behavioral changes, market shifts or implementation of specific management strategies.

Building a **conservation network** involves linking together and involvement of stakeholders including fishers, managers, scientists, advocates, educators, funders, etc. The inclusion of so called "enemies," such as poachers, developers and politicians, in the network can often bring unexpected insights. The goal of the network is to remind its members that they are not alone and that they are part of something larger than themselves. Maintaining the connectivity of the network can be done both formally and informally and through "one-on-one" exchanges, working or theme group gatherings or "all network" meetings. The conservation network is the backbone of the Conservation Mosaic and, as such, its cultivation, growth and maintenance requires substantial commitment. There are many unexpected ways to grow the conservation network by aligning with existing social and professional networks. Two examples from the Baja California peninsula are the strong family networks where gatherings on Sundays are typically places where new knowledge is shared, and the public health network of health care providers who have clinics or mobile units in every coastal community and who have demonstrated an interest in working together to share information on the ocean-human health connection. Advances in technology allow network members to inexpensively remain in regular contact through phone and internet. However, there is no substitute for face-to-face meetings and the social bonding this allows.

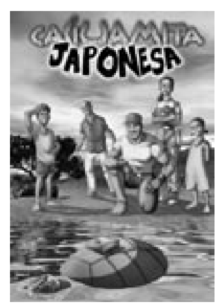
The second component of the Conservation Mosaic is the generation of **knowledge**, understanding and solutions. This ranges from the traditional natural science and social science studies to inclusion of local or traditional knowledge. The goal is to acquire as much of the information needed to reach the conservation goal as possible. Advances in technology have expanded the reach of science and have also allowed for widespread collaboration. Integration of many disciplines is now considered standard for any conservation project. Participatory research is another ideal, where stakeholders play a role in the generation of new knowledge. For example, in Bahia Magdalena fishermen take the lead in on monitoring sea turtles. This is an empowering as well as transformative experience for some and the "ownership" and credibility of the data serves sea turtle recovery efforts.

**Communication** of knowledge and solutions through education, outreach and advocacy programs relies on the strength of the network. Resonant and relevant messages that portray understandable and memorable messages should be carefully chosen, using test or focus groups as needed and professional social marketing information when available. The necessary steps to understanding the "big picture" should be provided. Appropriate media should be used. Both formal and informal communication should be considered. One goal of sharing knowledge is to provoke or inspire conversations well after the communication "event" has been completed. These conversations are what ultimately drive social change and adoption of more sustainable behaviors.

Sea turtle conservation is multidimensional, as the causes of declines are multifaceted. Therefore, it is our responsibility to advocate adaptive management techniques. An interdisciplinary approach allows for the utilization of many "sciences" and provides a more holistic view of how sea turtles fit into the grand picture. By avoiding a purely biological and "turtle-centric" approach, and instead investigating the overall turtle habitat, including the cultural and socioeconomic communities of which turtles are a part, our understanding is greatly enhanced. The inclusion of local people in resource management can provide many benefits. Stronger conservation alliances based on the mutual sharing of knowledge, along with the combination of local science and structured monitoring, may produce the greatest conservation benefits.

*Deployment of satellite telemetry on loggerhead to gather valuable habitat use information for making effective, science-based management decisions.*

*Sea turtle festival activities to raise community awareness in Lopez Mateos.*




*Creative communication strategies promote education and awareness, such as this comic book.*


*Jose Valdez Romero, respected community member, fisher, and sea turtle advocate.*

## CONCLUSION

Because of the intimate relationship between the turtles and the Bahía Magdalena communities, using community-based conservation strategies and developing the knowledge and trust of the fishers were crucial to research and conservation efforts. Although it has taken a great deal of time and patience to establish rapport within the community, resulting dialog has allowed us access to a more accurate understanding of the issues surrounding sea turtle recovery, as well as provided us with a forum for making recommendations. By combining the knowledge gained through scientific investigations with the insights of the social sciences, we now stand a much better chance of succeeding in recovery efforts.

Over the past decade, local involvement in turtle conservation has been increasing. The novelty and strength of this approach have yielded a conservation constituency among costeños (fishers) characterized by local pride, empowerment and stewardship. Preliminary results indicate decreased sea turtle bycatch and poaching, increasing government support and community-based enforcement, a growing conservation network, changes in local attitudes, an emerging "sea ethic", and more turtles.

## REFERENCES


Caldwell, D.K. 1963. The sea turtle fishery of Baja California, Mexico. *California Fish and Game* 49:140-151.

Caldwell, D. K. & M. C. Caldwell. 1962. The black "steer" of the Gulf of California. Los Angeles County Museum Contributions to Science 61:1-31.

Frazier, J.G. 1999. Community-based conservation. Pp.15-18 *in* K.L. Eckert, K.A. Bjorndal, F.A. Abreu-Grobois and M. Donnelly (editors). Research and management techniques for the conservation of sea turtles. IUCN/SSC Marine Turtle Specialist Group Publication No.4.

Govan, H. 1998. Community turtle conservation at Rio Oro on the Pacific coast of Costa Rica. *Marine Turtle Newsletter* 80:10-11.

Hackel, J.D. 1999. Community conservation and the future of Africa's wildlife. *Conservation Biology*. 13(4):726-734.

Nabhan, G., H.Govan, S.A. Eckert, and J.A. Seminoff. 1999. Sea turtle workshop for the indigenous Seri tribe. *Marine Turtle Newsletter* 86:44.

Bird, K.E. and W.J. Nichols. 2000. Community-based research and its application to sea turtle conservation in Bahia Magdalena, BCS, Mexico. Proceedings of the 20th Annual Symposium on Sea Turtle Biology and Conservation. March 2000. NOAA Technical Memorandum NMFS-SEFSC-477.

Tambiah, C. R. 1995. Integrated management of sea turtles among the indigenous people of Guyana: Planning beyond recovery and towards sustainability. Proceedings of the 12th Annual Workshop on Sea Turtle Conservation and Biology. NOAA Technical Memorandum NMFS-SEFSC-361.

Tambiah, C. 1999. Interviews and market surveys. Pp. 156-161 *in* K.L. Eckert, K.A. Bjorndal, F.A. Abreu-Grobois and M. Donnelly, (editors). Research and Management Techniques for the Conservation of Sea Turtles. IUCN/SSC Marine Turtle Specialist Group. Publication No.4.

Tambiah, C. R. 2000. "Community participation" in sea turtle conservation: Moving beyond buzzwords to implementation. *In*: H. Kalb and T. Wibbels (compilers). Proceedings of the 19th Annual Symposium on Sea Turtle Conservation and Biology. NOAA Technical Memorandum NMFS-SEFSC-443.


## QUESTIONS

**Ms. Fahy:** I have a quick question. You talk about social change within the fishing community and among poachers. But for those poachers who were making money off of turtles and now have switched to sea turtle conservation, how are they now replacing the money that they were making from poaching and selling sea turtles to restaurants.

**Dr. Nichols:** That's a good question. One can make a lot of money poaching sea turtles, and there is no way to make a one-to-one shift. Francisco Fisher who was the biggest sea turtle poacher in Baja went to work in a fish packing plant right out of the jail, cleaning lobster tails. So he found employment, but nowhere near the money – impossible for him to make the money that he made transporting sea turtles. It's kind of like, if you stop dealing drugs and then try to find a main stream, legal job. It's going to be really hard to match that. That's part of the challenge, he gave up a lot, he gave up his whole lifestyle and new cars to do it. And, admittedly, he says it's very, very difficult for him. But that's the social reality of that kind of shift, from making a lot of money doing something that is very illegal to just taking a job working in a fishery or in a packing plant or restaurant. Baja California is very fortunate, it's one of the richer states in Mexico and there are jobs available. They are low paying, but there are jobs.

**Ms. Fahy:** So it's just a change in his mindset.

**Dr. Nichols:** Yes.

# An Integrated Approach to Reducing Mortality of North Pacific Loggerhead Turtles in Baja California SUR, Mexico[1]

Hoyt Peckham and
Dr. Wallace J. Nichols
*ProPeninsula*

*ProCAGUAMA 2005 team*

*BCS, Mexico state senator releases a loggerhead turtle, embracing turtle ecotourism (effort supported through ProPeninsula).*

## EXECUTIVE SUMMARY

There are currently no more than a few thousand loggerhead turtles nesting each year in Japan, the primary nesting site for this species in the North Pacific, representing a rapid decline in recent decades. The small-scale fisheries of Baja California Sur (BCS), Mexico are a leading source of loggerhead turtle mortality in the North Pacific. The future of the imperiled North Pacific loggerhead turtle population is thus partly in the hands of Mexican small-scale fishers.

We are raising awareness of the mortality problem among Mexican fishers and working with these fishers to develop mortality reduction solutions. Loggerhead poaching along the Baja California Sur (BCS), Mexico coast is another serious source of mortality.

Our objective is to reduce loggerhead turtle mortality due to fisheries bycatch and poaching in BCS, Mexico. In April 2004 and May 2005, we convened three WPRFMC-funded bycatch reduction workshops in Puerto A. Lopez Mateos and Puerto Magdalena, BCS to identify feasible bycatch reduction strategies with local fishers. Based on input from the twelve working groups of fishers, managers, and researchers during the workshops, we identified the following goals for reducing BCS loggerhead mortality and began addressing them in summer 2004. In 2005, we expanded our efforts to include a systematic assessment of changes in attitude and behavior related to poaching and bycatch of sea turtles in the focal region. Issues related to human health and ocean health resonate the most among members of the communities in the region. A significant outcome of the 2005 season is the declaration of the Zona Auto Protegida (ZAP), a no-fishing turtle reserve, supported by local communities and fishers to reduce gillnet-fishery bycatch mortality of loggerhead sea turtles.

## PROJECT GOALS

- facilitate agency enforcement against poaching in BCS
- monitor mortality of loggerhead turtles along the Pacific coast of BCS, Mexico
- convey mortality problem to local fishers and other stakeholders
- investigate abundance, distribution, and foraging behavior of loggerhead turtles
- partner with fishers to mitigate turtle mortality through: 1) alteration of fishing techniques, 2) turtle rehabilitation/release, 3) reduction of poaching/piracy
- create and deliver compelling outreach content (videos, info sheets, children's books, comic books, etc.) of the turtle bycatch problem to engage fishers and their communities in developing solutions.
- share results widely with agencies, organizations and individuals working to protect loggerhead turtles around the North Pacific.

## ACTIONS COMPLETED

## COMMUNITY CONSERVATION NETWORKS

### OVERVIEW

To increase awareness of the sea turtle mortality problem in the Baja California peninsula, our team has built a conservation constituency for sea

[1] 2005 Final report submitted to the Western Pacific Regional Fishery Management Council (WPRFMC), January 20, 2006, Contract No. 05-WPC-018, NOAA award Nos.: NA03NMF4110017 and NA04NMF4410039. The project scope, goals and activities are similar from year one (2004) to year two (2005), however, due to the delay in publishing these proceedings, the year two final report is used in lieu of year one. Additionally, the results from the 2005 season are more comprehensive and contain an additional year's data that provides a more solid foundation to interpret results and actions.

turtles of the Californias composed of fishers' cooperatives, community groups, governmental agencies, and Mexican and US non-profits. We empower Mexican fishers to protect turtles through our constituency and the community-based conservation network Grupo Tortuguero. This network provides the core for our research and communications programs.

**REGIONAL MEETINGS**
**(supported by ProPeninsula, Packard Foundation, and WPRFMC)**

The following meetings were supported during the 2004 field season:

- **6th Annual Grupo Tortuguero Monitoring Meeting:** Mulege, BCS, August 2004. Sea turtle monitoring projects from NW Mexico meet annually to share data and describe regional trends. Stranding and tracking data from ProCAGUAMA were presented and discussed.
- **Fisher Workshops:** Bahia Magdalena region, April-Sept 2004, to discuss mitigation options with local cooperatives for regional halibut fishery.
- **2nd Annual Turtle Festival:** Puerto A. Lopez Mateos, August, 2004. This annual event brought together the people of the Bahia Magdalena region to celebrate loggerhead turtles as natural treasures special to the BCS coast. Several thousand people participated in the 2004 Festival.

The following meetings were supported during the 2005 field season:

- **7th Annual Grupo Tortuguero Monitoring Meeting:** Members of 15 communities where sea turtle monitoring is conducted in NW Mexico met to discuss trends and share data, Puerto Lopez Mateos, BCS, August 2005.
- **Fisher Workshops:** Bahia Magdalena region, April-Sept 2005, to discuss mitigation options with local cooperatives for regional halibut and shark fisheries.
- **3rd Annual Turtle Festival:** Puerto A. Lopez Mateos August 2005. This annual event brings together the people of the Bahia Magdalena region to celebrate loggerhead turtles as natural treasures special to the BCS coast. Several thousand people participated in the 2005 Festival. See Outreach section for more details

**EMERGING CONSERVATION LEADERS**
**(supported by ProPeninsula)**
Promising local individuals are being equipped with the information and resources to conduct local outreach and research activities towards reducing sea turtle bycatch. Current partners are being further empowered with our latest media offerings and enrichment through regional meetings. Emerging leaders were empowered in the communities of Puerto Magdalena, Ciudad Insurgentes, Santa Rosa, La Posa Grande, and Santo Domingo.

**INTERNSHIPS**
**(supported by NMFS-SWFSC and ProPeninsula)**
Eight university student interns (7 from across Mexico and 1 from Argentina) and five high school student interns (all from local fishing families – see attached list at end of chapter) worked on internships through September 2005 in which they conducted research and delivered outreach programs.

## LOGGERHEAD TURTLE RESEARCH

**Overview**
Basic information such as the diet, foraging behavior, and movement of loggerhead turtles on their BCS feeding grounds, is lacking. Such information is critical to identifying core foraging and developmental grounds and reducing bycatch. In 2005, we identified for the first time juvenile foraging hotspots off the BCS coast based on satellite telemetry. Moreover, in 2005, we concluded that net modifications and other proposed gillnet bycatch reduction measures were ineffectual. However, in the process of testing these measures, we identified a discrete zone of high loggerhead bycatch (which corresponds to telemetry hotspots).

In order to directly quantify and monitor turtle mortality, we continued to conduct systematic shoreline surveys at Playa San Lazaro, BCS. In addition to monitoring turtle strandings, we assess turtle bycatch directly through 1) a voluntary observer program for the halibut fleet of Puerto A. Lopez Mateos and 2) opportunistic observations of other fishing fleets.

**MORTALITY ASSESSMENT**
**(supported by NMFS-SWFSC, PACKARD, and WPFRMC)**

***Shoreline Surveys***
Systematic surveys have been conducted along the 45km Playa San Lazaro since 2003. Surveys are conducted by ATV on a daily basis from May to September and twice weekly from October through April. Carcasses of three turtle species were

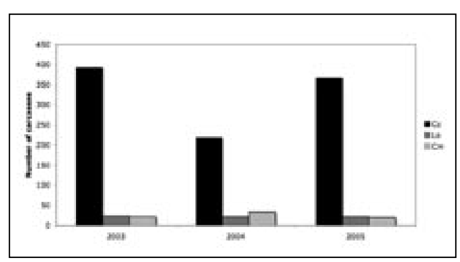


**FIGURE 1.** *Turtle carcasses encountered during systematic shoreline surveys of Playa San Lazaro 2003-2005.*

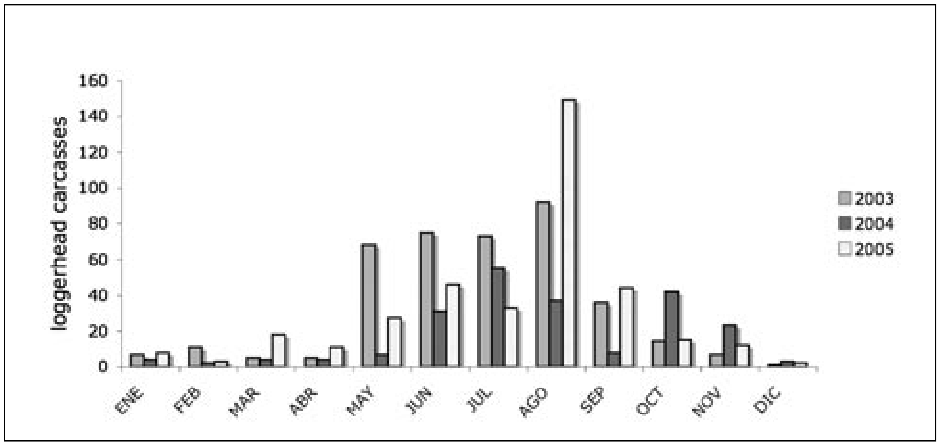



**FIGURE 2.** *Loggerhead turtle carcasses encountered during systematic shoreline surveys of Playa San Lazaro 2003-2005.*

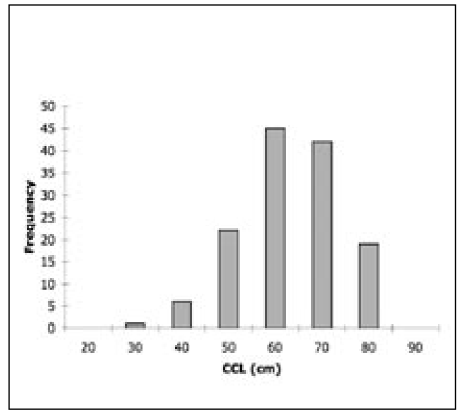



**FIGURE 3.** *Size frequency of loggerhead carcasses, Playa San Lazaro Jan-Aug 2004. N=135, SD=10.34, range=49.*

encountered. From 2003 to 2005, the numbers of olive ridley and black turtle carcasses encountered did not change significantly (Figure 1).

From 2003 to 2005, 982 loggerhead carcasses stranded along the 44.3km Playa San Lazaro. 56% fewer loggerhead carcasses were encountered in 2004 (220) than in 2003 (394) (Figure 1). Strandings were low again in 2005 through July (Figure 2), when frequency increased dramatically in August, resulting in an overall increase in 2005 to 368 carcasses (Figure 1).

Loggerhead strandings were considerably less common in winter months in all years (Figure 2). Summer peaks in strandings coincide with local fisheries. Social surveys indicated that the majority of loggerhead bycatch in the area occurs in local gillnets and longlines. The conspicuous increase in loggerhead strandings in October and November of 2004 coincided with intense nearshore shrimp fishing by 20-40m trawlers (Figure 2). This did not occur in 2003 or 2005. Fisheries observations in 2005 recorded high levels of loggerhead bycatch in bottom-set longline and gillnet fisheries.

The mean size of loggerhead carcasses encountered from January to August 2004 was 68.84 cm CCL. Size frequencies of loggerheads stranded at Playa San Lazaro from January through August 2004 are shown in Figure 3.

The decline in strandings in 2004 and the first half of 2005 could be due to several factors. Bycatch may have declined because: 1) there were fewer turtles in the area due to a) population decline, or b) unfavorable oceanographic conditions, and 2) due to changes in fishing methods to avoid bycatch. However, since olive ridley and black turtle carcasses numbers did not change between years, it appears unlikely that oceanographic conditions would have affected only loggerheads. It is unclear what proportion of the decline in bycatch that these different factors contributed.

Based on Hart et al (in press) and Epperly et al (1996), the 982 loggerhead carcasses which stranded at Playa San Lazaro from 2003-5 probably represent less than 30% of total loggerhead mortality, and this only of turtles killed nearby. Puerto A. López Mateos is one gillnet fishing community among many along the BCS coast. Total loggerhead mortality for the region is likely to be considerably higher.

## FISHERIES OBSERVATIONS (supported by WPRFMC and NMFS-SWFSC)

### *Bottom-set gillnet*

We observed bottom set longline and gillnet fishing operations. From June to August 2005, we made 73 day-long bottom set gillnet trips with a total of 10 local fishing crews. Nets were checked every 24 hours, the traditional local practice. Crews fished nets in depths ranging from 5 to 23m. Crews were compensated MN$500 per day (USD $50), roughly 2/3 of daily gasoline expenditure. In 73 gillnet trips, 11 loggerhead, 1 green, and 1 olive ridley turtles were caught. Three of the eleven loggerheads were caught and released alive, as were both the green and olive ridley turtles. All loggerheads were caught at an average depth of 21 fathoms (range 20 to 23 fathoms). Green and olive ridley turtles were caught at 6 and 14 fathoms, respectively. Overall, fishermen caught an average of 1.05 loggerheads per week per boat. When fishing in areas deeper than 18 fathoms (17 of 73 trips observed), fishermen caught an average of 4.52 loggerheads per week, 73% of which were caught dead.

### *Bottom-set Longline*

In September 2005, we made 7 day-long bottom-set longline trips with a total of 4 crews to quantify the turtle interaction rates of this fishery operating out of Santa Rosa. Longlines targeted shark species and were anchored in 60 to 90m depths and checked each day. Fishermen used freshly caught mackerel for bait on "Japanese J-hooks" with inflected shanks. Fishermen were asked about the duration, weekly effort, and history of using bottom-set longlines.

In 7 daylong longline trips from 7 to 26 September, 2005, 1 olive ridley and 26 loggerhead turtles were caught on a total of 1,200 hooks set, resulting in a bycatch rate of 19.3 loggerheads per 1,000 hooks, or 3.85 turtles per trip. 22 of the 27 turtles were caught dead and two more died in the boats, resulting in a bycatch mortality rate of 89%. With the exception of the olive ridley, which was released in apparently good condition, turtles caught alive were moribund. No black turtle and only one olive ridley turtle were caught, despite high numbers of olive ridleys observed during fishing observations. Mean CCL of loggerhead turtles caught was 79.3cm (range 65.8 to 88.0, SD 5.89), and the olive ridley measured 71cm CCL. Fishermen reported that they had begun fishing bottom-set longlines in August 2005 to explore profitability. They reportedly fished 5 or 6 boats for 6 days a week from early August through the end of September with plans to continue into the fall, depending on shark catch.

### *Estimating annual, local bycatch of loggerhead turtles*

Based on gillnet fisheries observations, we combined the average bycatch rate with the number of pangas and length of season to extrapolate a minimum annual bycatch estimate for the Puerto Lopez Mateos gillnet fleet as follows: we multiplied the average number of turtles caught per boat per week (4.52) by the minimum number of boats fishing (40) by the reported proportion of time fishermen fish waters deeper than 18 fathoms (0.25) by the minimum number of weeks fished per year (10) and discounted by the proportion of turtles released alive (27%). Based on this simple calculation, we extrapolated a minimum annual bycatch mortality rate of 330 loggerhead turtles for the Puerto A. López Mateos gillnet fleet from fisheries observations.

Based on longline fisheries observations at Santa Rosa, we combined the average bycatch rate with the number of pangas and length of season to extrapolate a minimum annual bycatch mortality estimate for the Santa Rosa longline fleet as follows: we multiplied the average number of turtles killed per boat per trip (3.43) by the minimum number of boats fishing (5) by the minimum number of days fished per month (27). We therefore extrapolated a minimum annual bycatch mortality rate of 463 loggerhead turtles per month for the Santa Rosa bottom-set longline fleet from fisheries observations.

Observations of this experimental, bottom-set longline fishery would explain the dramatic increase in strandings at Playa San Lazaro in August and September 2005 (Figure 2).

## SEA TURTLE ECOLOGY (supported by Packard Foundation, NMFS-SWFSC, and TOPP)

### *Satellite telemetry*

We instrumented 14 loggerhead turtles with CCL of 66.0 cm in summer 2005 satellite location transmitters. Eight of these were also equipped with Microwave Telemetry pop-up satellite dive recorders (Table 1). 71% or 22 of the 29 juvenile loggerheads we have tagged since 1998 did not leave the Bahia de Ulloa (an 80km radius area) in the total time tagged, strongly implying that the area represents a juvenile loggerhead foraging hotspot (Figure 4).

### *Gut contents*

A total of 17 fresh stomachs were collected from the carcasses encountered at Playa San Lazaro in 2005. Contents were weighed and keyed to the finest taxonomic level possible. Eight of the thirteen stomachs contained only fish. Pelagic red crabs (*Pleuroncodes planipes*) were encountered in only 4 of the 17 stomachs. Three stomachs were

Table 1. Loggerhead turtles instrumented in 2005.

| FECHA | NOMBRE | CCL | CCW | Satellite tag | ARGOS | PSAT |
|---|---|---|---|---|---|---|
| 24-Jun-05 | Miranda | 70.4 | 69 | Telon ST20 | 42979 | yes |
| 24-Jun-05 | Estefania | 75.5 | 74 | Telon ST20 | 42978 | yes |
| 24-Jun-05 | Brismar | 75 | 70 | Telon ST20 | 42977 | yes |
| 25-Jun-05 | NAZDA | 74.5 | 70.4 | Telon ST20 | 42980 | yes |
| 25-Jun-05 | Juliette | 66.3 | 65.5 | Telon ST20 | 42981 | yes |
| 1-Jul-05 | Penelope | 73 | 74 | Telon ST20 | 42983 | yes |
| 3-Jul-05 | Joanna | 61 | 67.5 | Telon ST20 | 42985 | yes |
| 3-Jul-05 | Madai | 70.5 | 68 | Telon ST20 | 42986 | yes |
| 2-Aug-05 | Agnes | 76 | 73.5 | SPOT | 17710 | no |
| 31-Aug-05 | Licet | 70 | 66 | SPLASH | 60247 | no |
| 31-Aug-05 | Emiliana | 75 | 72 | SPLASH | 60250 | no |
| 3-Sep-05 | Zapata | 88 | 83 | SPOT | 16264 | no |
| 4-Sep-05 | Angel | 80 | 71 | SPLASH | 60248 | no |
| 4-Sep-05 | Nitse | 73 | 72 | SPLASH | 60249 | no |

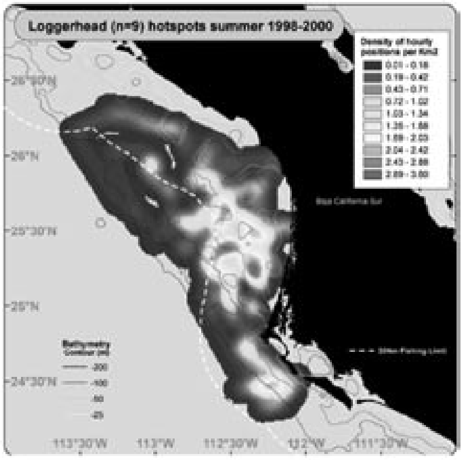



**FIGURE 4.** *Normalized kernel density map of 9 Argos tracked juvenile loggerhead turtles off Baja California Sur between 2002-2004 showing localized high use areas, or hotspots. White dashed line approximates offshore range of local small-scale fishermen (30 Nm). Analysis conducted in collaboration with Andreas Walli.*

empty. Fish species appear to be discarded bycatch because of their low economic value, including sea robin (*Prionotus albirostris*), lizardfish (*Synodus* sp.), and pacific sand perch (*Diplectrum* sp.).

### *Past diet*

Liver, skin, and bone samples were collected from carcasses and archived for future isotope analysis. Blood and skin samples were collected from live-captured turtles for the same purpose. Samples await CITES permits to be brought to the US.

## SOLUTIONS TESTING (supported by WPRFMC and BOI)

In partnership with Puerto A. Lopez Mateos halibut fishing cooperatives, bycatch reduction solutions were empirically tested. Teams of fishermen were paid to modify gear to test for solutions. See Maldonado report of these proceedings for detailed presentation of research results.

In 2004, the project investigated bycatch reduction options, such as decreased soak times, pulling nets at dawn, reduced net height and identification of loggerhead hotspots. Following experimental results, our fisher partners demonstrated that decreased soak times would not be a viable solution from their perspective, so this idea was dismissed. Additionally, dive data from loggerhead turtles has indicated that they feed intensively in the hours just after dawn. Fishers experimented with holding their nets out of the water for two hours after dawn in 2004, but this idea was also dismissed as a viable option until better dive data is available.

In 2005, upon refinement of fishery experimental methods based on results of the 2004 season (see Maldonado report in these proceedings), the project further investigated bycatch reduction options, such reduced net height and identification of loggerhead hotspots.

### *Reduced net height*

Halibut nets are usually 4-6m in height. But because target halibut are forage primarily on the benthos, turtle bycatch in nets of 1-3m height were compared against bycatch in unmodified nets. In 2004, four boats were contracted to each fish a minimum of 15 days with both modified and normal nets. In 2005, ten boats were contracted to each fish a minimum of 15 days with both modified and normal nets for a total of 276 sets. We conclude that modifying gillnets in this fashion does not reduce sea turtle bycatch, and thus will focus on encouraging fishermen to avoid loggerhead hotspots (see Zona Auto-Protegida below).

### *Loggerhead hotspots*

In 2004, fishers reported that loggerheads are more likely to be caught outside 60m depth. Thus during the first season, effort was made to compare bycatch rates between sets inside and outside the 60m isobath using observer data. Further, fishers reported higher loggerhead capture rates at a rock reef at approximately 24 fathoms. Results from 2004 were inconclusive. However, upon refinement of fishery experimental methods in 2005 in conjunction with satellite telemetry, results showed (based on gillnet observations) that fishermen catch loggerheads in depths greater than 18 fathoms. Of their own accord, fishermen are proposing to limit bottom fishing outside 18 fathoms in front of Puerto Adolfo Mateos. See Zona Auto Protegida below for more information.

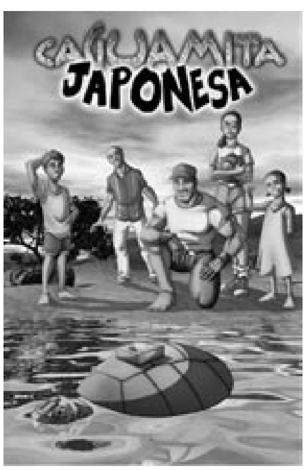
## STRATEGIC COMMUNICATION

### Overview

It is difficult for many of Baja California's halibut and shark fishers to understand that loggerhead turtles are endangered because they can catch up to seventy turtles in a single day. In partnership with the community-based Grupo Tortuguero, we are addressing sea turtle mortality by empowering fishers and other stakeholders through public outreach, educational enrichment, technical workshops, and media campaigns using the insights from social marketing theory and our own experience. We develop and deliver locally relevant and resonant video productions, PowerPoint presentations, information sheets, children's books, and comic books. Our local conservation partners in turn use this content to share marine conservation lessons in their own words for their own communities. As a result, citizens throughout the region are combating sea turtle poaching and are working to reduce sea turtle mortality in their fisheries (for more detail please see Maldonado report in these proceedings).

*Turtle outreach at Puerto Magdalena school.*

*Johath Laudino planning with Festival Committee members.*




*Comic book created and distributed in 2005.*

**EDUCATIONAL OUTREACH (supported by ProPeninsula and WPRFMC)**

Our outreach programs are focused at Puerto A. Lopez Mateos and Santo Domingo, home to the fishing fleets that are catching the most turtles. Educational presentations were offered in every classroom in these towns, reaching each of the students in the area when schools reopened in late August of both 2004 and 2005.

**PRIDE CAMPAIGN (supported by ProPeninsula, WPRFMC, and RARE )**

Drawing on the example of various whale festivals in the area, this festival engages, informs, and empowers the people of the Bahia Magdalena region by celebrating the unusual abundance of loggerhead turtles in local waters. The Festival is the cornerstone of our pride campaign, and other activities including local music competitions, beach cleanups, and art contests are being organized by outreach coordinator Johath Laudino-Santillan to build local people's pride in their natural resources. A peer-nominated, ten-woman committee organized both the 2004 and 2005 Festivals.

**COMIC BOOKS (supported by ProPeninsula, WPRFMC and Defenders of Wildlife)**

Engaging narrative and fetching imagery has enabled us to convey concepts and information that many fishermen need in order to understand the bycatch issue and appreciate their role in the future of the Pacific loggerhead. We produced our latest comic, *La Caguamita Japonesa*, in partnership with Juan Carlos Cantu from Defenders of Wildlife. Over 1,000 copies have been distributed in Pacific BCS fishing communities to date.

**LOCAL MUSIC (supported by ProPeninsula)**

Outreach Coordinator Johath Laudino Santillan is empowering local musicians to create, perform, and record songs about loggerhead turtles. To date three groups have been recorded. All will be showcased at the 2006 Festival.

**ALTERNATIVE INCOME SOURCES (supported by ProPeninsula and WPRFMC)**

We are partnering with Puerto A. Lopez Mateos whale watch cooperatives, the BCS Tourism board, and ecotour operators to explore the feasibility of turtle ecotour programs. The promotion and development of turtle ecotourism in these communities could provide alternative income to halibut gillnetters.

**GREEN MARKET OPPORTUNITIES (supported by ProPeninsula and WPFMC)**

We are investigating the feasibility of green market certification for halibut. Ideally, a system for certifying turtle-safe halibut could be established to leverage market support for responsible fishing practices. Recent advances, such as the certification of spiny lobster fisheries along Baja California's Pacific coast by the Marine Stewardship Council, may provide a relevant roadmap.

**SOCIAL SCIENCE ASSESSMENT (supported by ProPeninsula and WPRFMC)**

The ultimate measure for the success of our initiatives will be decreased loggerhead mortality; however, interpreting trends in mortality can be problematic. For instance, fewer dead turtles in local halibut nets could be due to either: 1) cleaner fishing practices, or 2) lower overall turtle abundance.

It is therefore important for us to assess the effectiveness of our outreach, network-building, and research initiatives for two reasons. First, we need to monitor fisher attitudes and practices to know what we are accomplishing. Second, we need to better understand fisher attitudes and practices in order to improve and refine our initiatives. For these reasons, we are partnering with experts in the field of community-based social marketing to help us assess the effects and refine the methods of our initiatives.

Community-based social marketing (CBSM) is based on social psychology behavior modification theory, and CBSM advocates a four-step process that first seeks to identify the key factors that determine a particular behavior in a particular population. Once a thorough understanding of a behavior has been accomplished, an appropriate social marketing program may be designed, a pilot program may be tested (and revised if necessary), and a program promoting a particular behavior may be implemented and evaluated (McKenzie-Mohr, 2000).

Accordingly, a mixed methods design study was undertaken in July and August 2004 to qualitatively and quantitatively assess key factors associated with sea turtle mortality, exploitation and conservation in the Bahia Magdalena region. The initial, qualitative phase of this study used both personal observation of and informal interviews with a representative sample of fishers and residents to identify key themes associated with sea turtle mortality, exploitation and conservation in the region.

The second, quantitative phase of the study in 2004 used a survey questionnaire to determine the extent to which the factors identified in the first phase of this study are generally and significantly associated with sea turtle mortality and exploitation in the larger population of fishers and others in the major communities in the Bahia Magdalena region. Data from the 2004 study were used to refine and implement our strategic, culturally appropriate communication and education campaigns to reduce sea turtle bycatch and exploitation during the upcoming season.

In 2005, assessments of the various sea turtle conservation issues were accomplished by means of a survey questionnaire, which was administered during July and August of 2005 in the communities of Puerto Adolfo Lopez Mateos (n=100), Puerto Bahia Magdalena (n=26), and Santo Domingo (n=25). To provide perspective on survey data from 2005, similar survey data from 2004 are compared to 2005 data. While the community of Puerto San Carlos was surveyed in 2004, data were not collected in this locale in 2005. An atmosphere of social and political animosity towards environmental conservation and conservationists existed in San Carlos during the summer of 2005, which precluded the possibility collecting unbiased data and ensuring the safety of surveyors.

The atmosphere of animosity in San Carlos was a direct result of the Mexican government's decision to declare the Bahia Magdalena region (as well as all coastal island regions in Baja California and Baja California Sur) a protected area. Unfortunately, in Baja California Sur, no assessment of the ecological, social, political, or economic impacts of declaring these coastal island regions protected areas was actually performed by the Mexican government. In short, local people were not involved in a decision that they perceived to be a direct threat to their livelihoods and lifeworlds. As a result of the social and political outcry, the decision to declare these coastal island regions protected areas was rescinded for Baja California Sur. Nonetheless, feelings of distrust and resentment toward the Mexican government and environmental conservationists lingered in local communities in summer 2005.

However, by winter 2006 conservation attitude had rebounded, as demonstrated by local fishers' embrace of the Zona Auto-Protegida. Clearly, it is essential to involve local people in decisions that impact their lives. Moreover, environmental conservation initiatives must address not only ecological factors, but rather social and economic concerns of local peoples as well.

## SUMMARY OF SOCIAL SCIENCE RESEARCH RESULTS[2]

- Both prevalence and frequency of sea turtle consumption appear to have decreased at least slightly from 2004 to 2005. Moreover, approximately three-fourths of respondents indicate that sea turtle consumption has declined over the past five years.
- Trash continues to be viewed as the most serious environmental problem in the Bahia Magdalena region. While most people (42%) report that environmental conditions have not changed over the past five years, more respondents report deteriorating (34%) rather than improving (21%) environmental conditions.
- This year, incidental bycatch is

[2] The complete social science project reports for 2004 and 2005, *Local Perceptions and Environmental Conservation: A Study of Human Consumption, Exploitation, and Conservation of Endangered Sea Turtles in the Baja California Region of Mexico,* are available upon request from the WPRFMC.

viewed as the greatest threat to sea turtles (34% of respondents), followed by human consumption (30% of respondents) and illegal capture (13% of respondents). However, most respondents (43%) report that threats to sea turtles are generally less than they were five years ago.
- Most respondents (36%) indicated that Grupo Tortugero and ProCaguama have made the greatest progress toward sea turtle conservation over the past five years. In ranking the efficacy of sea turtle conservation efforts on a scale of 1 (worst) to 10 (best), respondents on average awarded a grade of 9.6 to Grupo Tortugero/ ProCaguama.
- "Potential human health risks associated with the consumption of sea turtle meat and eggs: a global perspective" has been submitted for publication to EcoHealth and will serve as a scientific basis for the Las Tortugas Marinas y Tu Salud public health/ sea turtle conservation campaign.
- A Las Tortugas Marinas y Tu Salud media campaign will be developed in collaboration with and financed by Greenpeace.
- Production of a comic (in collaboration with Defenders of Wildlife and Greenpeace) that creatively illustrates human-sea turtle health themes is in the final stages of development.
- A collaboration between the Secretaría de Salud (Secretary of Health) of Baja California Sur and Proyecto Salud Humana-Ecosistema is in its formative stage.
- A campaign informing the public of the potential health risks associated with human consumption of sea turtle would be an effective means to mitigate consumption of these endangered species. While most people (62%) believe that sea turtle is a healthy food, the vast majority (81%) would stop eating sea turtle if they learned it was in fact an unhealthy food.

## ACTIONS IN PROGRESS/ PROPOSED FOR 2006

## COMMUNITY CONSERVATION NETWORKS

### LOCAL LOGGERHEAD RESERVE (supported by ProPeninsula and WPRFMC)

In response to local fishers' calls for a local no-fishing loggerhead reserve (based on our turtle foraging and bycatch hotspots, see section: Loggerhead Turtle Research), we are partnering with fishermen's co-operatives and local government to officially designate the reserve. In winter and spring 2006, pending support, we plan to involve state and federal officials from agencies including PROFEPA, PESCA, SAGARPA, and CONANP in order to authorize local fishermen to officially designate and protect the loggerhead reserve.

### COMMUNITY ENFORCEMENT PROGRAMS (supported by WPRFMC)

We are facilitating the establishment of PROFEPA community enforcement programs in the community of Puerto A. Lopez Mateos. Community-based enforcement programs are designed to supplement the limited number of and resources for PROFEPA agents.

### TURTLE ECOTOURISM (supported by ProPeninsula and WPRFMC)

We are partnering with Puerto A. Lopez Mateos whale watch cooperatives, BCS Tourism board, municipal, county and state politicians, and ecotour operators to plan and license turtle ecotour programs. Pending funding, in spring 2006, we will offer a turtle guide training program and establish offshore tourism safety guidelines. The promotion and development of turtle ecotourism in these communities would provide alternative income to local small-scale fishermen.

## LOGGERHEAD TURTLE RESEARCH

## MONITORING TURTLE MORTALITY

- Through 2006, index beach surveys will be continued to resolve patterns in bycatch location and frequency.
- Ongoing surveys of fishers to determine bycatch and hunting-related mortality.
- Fisheries observations will be made from Puerto López Mateos and from 6 other fishing communities which potentially overlap the loggerhead high use area.

## SEA TURTLE ECOLOGY

- Deploy satellite transmitters in collaboration with NOAA Fisheries.
- Deploy TDRs to determine dive behavior of loggerheads to use reduce turtle bycatch.
- Combine hydrographic surveys with real-time turtle tracking to elucidate the degree to which red crab distribution influences turtle distribution and abundance.
- Definitively determine proximate loggerhead diet off BCS through analysis of fresh stomachs (collected on beach surveys and from nets).
- Collect samples to assess historical loggerhead diet through stable isotope analysis.
- Publish results of hotspots analysis of loggerhead high use areas.

## STRATEGIC COMMUNICATION

All previous strategies, including: Pride Campaign; Comic Books; Local Music and Media Campaign, will continue in 2006.

**ZONA AUTO-PROTEGIDA**

In fall 2005, fishermen proposed the establishment of a Zona Auto-Protegida, or Fishermen's Turtle Reserve based on data generated by this project with WPRFMC support since 2004. Because loggerhead strandings occur only outside 18 fathoms depth (see Maldonado report in these proceedings), corresponding to loggerhead foraging hotspots (Figure 4), and because fish landings were up to 90% lower outside the 18 fathom isobath, fishermen have proposed to limit fishing of bottom set longlines and gillnets outside 18 fathoms. In this way the Zona Auto-Protegida will dramatically reduce loggerhead bycatch and protect them for local ecotour operations.

In 2006, we will launch a concerted campaign to build consensus among local fishermen and across neighboring communities for support for the Zona Auto Protegida. We will also seek funding to build capacity among whale watch guides/gillnet fishermen to run turtle ecotours. Finally, we will partner with legal consultants to establish federal protection and support of the Zona Auto-Protegida.

## REFERENCES

Epperly, S.P., Braun, J., Chester, A.J., Cross, F.A., Merriner, J.V., Tester, P.A., Churchill, J.H. 1996. Beach strandings as an indicator of at-sea mortality of sea turtles. *Bulletin of Marine Science 59*: 289-297

Hart, K.M., Mooreside, P., Crowder, L. 2006. Interpreting the spatio-temporal patterns of sea turtle strandings: Going with the flow. *Biological Conservation 129*: 283-290

MacKenzie-Mohr, J. and W. Smith. 1999. *Fostering Sustainable Behavior: An Introduction to Community-Based Social Marketing*. New Society Publishers, B.C. Canada and Academy for Educational Development, Washington D.C. 160 pages.

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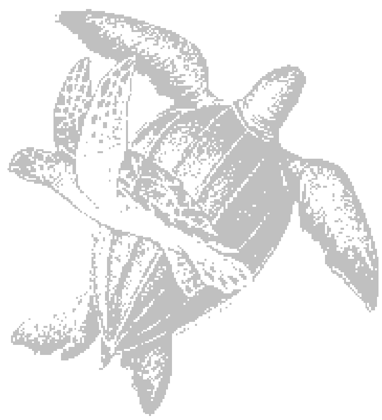

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# Reducing the Bycatch of Loggerhead Turtle (*Caretta caretta*) in Baja California SUR: Experimental Modification of Gillnets for Fishing Halibut[1]

*Fishermen displaying experimental gillnets.*


## SUMMARY (2004)

During July-August 2004, a study was undertaken to both characterize the halibut gillnet fishery operating out of the west coast of Magdalena Island, Baja California SUR, as well as implement experimental sets to investigate possible mitigation or gear modification measures for the fishery. 117 gillnet sets for halibut were carried out on with experimental gillnets of approximately 240 meters in length. Each experimental gillnet had four sections, two conventional sections (CS), of 60m each with a conventional depth of 2 fathoms (20 meshes deep) and length of the suspenders of 1.8m and, alternated, two test sections (TS) with a depth reduced to 1 fathom (10 meshes deep) and length of the suspenders shortened to 1m. The overall effect of the type of net (i.e., CS vs. TS) on fish catch and the bycatch of sea turtles was evaluated. A total of 2,180 fish of 27 different species was recorded. The dominant species were guitarfish (712 fish) and halibut (479 fish), which as a group represented 75% of the total value of the catch. Comparing the catch in weight of the CS (2,686 Kg.) to that of the TS (1,252 Kg.) showed a statistically significant difference $F=23.0069$ $p < .05$. The possible causes of these differences are discussed. In 117 gillnet sets, only one green sea turtle *Chelonia mydas* was taken in a conventional, non-experimental, section.

## SUMMARY (2005)

During July-August 2005, testing of modifications of halibut gillnets started in 2004 by *ProCaguama* were continued, this time reducing the length of the suspenders to 1m and keeping the net depth to 10 meshes. This experiment was performed in two phases, setting the nets at three different deep levels in the second phase exclusively. Statistical similarity in the performance of testing segments (TS) and conventional segments (CS) was observed. In 276 settings (129 corresponding to phase one and 146 to phase two), 16 sea turtles were captured (3 corresponding to phase one and 13 to phase two); 4 green turtles (*Chelonia mydas*), one olive ridley (*Lepidochelis olivacea*) and 9 Loggerheads (*Caretta caretta*). A strong correlation between depth of net setting and turtle bycatch was observed. Possible causes of this correlation are discussed. In 2005, activities focused on fishermen's involvement were intensified that helped identify regulation and eco-tourism as two strategies that can help to reduce turtle mortality at the area. Also, use of bottom set longliners was identified as another important source of turtle mortality at the area.


[1] Due to the delay in producing these workshop proceedings, the papers and results from both the 2004 and 2005 season are melded together into one final report. As a result, the evolution of the project is obvious as well as how the project has been refined over time to quantify results. This study is a sub-contract of contracts: 04-WPC-013 and 05-WPC-018, NOAA award #: NA03NMF4110017 and NA04NMF4410039.

## RESUMEN (2005)

Durante los meses de Julio y Agosto del 2005 se dio continuidad a la evaluación de modificaciones de redes para lenguado iniciada durante la temporada anterior del proyecto (ver informe técnico 2004), esta vez reduciendo el largo de los tirantes a 1 m y manteniendo la caída de la red a 10 mallas. El experimento se dividió en dos fases, haciendo tendidos a tres diferentes niveles de profundidad durante la segunda fase. A diferencia de la temporada anterior, el rendimiento en la captura de peces de los segmentos de prueba (TS) no mostró desventaja en comparación con los segmentos convencionales (CS). En 276 lances (129 de la primera fase más 146 de la segunda) se capturaron un total de 16 tortugas (3 en la primera fase y 13 en la segunda), cuatro prietas (*Chelonia mydas*), una golfita (*Lepidochelis olivacea*) y 9 amarillas (*Caretta caretta*), encontrándose una estrecha relación entre la profundidad de los tendidos y el número de tortugas capturadas. Se discuten los resultados. Por otro lado, se intensificaron las actividades para fortalecer el involucramiento de los pescadores llegándose a identificar la autorregulación y el ecoturismo como dos alternativas con potencial para reducir la mortalidad de tortugas en el área a través de talleres de trabajo con su participación. También se identificó, a través de visitas a diferentes campos pesqueros de la región, el uso de simbras de fondo como otra causa importante de la mortalidad de tortugas marinas.

## INTRODUCTION

Bycatch in gillnets used for capture of marine resources such as halibut is currently one of the most important causes of death of loggerhead turtles in Baja California. The ProCAGUAMA 2004 season focused on several actions for the protection of loggerheads that included: more effective law enforcement (with the facilitation and aid of Mexican authorities); environmental education; sensitizing of the local communities to decrease the consumption of turtle meat; research on the ecology of the species, and monitoring of sea turtle populations and mortality assessment via stranding surveys along the 45 km of beaches of Magdalena Island, Baja California SUR. Also undertaken was a project to characterize the halibut gillnet fishery operating out of the west coast of Magdalena Island, as well as implement experimental sets to investigate possible mitigation or gear modification measures for the fishery.

Considering the results of the 2004 season, the 2005 season maintained the depth reduction of the gillnets as an alternative in order to achieve the planned objective of reducing the bycatch of sea turtles. However, to improve the evaluation of this experiment, the assembling of the experimental gillnets was standardized, so the effect of the length of the suspenders and the depth of the gillnet could be evaluated in terms of the performance of the fishing equipment. Also, records during the entire fishing season were carried out in order to consider all the seasonal variations in the composition of the catch.

## PROJECT OBJECTIVES

- To reduce loggerhead mortality via bycatch in halibut gillnets, while maintaining the performance of fishing equipment for halibut and other species of high commercial value.
- To actively involve the small scale fishermen of Puerto Magdalena and Puerto López Mateos in conservation, fishery experiments, and sea turtle protection activities.

## PROJECT GOALS

- To evaluate the fishery and investigate fishery alternatives on their effect on the quantity and composition of catch and bycatch of sea turtles.
- **In 2004:** To evaluate the effect of reducing net depth and suspenders length (lines used to form a bag in the net by drawing the leadline and floatline closer together) of the halibut gillnets on the quantity, composition and economic value of the catch and on the bycatch of sea turtle.
- **In 2005:** Based on the results of the 2004 experimental modifications, fishermen were reconsulted via workshops and their suggestions were used to refine the alternatives tested in 2004 and investigate the experimental placement of nets to quantify if net depth has an effect on the composition of catch and bycatch of sea turtles.

## METHODOLOGY

Fishermen Enrollment. In order to facilitate the participation of the fishermen in the experimental design, in the data collection and in increasing their involvement relating to actions of conservation, meetings were organized at Puerto Magdalena and Puerto Adolfo López Mateos. The problems of loggerhead turtle were discussed, the results obtained in the workshops sessions were reviewed and the dynamics of the project were explained. Informative brochures were distributed in both communities with the same information, and individual informal interviews were carried out. Fishermen willing to participate, whether by directly modifying their fishing equipment or by contributing complementary information to the project, were engaged.

In 2004, four fishing teams, utilizing two gillnets each, were contracted to fish with modified nets. As a complementary action of local involvement, a local fisherman was hired to monitor the net tests, along with research interns who were also responsible for the project.

In 2005, fishermen were provided updated information regarding results from the gillnet modification experiments in 2004, stranding surveys, and data collection methodology. Fishermen were thus engaged in discussion regarding planning activities for the coming 2005 season. In order to involve a greater number of fishermen in the project, it was decided to work with two different groups of five teams. Again, fishers were granted interns to participate in data collection, thus giving more confidence to the experimental results.

***The assembling of experimental gillnets (2004).*** Design of experimental nets was arrived at through extensive discussion with the four fishing teams involved. Each gillnet was divided into four sections, two conventional sections (CS) and two test sections (TS), of approximately 60 meters in length each. The CS had a net depth of 2 fathoms approximately with suspenders of 1.8 m, while the TS had a net depth reduced to 1 fathom and suspenders reduced to 1 meter.

***The assembling of experimental gillnets (2005).*** Design of experimental gillnets was arrived at through extensive discussion with the fishing teams involved this year and those fishermen who participated in the 2004 experimental phase. This year, each gillnet was divided into four sections, of approximately 100 meters in length each, two conventional sections (CS) and two test sections (TS). the CS had suspenders of 1.8 m, while the TS had suspenders shortened to 1 meter; both the CS and the TS had a net depth of 2 fathoms approximately (20 meshes deep).

Number of fishing teams (2004). Four boats participated, each boat with two experimental gillnets.

Areas for anchoring experimental gillnets (2004). The areas for the anchoring of the experimental gillnets were not assigned, but rather left to the to the decision of the fishermen, whose selection of the area was based on their personal knowledge of the availability of fish just as it occurs in non -experimental conditions

Number of sets and areas for anchoring experimental gillnets (2005). The 2005 experimental gillnet test was performed in two phases. In each one of these phases 5 teams participated with two gillnets and 15 days of work (150 sets total by phase). In the first phase of the experiment, the areas for the anchoring of the experimental gillnets were, in the same way than 2004 season, not assigned, but rather left to the decision of the fishermen, whose selection of the area was based on their personal knowledge of the availability of fish just as it occurs in non-experimental conditions. In the second phase, and because during the performance of the first phase of the experiment, data collection was concentrated in shallow waters, the methodology was modified by asking the fishermen to separate the total 15 days of the test in 5 days periods and to set the gillnets in three different levels of depth: shallow waters (depth less than 10 fathoms); middle depth waters (depths between 10 and 16 fathoms); and deep waters (beyond 17 fathoms).

## DATA COLLECTION (2004 AND 2005):

The collection consisted of the following:

- Date
- Starting Time and End time of each anchoring
- Team number.
- Recorder.
- Starting and ending GPS Coordinates of each anchoring.
- Depth.
- Type of sea floor.
- Surface water temperature.
- Catch per species in number of fish and total weight for the CS and TS of the experimental gillnets.
- Comments.

In the case of sea turtle bycatch:

- Species
- Status (alive or dead).
- Length and width of carapace.
- Capturing section (conventional or test).

Equipment used. For the registration of geographic location, Garmin GPS's model Geko were used. Depth and temperature were measured with portable depth sounders.

Analysis of catch (2004). In order to compare the relative importance and value of each species in the catch and to evaluate the effect on the income of the fisherman with modifications made to the gillnets, an Index of Bio-economic Importance (Díaz and Ramírez 2004, in preparation) was calculated for each species in the following way:

IIBEj = (% Ci +%Vi)*%Fi

Where, IIBEi: index of Bio-economic importance of the species i; % Ci: percentage in weight of the species i in the total catch (weight of fish cleaned); % V: percentage in price of the species i in the total value of the catch; % Fi percentage of the number of sets in which the species i appears in the total number of sets registered.

The volume of catch in weight of gutted fish was calculated using an index of conversion calculated for each species from actual weights of the whole and gutted fish of a sample. The index used for each species is presented in Appendix 2 (at end of this report).

The Index of Bio-economic Importance was used to establish a hierarchical order of the resources and its relative importance to the value of the catch that is obtained with the experimental gillnet.

# RESULTS

## Fishery Characterization

**The Halibut Fishery operating in Magdalena Bay.** An artisanal fishery for halibut (see Appendix 2 for the scientific names of all species mentioned in this report) in Magdalena Bay has been conducted for several decades from small boats near the coast. The equipment that is used consists of boats of 21-25 feet long using outboard motor of 55-85 hp. These boats are commonly operated by two fishermen. The fishing gear utilized are gillnets that are usually 60 m (130 fathoms long) and 2-3 fathoms in depth with a stretched mesh size of 8 inches. In some cases, another kind of gillnet that is deeper (up to 5 fathoms) and has a larger mesh size is used for snapper. According to some fishermen of the community of Puerto Magdalena, this deeper gillnet catches a higher number of sea turtles. The gillnets are anchored in sandy or rocky sea floors, and checked each morning to collect the catch. The gillnets are set in depths between one to thirty fathoms and remain anchored in the same place for several days until the fisherman considers that there is a decrease in catch in that area and consequently will move to another place looking for a greater catch.

It is important to consider that several years ago, the halibut fishery was performed with line and fishhook. Currently, there are few cases of fishermen who still practice this fishing method, however, it requires considerably greater skill and effort to obtain the same amount of catch. Because the price of the fish does not depend on the fishing equipment used, the present tendency is to abandon the use of fishhook and use of gillnets. Fishing for halibut is an activity, of medium economic importance in the area, given the existence of better paying marine activities such as lobster or shrimp fishing and whale watching tours during the gray whale season. The halibut fishing season falls between whale watching season, and the shrimp and lobster fishing season (Table 1). The largest number of fishermen fishing halibut live in the two communities of Puerto Magdalena (24° 37’ N and 112° 08W) and Puerto Adolfo López Mateos (25° 12’ N and 112° 07’ W).

**The Halibut Fishery of Puerto Magdalena.** Approximately 10 boats are dedicated to fishing halibut in Puerto Magdalena. Given their location, the gillnets set outside of the Bay represents a greater expense of fuel and physical effort, so they concentrate their activity inside Magdalena Bay and less frequently on the Pacific side, where they only fish when the product is scarce inside the Bay. The place where the gillnet is placed also determines how frequently it is checked. If it is placed inside the Bay it is checked twice a day; but if is placed outside the Bay, it will be checked only once a day.

The Halibut Fishery of Puerto A. López Mateos. Currently, in Puerto Adolfo López Mateos, 50 to 60 boats are dedicated to this activity, concentrating the area of fishing in two areas: the first found between 6 and 12 fathoms deep, and the second one, approximately 23 fathoms deep. These areas are not exploited equally. While the shallower area results in a less expense of fuel, the deeper area is utilized when there is poor fishing in the nearby areas. Although the target species is halibut, other species with commercial value exist such as guitarfish and triggerfish, which represent a very high percentage of the fishermen’s incomes in some cases. According to the fishermen, the proportional volume between the target species (halibut) and the secondary species varies in the course of the season, registering a peak in halibut catch during May and June (spawning season) and a greater proportional volume in secondary species catch at the end of the halibut fishing season.

# FISHERY EXPERIMENTAL GILLNETS

***Number of sets (2004).*** Each boat performed 15 fishing trips in consecutive days, resulting in a total of 117 sets with experimental gillnets between July 29 to August 13, 2004. During three of the fishing trips, it was not possible to record data from one of the experimental gillnets due to damage that required major repair.

***Number of sets (2005).*** For the phase one of the experiment, a total of 129 sets were performed between June 18 to July 12, 2005. In the phase two of the experiment, a total of 147 sets were performed between July 12 to July 31, 2005.

***Area and depths of sampling (2004).*** The map shows the points where the experimental sets were performed. Due to the availability of product during to season in nearby areas, the total of the sets were performed in shallow waters with depths between 4.5 and 19 fathoms. Average value of depth = 11.09 fathoms. SD = 3.13. The type of sea floor, where the experimental gillnets were set varied between sandy, hard bottom and rocky.

***Area and depth of sampling (2005).*** In phase one, the total of the sets were performed in waters with depths between 1.22 and 12.67 fathoms. (Average=7.48 n=129). These sets were performed in areas where the fishermen considered to have a greater availability of product. The type of sea floor where the experimental gillnets were set varied between sandy (26 sets registered), hard bottom (18 sets registered) and rocky (43 sets registered). In the second phase of the experiment, 45 sets were performed in shallow waters, in depths between 3 and 9 fathoms; 66 sets performed in depths between 10 and 17 fathoms and 33 sets in depth between 17 and 23 fathoms.

***Catch per type of resource (2004).*** A total of 2,180 fish and 3,938 kg in weight (whole fish) belonging to 27 species (in some cases, different groups of species) were registered when CS and TS catch were considered together. Table 2 shows the number of fish and weight by species, as well as the relative price of the product in pesos and the IIBE (see the annex for reference of each species). The dominant species in biomass (weight of gutted fish) were the guitar fish (34.11% of total catch) and the halibut (29.6% including 1st and 2nd size). These two species represent more than the 75% of the total value of catch, while 90% of

Table 1. Timing of economic activities at the area throughout the year.

| | Jan | Feb | Mar | Apr | May | Jun | Jul | Aug | Sep | Oct | Nov | Dec |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Lobster | X | X | X | | | | | | | | X | X |
| Shrimp | | | | | | | | | X | X | X | |
| Catarina clam | | | | | X | X | X | | | | | |
| Halibut | | | | x | X | X | X | X | x | | | |
| Abalone | | | | | X | X | X | X | | | | |
| Tourism | X | X | X | | | | | | | | | |

Table 2. Values of IIBE for the catch of the CS's and TS's as 1 group. (see reference of species in annex 3).

| Species | PZ | KG | FR | KGE | $ | %PZ | %KGE | %$ | %FR | IIBE | %$CUM |
|---|---|---|---|---|---|---|---|---|---|---|---|
| GTR | 712 | 1556 | 144 | 933.6 | 7468.8 | 32.66 | 34.11 | 24.91 | 63.72 | 3760.66 | 24.91 |
| LDO 1 | 173 | 557 | 91 | 501.3 | 11529.9 | 7.94 | 18.32 | 38.46 | 40.27 | 2285.92 | 63.37 |
| LDO 2 | 306 | 343 | 121 | 308.7 | 4013.1 | 14.04 | 11.28 | 13.38 | 53.54 | 1320.49 | 76.75 |
| VDO | 246 | 197 | 114 | 177.3 | 709.2 | 11.28 | 6.48 | 2.37 | 50.44 | 446.08 | 79.12 |
| CCH | 176 | 451 | 39 | 248.05 | 1984.4 | 8.07 | 9.06 | 6.62 | 17.26 | 270.61 | 85.73 |
| MJR | 121 | 74 | 56 | 66.6 | 266.4 | 5.55 | 2.43 | 0.89 | 24.78 | 82.31 | 86.62 |
| GTA | 45 | 99 | 32 | 65.34 | 980.1 | 2.06 | 2.39 | 3.27 | 14.16 | 80.09 | 89.89 |
| GVL | 41 | 225 | 30 | 51.75 | 207 | 1.88 | 1.89 | 0.69 | 13.27 | 34.26 | 90.58 |
| CHN | 123 | 68 | 25 | 61.2 | 244.8 | 5.64 | 2.24 | 0.82 | 11.06 | 33.77 | 91.40 |
| GPA | 13 | 48 | 8 | 43.2 | 1080 | 0.60 | 1.58 | 3.60 | 3.54 | 18.34 | 95.00 |
| Other | 224 | 320 | | 279.9 | 1499 | 10.3 | 10.2267 | 5.00 | | | 100.00 |
| Total | 2180 | 3938 | | 2736.94 | 29982.7 | | | | | | |

PZ = Number of fish; KG = Total weight of catch in Kg; FR = Number of sets where the species was recorded; KGE = Weight of gutted fish; $ = Total value of the species in Mexican currency; % PZ, % KGE, % $, % FR = Same values represented in percentage; IIBE: Index of Bio-economic Importance; %$ACUM = Cumulative Percentage of the price of the catch. Numbers in green represent the 75% of the accumulated price; the numbers in orange represent the 90% of the accumulated price.

Table 3. Values of IIBE for catch in conventional sections (CS's). See explanation in Table 2.

| Species | PZ | KG | FR | KGE | $ | %PZ | %KGE | %$ | %FR | IIBE | %$CUM |
|---|---|---|---|---|---|---|---|---|---|---|---|
| GTR | 432 | 940 | 74 | 564 | 4512 | 28.72 | 30.35 | 22.00 | 65.49 | 3428.27 | 22.00 |
| LDO 1 | 122 | 402 | 58 | 361.8 | 8321.4 | 8.11 | 19.47 | 40.58 | 51.33 | 3082.04 | 62.58 |
| LDO 2 | 174 | 204 | 67 | 183.6 | 2386.8 | 11.57 | 9.88 | 11.64 | 59.29 | 1275.87 | 74.22 |
| VDO | 202 | 155 | 57 | 139.5 | 558 | 13.43 | 7.51 | 2.72 | 50.44 | 515.90 | 76.94 |
| CCH | 153 | 403 | 26 | 221.65 | 1773.2 | 10.17 | 11.93 | 8.65 | 23.01 | 473.38 | 85.59 |
| MJR | 94 | 57 | 41 | 51.3 | 205.2 | 6.25 | 2.76 | 1.00 | 36.28 | 136.46 | 86.59 |
| GTA | 24 | 51 | 20 | 33.66 | 504.9 | 1.60 | 1.81 | 2.46 | 17.70 | 75.63 | 89.05 |
| CHN | 109 | 61 | 18 | 54.9 | 219.6 | 7.25 | 2.95 | 1.07 | 15.93 | 64.11 | 90.12 |
| GVL | 33 | 177 | 22 | 40.71 | 162.84 | 2.19 | 2.19 | 0.79 | 19.47 | 58.11 | 90.92 |
| ARO | 56 | 35 | 12 | 31.5 | 126 | 3.72 | 1.69 | 0.61 | 10.62 | 24.52 | 91.53 |
| GPA | 9 | 36 | 4 | 32.4 | 810 | 0.60 | 1.74 | 3.95 | 3.54 | 20.15 | 95.48 |
| Other | 96 | 165 | | 143.4 | 927 | 6.383 | 7.716 | 4.52 | | | |
| Total | 1504 | 2686 | | 1858.4 | 20507 | | | | | | |

Table 4. Values of IIBE for the catch of the test sections (TS). See explanation in Table 2.

| Species | PZ | KG | FR | KGE | $ | %PZ | %KGE | %$ | %FR | IIBE | %$CUM |
|---|---|---|---|---|---|---|---|---|---|---|---|
| GTR | 280 | 616 | 70 | 370 | 2956.8 | 41.42 | 42.07 | 31.20 | 21.67 | 1587.99 | 31.20 |
| LDO 2 | 132 | 139 | 54 | 125 | 1626.3 | 19.53 | 14.24 | 17.16 | 16.72 | 525.00 | 48.37 |
| LDO 1 | 51 | 155 | 33 | 140 | 3208.5 | 7.54 | 15.88 | 33.86 | 10.22 | 508.17 | 82.23 |
| VDO | 44 | 42 | 57 | 38 | 151.2 | 6.51 | 4.30 | 1.60 | 17.65 | 104.09 | 83.82 |
| GTA | 21 | 48 | 12 | 32 | 475.2 | 3.11 | 3.61 | 5.01 | 3.72 | 32.03 | 88.84 |
| BCH | 27 | 55 | 16 | 50 | 0 | 3.99 | 5.63 | 0.00 | 4.95 | 27.91 | 88.84 |
| CCH | 23 | 48 | 13 | 26 | 211.2 | 3.40 | 3.01 | 2.23 | 4.02 | 21.07 | 91.07 |
| MJR | 27 | 17 | 15 | 15 | 61.2 | 3.99 | 1.74 | 0.65 | 4.64 | 11.09 | 91.71 |
| GPA | 4 | 12 | 4 | 11 | 270 | 0.59 | 1.23 | 2.85 | 1.24 | 5.05 | 94.56 |
| GVL | 8 | 48 | 8 | 11 | 44.16 | 1.18 | 1.26 | 0.47 | 2.48 | 4.27 | 95.03 |
| Other | 86 | 127 | | 111 | 471.2 | 12.722 | 12.67 | 4.97 | | | |
| Total | 676 | 1252 | | 879 | 9475.76 | | | | | | |

Table 5. The catch of fish, per item and kg, for experimental phase 1 and 2.

| Phase One | Conventional Sections (CS) | Test Section (TS) |
|---|---|---|
| Total catch # | 869 | 1,309 |
| Total catch (kg) | 2,397 | 3,330 |
| Halibut catch # | 193 (21.6%) | 280 (21.4%) |
| Halibut catch (kg) | 700 (29.2%) | 1,013 (30.4%) |

| Phase Two | Total | | SW | | MW | | DW | |
|---|---|---|---|---|---|---|---|---|
| | CS | TS | CS | TS | CS | TS | CS | TS |
| Total catch # | 1,726 | 1,832 | 602 | 629 | 924 | 927 | 200 | 276 |
| Total catch (kg) | 4,536 | 4,292 | 1,324 | 1,294 | 2,112 | 1,960 | 1,100 | 1,038 |
| Halibut catch # | 95 (5.5%) | 106 (5,8%) | 41 (6.8%) | 42 (6.7%) | 49 (5.3%) | 58 (6.3%) | 5 (2.5%) | 6 (2.2%) |
| Halibut catch (kg) | 378 (8.3%) | 485 (11.3%) | 161 (12.2%) | 181 (14%) | 196 (9.3%) | 283 (14.4%) | 21 (1.9%) | 21 (2%) |

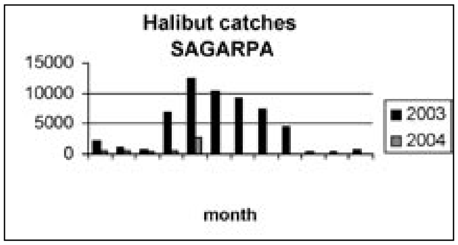


FIGURE 1. *Halibut catch at the area of López Mateos during 2003-2004 fishing seasons.*

Table 6. Sea turtles captured during phase one and two of experiments.

| No. | Sp. | L (cm) | Date | Depth (fathoms) | Depth (level) | Segment (CS or TS) | Condition |
|---|---|---|---|---|---|---|---|
| Phase One | | | | | | | |
| 1 | Cm | 47 | Jun 25 | 3 | 1 | TS | alive |
| 2 | Cm | 40 | Jul 1 | 6 | 1 | TS | alive |
| 3 | Cm | 45 | Jul 5 | 7 | 1 | TS | alive |
| Phase Two | | | | | | | |
| 4 | Cm | 45 | Jul 17 | 6 | 1 | TS | alive |
| 5 | Cc | 73 | Jul 20 | 22 | 3 | CS | dead |
| 6 | Cc | 65 | Jul 26 | 22 | 3 | TS | dead |
| 7 | Cc | 85 | Jul 29 | 23 | 3 | TS | dead |
| 8 | Lo | 66 | Jul 30 | 14 | 2 | CS | alive |
| 9 | Cc | 83 | Jul 30 | 22 | 3 | CS | alive |
| 10 | Cc | 86 | Jul 30 | 21 | 3 | TS | dead |
| 11 | Cc | 86 | Jul 30 | 21 | 3 | TS | alive |
| 12 | Cc | 67 | Jul 30 | 21 | 3 | CS | alive |
| 13 | Cc | 83 | Jul 31 | 21 | 3 | CS | dead |
| 14 | Cc | 75 | Jul 31 | 21 | 3 | CS | dead |
| 15 | Cc | 70 | Jul 31 | 21 | 3 | CS | dead |
| 16 | Cc | 80 | Jul 31 | 21 | 3 | TS | dead |

Table 7. Bycatch of sea turtle in conventional versus test sections.

| Bycatch | Total | | SW | | MW | | DW | |
|---|---|---|---|---|---|---|---|---|
| | CS | TS | CS | TS | CS | TS | CS | TS |
| Total | 7 | 9 | 0 | 4 | 1 | 0 | 6 | 5 |
| Dead | 4 | 4 | 0 | 0 | 0 | 0 | 4 | 4 |
| Alive | 3 | 5 | 0 | 4 | 1 | 0 | 2 | 1 |
| Loggerhead (dead) | 4 | 4 | 0 | 0 | 0 | 0 | 4 | 4 |
| Loggerhead (alive) | 2 | 1 | 0 | 0 | 0 | 0 | 1 | 1 |

*In Table 7, bycatch of sea turtles, particularly of loggerhead, by type of net (CS or TS) and depth of setting are compared (both phases included).*

the total value of the catch can be reached if including the value of the spotted sandbass, the trigger fish, the mojarra, the hammerhead, and the eagle ray.

***Catch per type of section (2004).*** Comparing the catch in weight in the CS's (2,686 Kg.) and the TS's (1,252 Kg.), a statistically significant difference was observed F=23.0069 p <.05. In this way, the catch obtained with the CS's contributed 68% (20,507 pesos) of the total value whereas the TS's contributed 32% (9,475 pesos) of the total value. Tables 3 and 4 show the catch by type of section, as well as the values of IIBE calculated in base to the catch of the type of section. Figure 1 is halibut catch reported by government office in Lopez Mateos, SAGARPA-CONAPESCA.

***Bycatch of sea turtles (2004).*** Only one record of bycatch of sea turtle was registered in experimental gillnets. It was a specimen of green turtle (Chelonia mydas) with a carapace 51 cm in length by 42 cm wide captured in August 12 (25º 12.237'N 112º 10.538'W). This turtle was enmeshed in a CS of the experimental gillnet which was set in a rocky sea floor. The turtle was alive at the time the gillnet was checked thus it was returned to the sea in good condition for surviving.

***Catch per type of section (2005).*** Table 5 shows catch in number of fish (items), and kilograms for phase one and two. It also shows the catch for halibut as the species more representative of the actual value of the catch. Catch rates were identified in terms of water depth, such as shallow water (SW), medium depth water (MW), and deep water (DW).

***Bycatch of sea turtles (2005).*** In 276 settings (129 corresponding to phase one and 146 to phase two), 16 sea turtles were captured (Table 6). During the first experimental phase, three sea turtles were captured. There were three specimens of green turtle (*Chelonia mydas*). During the second phase of the experiment, 13 sea turtles were captured. There were one specimen of green turtle (*Chelonia mydas*), one specimen of Olive's Ridley, (*Lepdochelis olivacea*) and 11 specimens of loggerheads (*Caretta caretta*).

In Table 7, bycatch of sea turtles, particularly of loggerhead, by type of net (CS or TS) and depth of setting are compared (both phases included).

*Fishermen who attended the workshop in 2004 from Magdalena Island.*

*Fishermen who attended the workshop in 2004 from Lopez Mateos.*

*Workshop attendance by fishermen in 2005 (top & bottom).*

## DISCUSSION

***Involvement of fishermen in the process of protection and conservation of sea turtles.*** Enrollment and involvement of fishermen in the experimental component of the project is taken to be a sign of increased awareness for the protection of sea turtles. This process will be facilitated in the future by the multiplicative effect of all those who supported the project. Particularly noteworthy is the increase of fishers attending workshops from 2004 to 2005. Throughout the project, fishermen have become increasingly more organized and supportive of each other to avoid illegal activities commonly linked to a greater impact on fish resources and fishing economy. Interest in alternatives, such as the promotion of eco-tourism (to include turtle and bird watching, camping on the dunes, visits to the estuaries, etc.) or sport fishing, was shown as complementary activities to the commercial fishing. The fishermen of the area already have a very clear idea of the requirements of this kind of activity, because they have acquired skills, as managers and guides, for whale watching activities in winter time.

This kind of organization is expected to help reduce the impact on the sea turtle populations. Related to aspects such as zoning focused to promote a more efficient, rational, and responsible use of the local natural resources, are also reducing the pressure on all other prohibited resources. In relation to this last point, it was agreed that fishermen would formulate a proposal, with the help of Procaguama, to be presented in the second weekend of January 2006 to be analyzed and, if possible, applied in the summer 2007 in an experimental way. The goal of this experimental eco-tourism program would be to get the fishermen interested in the process as a potential economic alternative for them. It is important to note the positive effect of motivating the participation of these people through public acknowledgements for those who collaborated (see Appendix 1 at the end of this chapter).

***Importance of the fishing activity at the area.*** Small scale fishing of this kind is not a highly lucrative activity for the local communities, compared to other activities such as whale watching or shrimp or lobster fishing. But during those months of the year when there is not availability of these resources (April-August), its relative importance is higher because there are few alternatives for work (Table 1). However, developing alternatives of sustainable use of natural resources in those months are possible, such as turtle tours, sport fishing or bird watching. We recommend such promotion in order of reduce the impact of fishing on sea turtles.

***Performance of the experimental gillnets (2004).*** It was hypothesized that reducing the gillnet depth, by using shorter suspenders and by cutting the net might be a viable

*Catch from the experimental gillnets.*

alternative that would result in an fishing equipment to be more selective for abundant species of high commercial value. As expected, the modified gear performed better for those species of fish living near the seafloor (halibut, guitarfish), that, in turn, have a relatively high commercial value and, consequently, represent the major value of the catch (see Tables 2, 3 and 4). It is important to keep a good catch performance for any modified equipment for these species (number and size of fish taken), to ensure there is minimum or no decrease of the fishermen's income. In addition, using a shortened gillnet would result in a lower price of the fishing equipment.

Besides the net depth and the suspenders length, other factors exist that can affect the performance of the gillnets which were not possible to evaluate. Some of them were related with the way the experimental gillnets were assembled and others with the timing of the data collection.

In relation to the assembling the experimental gillnets, the conventional sections (CS) of nets were made of a mesh of 8", while the test sections (TS) used a mesh of 7.5". This inconsistency was due to the unavailability in the market of the larger size mesh. This difference, according to the perception of the fishermen, could cause a poorer efficiency of the TS to catch fish of greater size. This was supported in the case of the halibut, the CS presented a greater proportion of first class halibut (more than 2 kg), whereas the TS took a greater proportion of halibut of second class of smaller size (less than 2 kg). Also, according to the opinion of the fishermen, the decrease in the net depth of the TS caused a reduction of the size of the bag that is formed in the bottom of the gillnet once this is set. This bag helps to enmesh fish that touch the gillnet due to the movement of the prey trying to get free. From these comments, the suggestion came to assemble the gillnets with bales of deeper netting (8 feet) in order to keep an adequate proportion among the length of the suspenders and the depth of the mesh.

Regarding the timing of the experiment, the fishing season for halibut in 2004 started in early May with a peak of captures at the end of the same month. If the catch of the target species (e.g., halibut) decreases, the fishery of secondary species, such as guitarfish or triggerfish, continues. This can cause the results of evaluating the effect in the income of the fishermen to be imprecise because they are not representative of the whole fishing season. For this reason, it is recommended to record the entire fishing season to ensure that changes in the availability of some species with a high price (halibut) or big volumes (triggerfish, guitarfish) can be evaluated.

***Bycatch of sea turtles in the experimental gillnets (2004).*** Based on the stranding rates of sea turtles (see Peckham report Figure 2, these proceedings) and volumes of halibut catch according to information provided by SAGARPA-CONAPESCA office in the area of López Mateos during 2003 and 2004 (Figure 1), a coincidence can be seen in the annual halibut fishing season and the number of beached turtles. This information is also supported by the data provided by the fishermen during the months when this activity is carried out. However, only one sea turtle was caught during the experimental gillnet study. This could be the result of several factors: 1) a difference in time between the halibut fishing season and the time of high concentration of sea turtles at the area due to unidentified environmental factors; or 2) performance of the fishing activities in different areas from those of high concentration of the sea turtles. It is important to emphasize that during the experiment, the fishermen fished exclusively in shallow waters near to the coast where there seems to be a lesser concentration of sea turtles.

Unfortunately, because of the low catch rate of sea turtles in the experimental component of the study, results are inconclusive for making any solid recommendations about reduced net height or depth. However, considering that reducing the depth of gillnets may reduce the bycatch of sea turtles, this option continues to be a viable alternative to test in the future.

***Performance of the experimental gillnets in 2005.*** In 2005, about 10 percent of the fishing fleet participated in the project (approximately 50 boats). In contrast to the 2004 season, the 2005 recorded catch data during the entire fishing season to assist in quantifying variations caused by the availability of species of high commercial value. Also, the experimental gillnets were standardized in relation to length and mesh size. This made it possible to obtain more precise results. In 2005, no additional experimental variables were added, however, and refinement to the gear was made to provide greater understanding of the performance measures of reducing gillnet depth (by using shorter suspenders, thus fishing deeper), and the placement of nets to quantify the effects of fishing deep versus shallow.

In the first phase, the experimental gillnet performance showed an important difference between the CS and the TS in that the TS were more efficient in catching fish (896 utilizing CS vs. 1,309 in TS) and in total catch weight (2,397.5 kg in CS vs. 3,330.2 kg in TS). In the second phase, shallow water settings contributed to the 34.5% of the total catch in the second phase of the experiment; middle water settings contributed with 52% of the catch; and the deep water settings contributed with 13.4% when number of fish considered. This supports the fact that the availability of fish is higher in depths lower than 16 fathoms. Also, there was higher contribution of the TS to the catch in any of the depths the experimental gillnets. Thus shortening of the suspenders in the experimental nets helped to get higher catch rates of fish.

***Bycatch of sea turtles in the experimental gillnets (2005).*** In both the first and the second phases of the experiment, the proportion of sea turtles caught in the TS vs the CS does not support that the shortening of the suspenders could help to reduce the bycatch of sea turtles or that it helps to reduce the number of sea turtles dead in the gillnets (Table 7). In the second phase of the experiment, there was remarkably strong correlation between depth of net setting and turtle bycatch (Table 6), and the frequency of dead turtles caught in deep water. Taken this into consideration, it is very important that the depth and capture rates be discussed at coming workshops. Avoiding fishing in depths shallower than 12 fathoms may be an effective measure to reduce sea turtle bycatch and mortality.

Importance of other fishing activities in the area in relation to sea turtle mortality (2005). The number of sea turtle strandings recorded by the monitoring of San Lázaro beach in 2005 (see Peckham report, Figure 2, these proceedings) is not totally explainable by the estimated mortality caused by the halibut gillnet fishing activity. In 2005, the use of gillnets for halibut in López Mateos and other fishing camps and communities like Santo Domingo and Cabo San Lázaro ended in mid-July. Therefore, the lack of gillnet fishery activity does not correspond to the number of beached turtles in August that reached a historical maximum of 167 dead turtles.

During this same period, however, a bottom-set longline fishery was detected by some fishermen. This activity originated from the Santa Rosa fishing camp. Personnel of ProCaguama visited the camp and fisherman agreed to allow personnel to accompany them on some sets. From September 7 – 22, 2005, 12 longline sets were observed, and 25 loggerheads were captured, 15 of them dead. The fishery was characterized by 6 fishing teams fishing with bottom-set longlines targeting sharks (two longlines per boat, deploying between 90-100 hooks each). Personnel were informed that this fishery had just recently begun last year (which may explain the increased stranding rates seen in October and November 2004). It was fortunate that dialogue has been initiated and the project is now working with the fishermen to identify alternatives to this high impact gear. This interaction with the fishery verifies the importance of using caution when authorizing the use of new fishing gear (such as bottom-set longlines).

## RECOMMENDATIONS

In order to give continuity to the ProCaguama project, we make the following recommendations for the 2006 season:

- Promote responsible fishing, by informing local fishermen of López Mateos, communities and fish camps of the area of the findings of the experiments carried out to date, and the agreements made in the workshops by the fishermen participants in the project. Specifically, highlight the importance of respecting areas of high concentration of sea turtles (i.e., in depths beyond than 12 fathoms).
- Promote the formulation of a plan for the organization focused on small scale fisheries with the involvement of local fishermen of the area, in order to promote and reinforce, in the long term, the responsible use of the resources, self regulation and collaboration of the community with the local and federal authorities in the administration and protection of the marine resources.
- Help and support the fishermen of López Mateos in formulating and developing an eco-tourism program which bring about an economic alternative for them, and contribute to reduce the pressure on marine resources of the area and, in particular, on the sea turtle populations.
- Continue investigations of new alternatives to high impact fishing gear, such as bottom-set longlines, and provide fishermen with relevant information to make informed choices about gear and the preference for low versus high impact techniques.

## APPENDIX 1. Participating Fishermen and ProCaguama team including Research Interns.

**PARTICIPATING FISHERMEN (2004)**

Jose Collins Parra
Carlos Sigalas
Tony Sigalas
Alfredo de la Toba
Arturo Contreras Camacho
Arturo de la Toba Domínguez
Cesareo Castro González (observador)
Carlos Sigala Villavicencio
Giovanni Collins González
Refugio Villa Aguilar
Alfonso Loera de la Toba
Antonio Sigala Villavicencio
Leonardo de la Toba González
Arturo de la Toba González
Jose Maria de la Toba González

**RESEARCH INTERNS (2004)**

Bertha Montaño Medrano
Ruth Ochoa Diaz
Vladimir de la Toba
Xochil Cortes Rodriguez

**PARTICIPATING FISHERMEN (2005)**

Néstor Iván Camacho (Cochita)
Juan Carlos Contreras (Monochuki)
Modesto Contreras
Eliseo de la Toba Lucero (Prieto)
Ulises de la Toba Romero
Darío de la Toba Miranda
Alejandro Rodríguez
Adrián Geraldo Murillo
Juan de la Rosa Sandoval
José Pantaleón de la Rosa Sandoval (Panta)
Genaro de la Rosa Sandoval
Edgar Burgoin Sánchez (Güero)
Miguel Rodríguez Cinco
Everardo Álvarez López
Javier Romero (Memín)
Marcelo Romero
Carlos Sigala
Antonio Sigala
Bernabé de la Toba Romero (Boli)
Espriridión de la Toba Romero (Chacuiri)
José Domínguez
Oscar Domínguez

**RESEARCH INTERNS & VOLUNTEERS(2005)**

Edgar Caballero.
Cesareo Castro.
Rodrigo Donadi.
Eglé Flores.
Alexander Gaos.
Bertha Montaño.
Ruth Ochoa.
David Ramírez.
Rodrigo Rangel.
Natalia Rossi.
David Soriano.

**Appendix 2. Catch: species, key, scientific name, price in 2004 and "gutted fish weight" conversion factor by species, used to obtain the IIBE.**

| KEY | LOCAL COMMON NAME | ENGLISH NAME | SCIENTIFIC NAME | PRICE (pesos) | GUTTED FISH WEIGHT CONVERSION FACTOR |
|---|---|---|---|---|---|
| ACZ | ANGEL DE CORTEZ | CORTEZ ANGELFISH | *Pomacanthus zonipectus* | 8 | 0.5 |
| ARO | ARENERO | SPOTTER SANDBASS | *Paralarax maculofasciatus* | 4 | 0.9 |
| BAC | BACOCO | BURRITO GRUNT | *Anisotremus interruptus* | 4 | 0.9 |
| BTO | BONITO | BONITO | *Sarda sp.* | 0 | 0.9 |
| BTE | BOTETE | BULLSEYE; PUTTERFISH | *Sphoeroides sp.* | 20 | 0.9 |
| CBA | CABRILLA | SANDBASS | *Paralabrax sp.* | 4 | 0.9 |
| CZN | CAZON | SMOOTHOUND | *Mustelus sp.* | 15 | 0.9 |
| CHN | CHANO | YELLOWFIN CROAKER | *Umbrina roncador* | 4 | 0.9 |
| CCH | COCHITO | FINESCALE TRIGGERFISH | *Balistes polylepis* | 8 | 0.55 |
| CTA | CURRICATA | PACIFIC SAND PERCH | *Diplectrum pacificum?* | 4 | 0.9 |
| CNA | CURVINA | CORVINA | *Cynosion sp.* | 18 | 0.9 |
| GPA | GARROPA | BROOMTAIL GROUPER | *Mycteroperca xenarcha* | 25 | 0.9 |
| GVL | GAVILAN Y MANTAS | RAYS, ROUND STINGRAY BAT RAY | *Raja sp; Urolophus sp.; Myliobatis sp.* | 4 | 0.23 |
| GTA | GORRETA | HAMMERHEAD SHARK | *Sphyrna sp.* | 15 | 0.66 |
| GTR | GUITARRA | SHOVELNOSE SHARK | *Rhinobatos productus* | 8 | 0.6 |
| LDO 1 | LENGUADO 1A | HALIBUT | *Paralichthys sp.* | 23 | 0.9 |
| LDO 2 | LENGUADO 2DA | HALIBUT | *Paralichthys sp.* | 13 | 0.9 |
| LPN | LUPON | SCULPIN | *Scorpaena sp* | 4 | 0.5 |
| MRO | MERO | CABRILLA | *Epinephelus sp.* | 20 | 0.9 |
| MJR | MUELUDA | PACIFIC PORGY | *Calamus sp.* | 4 | 0.9 |
| PPN | PAMPANO | PAMPANO | *Trachinotus sp.* | 4 | 1 |
| PGO | PARGO | SNAPPER | *Lutjanus sp.* | 14 | 0.9 |
| BCH | PEZ PERRO | SMOOTH STARGAZER | *Kathetostoma averruncus* | 0 | 0.9 |
| RCH | RONCACHO | BLACK CROAKER | *Cheilotrema saturnum* | 4 | 0.9 |
| SRA | SIERRA | SIERRA MACKEREL | *Scomberomorus sierra* | 12 | 0.9 |
| VDO | VERDILLO | SPOTTED SANDBASS | *Paralabrax sp.* | 4 | 0.9 |
| VJA | VIEJA | SHEEPHEAD | *Semicossyphus pulcher* | 14 | 0.9 |

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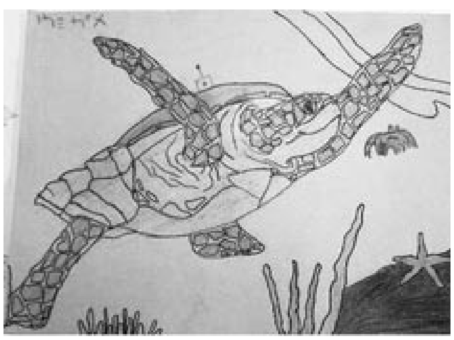
*Sea Turtle Association of Japan*
**Johath Laudino-Santillán**
*Grupo Tortuguero*
**Hoyt Peckham**
*ProCaguama*

# Environmental Education on Pacific Loggerhead Turtles for School Children in Mexico and Japan

The loggerhead sea turtle is the Pacific "ambassador" connecting communities and cultures across the north Pacific. A unique exchange program has been implemented through *ProCaguama* that has proven effective for broadening perspectives and increasing capacity for conservation among communities in Baja and Japan.

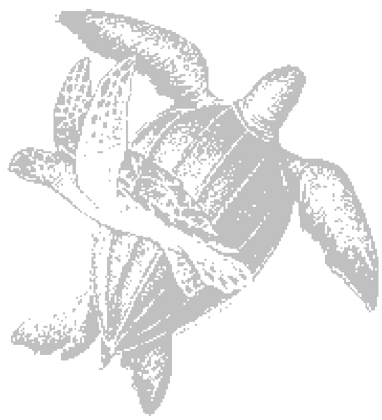
The unique characteristic that defines this exchange program is due to one individual, Kojiro Mizuno, who speaks fluent Japanese and Spanish. A native of Japan, Mizuno's father worked as an entomologist in Peru where Mizuno learned Spanish. The program has thus been able to capitalize on his talents to transcend the language barrier to connect school children from both sides of the Pacific for one common cause: the conservation of loggerheads.

Working together with Johath Laudino, Grupo Tortuguero education coordinator, Mizuno is able to bring stories from school children in Japan to children in Baja, and vice versa. The most universal language, however, is art. And through the arts, children are able to share their experiences, thoughts and stories about sea turtles.

The project works with coastal communities in Japan that have nesting loggerhead sea turtles. In Baja, the rich coastal waters harbor important developmental and foraging habitats for turtles. Thus, by connecting the children and students of Japan with Baja, tangible knowledge is acquired about the life cycle, migratory capabilities and survival challenges for turtles. By empowering children on both sides of the Pacific to become involved in sea turtle conservation, greater capacity within communities is fostered to support sustainable use practices to reduce local harvest pressure.

In the future, the project will expand to bring respected, yet skeptical fishers from core communities in Baja to Japan to witness "Mexican" turtles nesting in Japan. It is hoped that this trans-Pacific experience will broaden perspectives and make a big difference in engaging these fishermen, their kids, their families, in developing solutions for both bycatch and poaching solutions.

**Mr. Peckham:** One comment about Mizuno. He's a big man in Mexico. He's large. But the effect of Mizuno walking into one of these small villages, with his size and the fact that he speaks Spanish, is extraordinary. We are very lucky to have him to bring this message from Japan to these small Mexican communities, and vice versa.



# Health Issues of Sea Turtles: A Conservation Medicine Approach

**Dr. Alonso Aguirre D.V.M.**
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## INTRODUCTION TO CONSERVATION MEDICINE

In recent years, the term Conservation Medicine has been used in several contexts within different scientific communities, national/international organizations and research groups. The book *Conservation Medicine: Ecological Health in Practice* (Aguirre et al. 2002) was published in an attempt to define a new discipline that links human and animal health with ecosystem health and global environmental change. This novel approach in the protection of biological diversity challenged scientists and practitioners in the health, natural and social sciences to think about new, collaborative ways to address ecological health concerns in this deteriorating world.

Conservation Medicine is a transdisciplinary scientific field devoted to understanding the interactions among: (1) human-induced and natural changes in climate and habitat structure; (2) emergence of pathogens, parasites, and pollutants; (3) biodiversity and health within animal communities; and (4) health of humans. Conservation medicine has both scientific and applied elements, and many endeavors in this field combine aspects of both. Simply stated, Conservation Medicine is the science and practice of ecological health and is especially relevant in today's human-modified landscapes, where habitat destruction and degradation and episodes of emerging human and wildlife diseases are increasing. In this context, ecological health is at the nexus of the fields of human health, animal health and ecosystem health. Conservation Medicine embraces participation by scientists and practitioners in the fields of ecology; organismal, cellular, molecular, and conservation biology; toxicology; epidemiology; veterinary and human medicine; and public health. In addition, perspectives from the social and political sciences are fundamental in understanding the underlying causes of human-induced changes in climate, habitat, and the use of terrestrial and marine ecosystems. Although Conservation Medicine is a scientific discipline, it may provide the basis for political positions on the conservation and management of species and ecosystems. The hope is that once armed with the appropriate knowledge, public policymakers and scientists will proactively devise and implement epidemiological strategies to better ensure ecological health.

In comparison to human and veterinary medicine, Conservation Medicine addresses the examination of ecological health concerns beyond the species-specific approach. Clearly, in some respects, human health holds a greater priority than the health of other species. To date, human medicine has been limited in looking at the health connections between species and the environment (i.e., ecosystem health). Human health intervention has been focused on the downstream effects of environmental impacts (e.g., health consequences of landscape changes or pollution emissions) rather than encompassing a preventive approach in looking at upstream events, for example, prevention of massive ecological degradation or pollution prevention (Aguirre et al. 2002; Tabor et al. 2001).

There are no simple solutions to address global environmental problems. A multi-pronged strategy is required. By bringing disciplines together, Conservation Medicine can contribute to solving environmental problems by improving problem definition requiring new tools for assessing and monitoring ecological health concerns. Perhaps, incorporating aspects of environmental indicator studies with specific biomedical diagnostic tools can develop integrated ecological health assessment. Tools include the development of non-invasive physiological and behavioral monitoring techniques; the adaptation of modern molecular biological and biomedical techniques; the design of population level disease monitoring strategies; the creation of ecosystem-based health and sentinel species surveillance approaches; and the adaptation of health monitoring systems for appropriate developing country situations. Beyond monitoring and assessment is action.

Improving medical and ecological education and the need for public policy development in promoting ecological health are fundamental goals of Conservation Medicine (Aguirre et al. 2002).

## CONSERVATION MEDICINE AND SEA TURTLES

There are seven species of hard-shelled sea turtles belonging to the family Cheloniidae recognized worldwide including green turtle (*Chelonia mydas*), black turtle (*C. aggassizii*), loggerhead turtle (*Caretta caretta*), olive ridley turtle (*Lepidochelys olivacea*), Kemp's ridley turtle (*L. kempii*), hawksbill turtle (*Eretmochelys imbricata*) and the flatback turtle (*Natator depressus*). The only member of the Dermochelyidae family is the leatherback turtle (*Dermochelys coriacea*). All species have a biphasic life cycle nesting and hatching on the beach and then departing to the ocean where they spend most of their lives.

Several immature and nesting migratory routes have been described with the use of flipper tags and more recently with GPS and satellite tags. The feeding habits depend on the species. For example, loggerheads, ridleys and flatbacks feed on crustaceans and mollusks; hawksbills feed on sponges; leatherbacks and olive ridleys feed on gelatinous zooplankton and green turtles and black turtles feed on algae and seagrasses. All species are considered endangered or threatened of extinction and are listed in the IUCN Red Data List of Endangered Species (IUCN 2003). Natural mortality factors have been described for sea turtles including shark, raccoon, vulture, and crab predation. However, the factors leading to species decline are in most cases induced by anthropogenic change. These include incidental mortality by fisheries bycatch, net entanglements, boat strikes, overharvesting and nesting sites development (Lutz and Musick 1997).

The need for an up-to-date guide to the anatomy of sea turtles became clear toward the end of the 1900s (Rainey 1981). Increasing numbers of individuals developed the interest, talents, and techniques to study the biology of sea turtles, contend with their illnesses and injuries, and address the nature of sea turtle mortalities. A manual has been recently published in response to these needs providing a fundamental background, reference photos of normal anatomy, and diagrams to guide novice or professional biologists, stranding personnel, and veterinarians. Species identification, standard dissection techniques, standard measurements, and basic anatomy are covered (Wyneken 2001). Also, field necropsy techniques have been described (Wolke and George 1981; Work 2000).

The diagnostic techniques employed in sea turtles are similar to other species, including blood collection from the external jugular vein (dorsal venous sinus), swabs taken from oropharynx and cloaca, skin and tumor biopsies using a human biopsy system Dermapunch®, and the use of x-ray machine, ultrasound machine, endoscopes and gas anesthesia (Campbell 1996).

Marine turtle fibropapillomatosis (FP) is one of the most important diseases among the health problems affecting free-ranging sea turtles (George 1997). Although reported since the late 1930's in Florida (Smith and Coates 1938) and since 1958 in the Hawaiian Islands (Balazs and Pooley 1991), the disease has recently reached epizootic proportions. It has primarily affected green turtles in many pantropical regions of the world. Also, it has been confirmed histopathologically in other species including loggerhead (Herbst 1994), olive ridley (Aguirre et al. 1999), Kemps ridley (Harshbarger 1991), leatherback (Huerta et al. 2000), and more recently in captive-raised hawksbill turtles (D'Amato and Moraes-Neto 2000). Flatback turtles in Australia were also reported with tumors by gross examination (Limpus and Miller 1994).

The potential interactions and epidemiological links regarding the causal hypotheses of FP have been the subject of discussion. PCR techniques applied on a large number of freshly isolated tumor samples failed to detect papillomavirus. The molecular identification of one or more herpesviruses (Aguirre and Spraker 1996; Herbst et al. 1995, 1999; Lackovich et al. 1999; Lu et al. 2000b; Quackenbush et al. 1998, 2000), a papilloma-like virus (Lu et al. 2000a), and a retrovirus (Casey et al. 1996) in tumors from different species collected around the world has complicated the scenario to determine the primary etiology of tumor formation. Other co-factors may play a role including immunosuppression, genetic susceptibility, biotoxins, chemical carcinogens, environmental pollutants, ultraviolet light, spirorchid trematodes and other potential pathogens (Aguirre 1991; Aguirre and Lutz 2004; Aguirre et al. 1998, 2002; Dailey and Morrris 1995; Landsberg et al. 1999).

These debilitating and disfiguring tumors can measure from 1 mm up to 40 cm in diameter and have been reported in practically all keratinized tissues including skin, plastron and carapace. Tumors are more prominent on the axillae, inguinal region, neck, cloaca, tail, between scales and scutes, eyes and conjunctiva. Ocular fibropapillomas have been described in detail as locally invasive associated with severe blindness, secondary panophthalmitis, destruction of the globe, and systemic debilitation (Brooks et al. 1994). Tumors have been reported in most internal organs. Visceral fibromas are known to cause cardiac and respiratory disease, hydronephrosis, and gastrointestinal obstruction (Herbst 1994). Also, leiomyomas, fibromas and low-grade fibrosarcomas have been described (Aguirre et al. 2000).

The histopathology of external fibropapillomas has been previously described for green turtles in Florida (Jacobson et al. 1989) and the Hawaiian Islands (Aguirre et al. 1994). The usual outcome of most affected turtles in Hawaii is debilitation over a protracted period, followed by death. The disease is known to interfere with the hydrodynamic and buoyancy features of turtles affecting their ability to swim. If the tumors are located around the eyes and mouth, turtles present reduced vision or complete blindness, disorientation, and physical obstruction of basic functions such as feeding and breathing. In addition, FP may drastically reduce the capacity for predator avoidance and increase the susceptibility of affected individuals to stranding, threatening their survival (Balazs and Pooley 1991; Morris and Balazs 1994).

Monitoring of tumors may be used as another parameter when evaluating the clinical condition and state of the affected individuals and their ability to survive in the wild. This monitoring also has implications during rehabilitation efforts. Survivability rates of about 50% in turtles with FP have been reported in a rehabilitation center in Florida (Herbst 1994). Studies on the progression of the disease are needed to establish severity of FP and their impact on sea turtle populations.

Other common health problems reported in sea turtles in the Hawaiian Islands include traumatic injuries, entanglement in fish lines or nets, gastrointestinal obstructions, buoyancy problems, emaciation, intoxication with petroleum problems and hypothermia or cold-stunning events. A loggerhead lethargic syndrome in Florida has also reported recently linked to harmful algal blooms (brevetoxin) and spirorchid trematodes. Over 154 species of spirorchid trematodes have been described in sea turtles worldwide. Three species have been reported in Hawaii closely linked to fibropapillomatosis (Aguirre et al. 1998; Graczyk et al. 1995).

Several disease reports of sea turtles are scattered in the literature including *Mycobacterium* infection in Hawaiian green turtles, “grey patch” disease in captive green turtle hatchlings linked to a herpesvirus, *Vibrio damsela* infection on a stranded leatherback turtle, integumental ulcerative disease in a loggerhead in the Bermuda Aquarium, mycotic lung disease in a stranded Kemp’s ridley turtle, a *Caryospora* dieoff in captive 30-day old green turtles, and *Chlamydophila* mortality in the Cayman Turtle Farm five-year old turtles. A report of *Cryptosporidium* in healthy Hawaiian greens has also been documented speculating on the potential public health risks (Graczyk et al. 1997).

The potential for applying existing diagnostic capacity to health monitoring of sea turtles is immeasurable. Particularly, the limitation of financial resources has been a major barrier. Laboratory support for performing diagnostic testing is minimal, occurring in limited laboratories with other primary research activities in Hawaii, Florida and New York, among others. Cross-species diagnostic testing, in which one laboratory can do comparative assessment of disease between populations and species, is sorely lacking. Yet, diagnostic laboratory testing plays an important role in monitoring health and diseases such as FP. The results of diagnostic testing are most useful when used to complement thorough field-based ecological research. These will represent the next steps to address ecosystem health in the marine environment.

## ECOSYSTEM HEALTH AND THE MARINE ENVIRONMENT

Methods to assess marine ecosystem health are grossly lacking and a system to monitor and gauge marine health threats linked to conservation and management policies is needed. Emerging infectious diseases, mass mortality events, harmful algal blooms, and anomalous changes in selected marine species abundance and composition — occurrences which can be defined as major marine ecological disturbances — may signal a decline in ecological health. There is currently an effort by many scientists to examine the systemic health threats to marine vertebrate species as they relate to marine environmental health. Unprecedented number of emerging and re-emerging diseases have occurred in recent times, such as brucellosis in dolphins, aspergillosis in coral reefs, and morbillivirus infections linked to large-scale marine mammal die-offs. Sea turtles are facing a worldwide epidemic of fibropapillomatosis and domoic acid poisoning killed thousands of California sea lions and brown pelicans in the Californias with unknown long-term population impacts. Threats to these charismatic megavertebrates are linked to human activities, including habitat degradation, loss of biodiversity and biomass, climate change, pollution, agricultural activities, and commercial fisheries. These impacts can ripple throughout ecological communities. The demise of one species or the rise of one species at the expense of another may establish a trophic cascade of devastating ecological responses.

One proactive method of trying to get a handle on the large-scale problem of disease emergence and resurgence is by surveying sentinel species (SS). Sentinel species serve as indicators of their environment and may reflect the quality of health in marine ecosystems. The single species approach may provide a series of "snap shots" of environmental changes to determine if animal, human or ecosystem health may be affected. Marine vertebrates are good integrators of changes over space and time and represent excellent sentinels of ecosystem health. By moving in and out of infected/polluted areas, they can spread pathogens and contaminants geographically as well as throughout the food chain. The "utility" of the SS selected should consider its value and relevance to decision makers, conservationists, local communities and to society at large.

The SS concept is a proactive approach in the development of an "Escalera Ecologica." We will be able to measure the health impacts in this fragile ecoregion by providing an "early warning" system for emerging diseases and environmental contaminants and proactively monitoring the course of disease related activities requiring prevention, remediation or control as the "Escalera Nautica" develops in Baja California, Mexico. It will require a suite of sentinel species (sea turtles, sea birds and marine mammals) including different trophic levels, ecological roles, taxa and different spatial/temporal scales and conservation medicine teams. Sentinel species are the proverbial "canaries in the mineshaft," clearly indicating the health and condition of this threatened ecoregion. We have identified a number of critical research needs and opportunities for transdisciplinary international collaboration with a proactive vision that could help advance the use of marine vertebrates as SS to monitor the health of the Baja California ecoregion and in turn the "Escalera Ecologica".

## REFERENCES


Aguirre, A. A. 1991. Green turtle fibropapilloma – an epidemiologic perspective. In: Research Plan for Marine Turtle Fibropapilloma. G. H. Balazs and S. G. Pooley, eds. NOAA Tech Memo NMFS-SWFSC-156, Honolulu, Hawaii, pp. 107-113.

Aguirre, A. A. and T. R. Spraker. 1996. Microscopic and ultrastructural evidence of a herpesvirus-like virus in Hawaiian green turtles (*Chelonia mydas*) with fibropapillomatosis, NOAA NMFS Admin Rep H-96-06C, Honolulu, Hawaii, pp 1-14.

Aguirre A. A., G. H. Balazs, B. Zimmerman and T. R. Spraker. 1994. Evaluation of Hawaiian green turtles (*Chelonia mydas*) for potential pathogens associated with fibropapillomas. *Journal of Wildlife Diseases* 30:8-15.

Aguirre A. A., T. R. Spraker, G. H. Balazs and B. Zimmerman. 1998. Spirorchidiasis and fibropapillomatosis in green turtles from the Hawaiian Islands. *Journal of Wildlife Diseases* 34:91-98.

Aguirre A. A., C. J. Limpus, T. R. Spraker and G. H. Balazs. 2000. Survey of fibropapillomatosis and other potential diseases in marine turtles from Moreton Bay, Queensland, Australia. *In* H. Kalb and T Wibbels, eds. Proc 19th Sea Turtle Symp, NOAA Tech Memo NMFS-SEFSC-443, Miami, Florida, p. 36.

Aguirre A. A., T. R. Spraker, A. Chaves-Quiroz A, L. A. du Toit and G. H. Balazs. 1999. Pathology of fibropapillomas in olive ridley turtles (*Lepidochelys olivacea*) in Ostional, Costa Rica. *Journal of Aquatic Animal Health* 11:283-289.

Aguirre, A. A., R. S. Ostfeld, G. M. Tabor, C. A. House and M. C. Pearl (eds.). 2002. Conservation Medicine: Ecological Health in Practice. Oxford University Press, New York, 407 pp.

Balazs G. H. and S. G. Pooley, eds. 1991. Research Plan for Marine Turtle Fibropapilloma. NOAA Tech Memo NMFS-SWFSC-156, Honolulu, Hawaii.

Brooks D. E, P. E. Ginn, T. R. Miller, L. Bramson and E. R. Jacobson. 1994. Ocular fibropapillomas of green turtles (*Chelonia mydas*). *Veterinary Pathology* 31:335-339.

Campbell T. W. 1996. Sea turtle rehabilitation. *In*: Reptile Medicine and Surgery. D. R. Mader (ed), W. B. Saunders Company. Philadelphia, pp. 427-436.

Casey R. N., S. L. Quackenbush, T. M. Work, G. H. Balazs, P. R. Bowser and J. W. Casey. 1996. Evidence for retrovirus infections in green turtles *Chelonia mydas* from the Hawaiian Islands. *Diseases of Aquatic Organisms* 31: 1- 7.

D' Amato A. F. and M. Moraes-Neto. 2000. First documentation of fibropapillomas verified by histopathology in *Eretmochelys imbricata. Marine Turtle Newsletter* 89:12-13.

Dailey M. D. and R. Morris. 1995. Relationship of parasites (Trematoda: *Spirochidae*) and their eggs to the occurrence of fibropapillomas in the green turtle (*Chelonia mydas*). *Canadian Journal of Fisheries and Aquatic Sciences* 52 (Suppl 1): 84-89.

George R. H. 1997. Health problems and diseases of sea turtles. In: P. L. Lutz and J. A. Musick, eds. The Biology of Sea Turtles. CRC Press, Boca Raton, Florida, pp. 363-385.

Graczyk, T. K., A. A. Aguirre, and G. H. Balazs. 1995. Detection by ELISA of circulating anti-blood fluke (*Carettacola, Hapalotrema, and Learedius*) immunoglobulins in Hawaiian green turtles (*Chelonia mydas*). *Journal of Parasitology* 81(3):416-421.

Graczyk, T. K., G. H. Balazs, T. Work, A. A. Aguirre, D. M. Ellis, S. K. K. Murakawa and R. Morris. 1997. *Cryptosporidium* sp. infections in green turtles, *Chelonia mydas*, as a potential source of marine waterborne oocysts in the Hawaiian Islands. *Applied and Environmental Microbiology* 63(7): 2925-2927.

Harshbarger J. C. 1991. Sea turtle fibropapilloma cases in the registry of tumors in lower animals. *In*: G. H. Balazs and S. G. Pooley, eds. Research Plan for Marine Turtle Fibropapilloma, NOAA Tech Memo NMFS-SWFSC-156, Honolulu, Hawaii, pp. 63-70.

Herbst L. H. 1994. Fibropapillomatosis of marine turtles. *Annual Reviews of Fish Diseases* 4: 389-425.

Herbst L. H., E. R. Jacobson, R. Moretti, T. Brown, J. P. Sundberg and P. A. Klein. 1995. Experimental transmission of green turtle fibropapillomatosis using cell-free tumor extracts. *Diseases of Aquatic Organisms* 22:1-12.

Herbst L. H., E. R. Jacobson, P. A. Klein, G. H. Balazs, R. Moretti, T. Brown and J. P.Sundberg.1999. Comparative pathology and pathogenesis of spontaneous and experimentally induced fibropapillomas of green turtles (*Chelonia mydas*). *Veterinary Pathology* 36:551-564.

Huerta P., H. Pineda, A. A. Aguirre, T. R. Spraker, L. Sarti and A. Barragan. 2000. First confirmed case of fibropapilloma in a leatherback turtle (*Dermochelys coriacea*). Proc 20th Sea Turtle Symp. NOAA Tech Memo NMFS-SEFSC-477.

IUCN. 2003. Red Databook of Threatened Species, IUCN, Gland, Switzerland.

Jacobson E. R., J. L. Mansell, J. P. Sundberg, G. V. Kollias and M. K. O'Banion. 1989. Cutaneous fibropapillomas of green turtles (*Chelonia mydas*). *Journal of Comparative Pathology* 101:39-52.

Lackovich J. K., D. R. Brown, B. L. Homer, R. L. Garber, D. R. Mader, R. H. Moretti, A. D. Patterson, L. H. Herbst, J. Oros, E. R. Jacobson, S. S. Curry and P. A. Klein. 1999. Association of herpesvirus with fibropapillomatosis of the green turtle *Chelonia mydas* and the loggerhead turtle *Caretta caretta* in Florida. *Diseases of Aquatic Organisms* 37: 889-897.

Landsberg, J. H., G. H. Balazs, K. A. Steidinger, D. G. Baden, T. M. Work and D. J. Russell. 1999. The potential role of natural tumor promoters in marine turtle fibropapillomatosis. *Journal of Aquatic Animal Health* 11:199-210.

Limpus, C. J. and J. D. Miller. 1994. The occurrence of cutaneous fibropapillomas in marine turtles in Queensland. In: Proc Australian Marine Turtle Conservation Workshop, Queensland Department of Environment and Heritage and The Australian Nature Conservation Agency, Brisbane, pp. 186-188.

Lu Y., A. A. Aguirre, T. M. Work, G. H. Balazs, V. R. Nerurkar and R. Yanagiliara. 2000a. Identification of a small, naked virus in tumor-like aggregates in cell lines derived from a green turtle, *Chelonia mydas*, with fibropapillomas. *Journal of Virological Methods* 86:25-33.

Lu Y., Y. Wang , Q. Yu, A. A. Aguirre, G. H. Balazs, V. R. Nerurkar and R. Yanagiliara.

2000b. Detection of herpesviral sequences in tissues of green turtles with fibropapilloma by polymerase chain reaction. *Archives of Virology* 145:1-9.

Morris R. A. and G. H. Balazs. 1994. Experimental use of cryosurgery to treat fibropapillomas in the green turtle, *Chelonia mydas*. In: Proc 13th Ann Symp Sea Turtle Biol Conserv NOAA Tech Memo NMFS-SEFSC-341, Miami, Florida, pp. 111-114.

Lutz P. L. and J. A. Musick, eds. 1997. The Biology of Sea Turtles. CRC Press, Boca Raton, Florida.

Parsons T. S. 1968. Variation in the choanal structure of recent turtles. *Canadian Journal of Zoology* 46:1235-1263.

Rainey, W. E. 1981. Guide to Sea Turtle Visceral Anatomy. NOAA Technical Memorandum NMFS-SEFC-82. Panama City. 85 pp.

Quackenbush S. L., T. M. Work, G. H. Balazs, R. N. Casey, J. Rovnak, A. Chaves, L. duToit, J. D. Baines, C. R. Parrish, P. R. Bowser and J. W. Casey. 1998. Three closely related herpesviruses are associated with fibropapillomatosis in marine turtles. *Virology* 246:392-399.

Quackenbush, S. L., C. J. Limpus, A. A. Aguirre, T. R. Spraker, G. H. Balazs, R. N. Casey, and J. W. Casey. 2000. Prevalence and phylogeny of herpesvirus sequences from normal and fibropapilloma tissues of green and loggerhead turtles sampled at Moreton Bay, Australia. *In*: H. Kalb and T. Wibbels (comps.), Proc 19th Ann Symp Sea Turtle Conservd Biol U.S. Dep. Commer., NOAA Tech. Memo. NMFS-SEFSC-443. pp. 242-243.

Smith G. M. and C. W. Coates. 1938. Fibro-epithelial growths of the skin in large marine turtles, *Chelonia mydas* (Linnaeus). *Zoologica NY* 23:93-598.

Tabor, G. M., R. S. Ostfeld, M. Poss, A. P. Dobson, and A. A. Aguirre. 2001. Conservation biology and the health sciences: defining the research priorities of conservation medicine. In: M. E. Soulé and G. H. Orians, eds. Research Priorities in Conservation Biology. 2nd edition. Island Press; Washington, D.C. Pp 165-173.

Wolke, R. E. and A. George. 1981. Sea Turtle Necropsy Manual. NOAA Technical Memorandum NMFS-SEFC-24.

Work, T. M. 2000. Field necropsy techniques of sea turtles for biologists in remote places. U.S. Geological Survey, National Wildlife Health Center Honolulu Research Station, Hawaii, 25 pp.

Wyneken, J. 2001. The Anatomy of Sea Turtles. U.S. Department of Commerce NOAA Technical Memorandum NMFS-SEFSC-470, 1-172 pp.

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# New Caledonian Loggerhead Turtle Population Assessment: 2005 Pilot Study[1]

## INTRODUCTION

Loggerhead turtle nesting in the North Pacific Ocean is restricted almost entirely to Japan where it is under extensive research and monitoring (Kamezaki et al. 2003).

In the south Pacific, loggerhead turtle breeding is restricted almost entirely to eastern Australia and New Caledonia (Limpus and Limpus, 2003). The eastern Australian population has been extensively monitored and researched, including long term census trends, genetics analysis and demographic studies since 1968 (Limpus, in press). The eastern Australian stock could qualify under IUCN Red-listing criteria as critically endangered as a result of an 86% decline in breeding females over the past 25yr (less than 1 generation). Extensive management actions have been implemented in Australia to conserve this species and to halt the population decline, including (Limpus, in press):

- The vast majority of the loggerhead turtle nesting of eastern Australia in now protected with the National Park estate of the Queensland Parks and Wildlife Service.
- A major portion of the foraging, courtship and inter-nesting habitats used by the species in eastern Australia is managed within the Great Barrier Reef Coastal Marine Park and the adjacent Great Barrier Reef Marine Park, and the Woongarra Marine Park and Moreton Bay Marine Park to the south.
- No harvest of the species by non-indigenous persons in currently permitted in Australia.
- The use of Turtle Exclusion Devices to reduce trawling induced turtle mortality is now mandatory in the trawl fisheries of Eastern Queensland, Torres Strait and northern Australia.
- Fox-baiting in the vicinity of the important mainland nesting beaches to minimize predation of loggerhead turtle eggs has been implemented since the late 1980s.
- Doomed eggs likely to be killed through flooding or erosion on the mainland nesting beaches of the Woongarra Coast are rescued and moved to adjacent safe incubation habitat.

The New Caledonian stock has not been studied in any detail. It is not known if it is a separate stock to the Australian stock that breeds on the opposite side of the Coral Sea. Given that the two nesting aggregations are separated by approximately 1,300km of oceanic water, it is anticipated that they could represent separate stocks. The emerging anecdotal data indicates that the New Caledonia population has undergone a similar major population decline to the Australian population since about the 1970s.

Given the poor conservation status of the other loggerhead turtle populations of the Pacific Ocean (Kamezaki et al. 2003; Limpus and Limpus 2003), there is a high probability that this remaining unstudied Pacific loggerhead turtle population is in urgent need of assistance.

## PROJECT AIM

To provide a bench-mark assessment of a loggerhead turtle nesting population at a New Caledonian index rookery.

## PROJECT GOALS

The goal of this pilot study is:

- To assess the genetic relationship of the New Caledonian nesting population to the Australian population using mtDNA analysis and microsatellites as required.
- To conduct a two-week tagging census to establish the size of the current nesting population.
- To map the spatial distribution of nesting with respect to the available habitat for the area.
- To quantify some basic demographic parameters for the population including: nesting success, size of adult females, clutch size, egg measurements, nest measurements, frequency of anthropogenic impacts on the turtles (fractures, hooking scars, GTFD tumors) and their nests (dog predation, human interference).
- To train local residents in appropriate methods by which they can continue the monitoring of the population and contribute to its conservation.

[1] Final report to the WPRFMC, Contract No. 04-WPC-03, NOAA award # NA04NMF4410164.

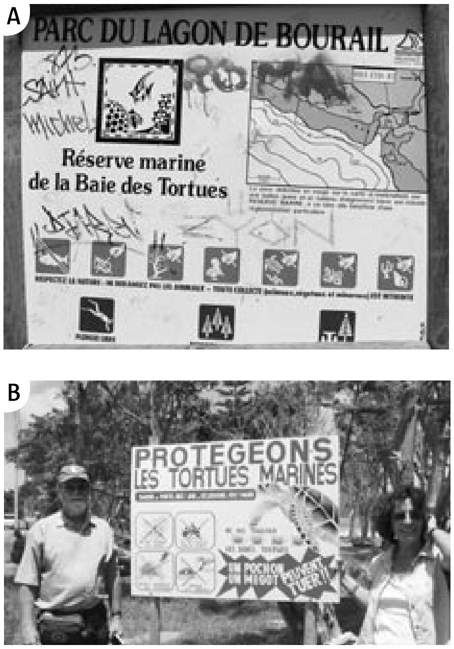


**FIGURE 1.** *Existing conservation signage in Roche Percée (A to B).* **1A**. *Marine Protected Area sign.* **1B.** *Sign erected by local community to enhance turtle breeding on la Plage de la Roche Percée. Col Limpus and Marile Marteaud, February 2004.*

**FIGURE 2.** *La Plage de la Roche Percée*

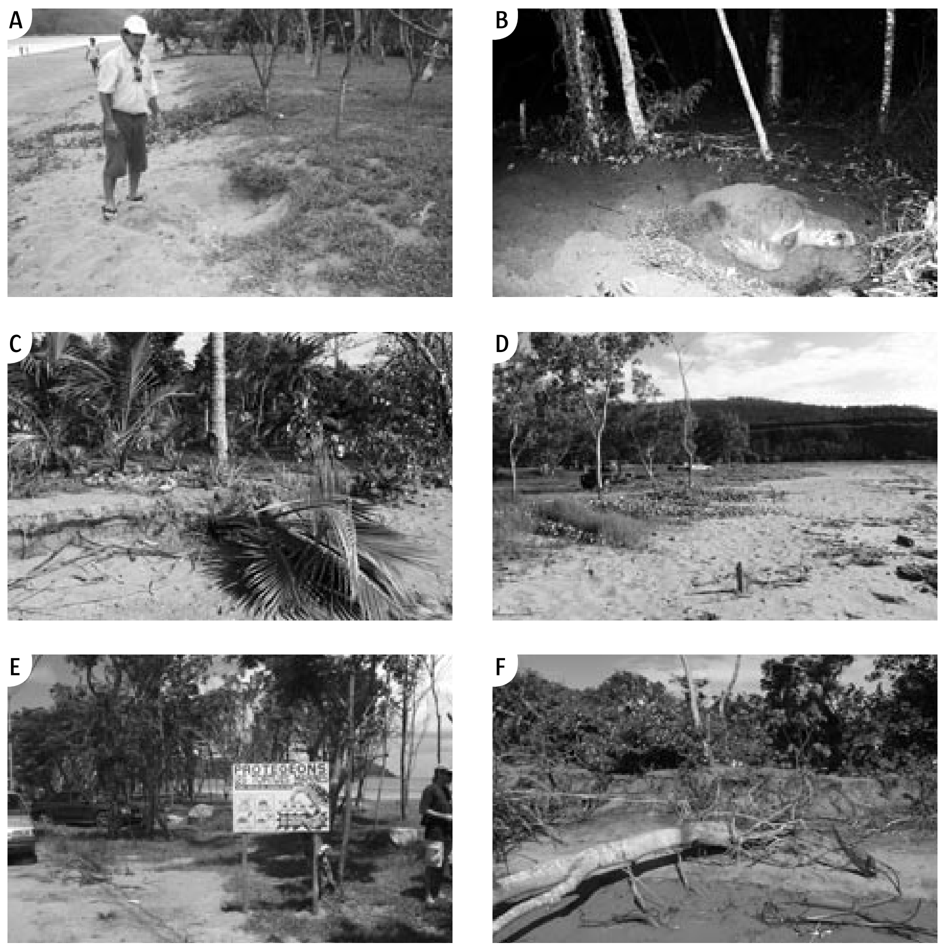


**FIGURE 3.** *Dune vegetation along la Plage de la Roche Percée (A to F).* **3A.** *Partially cleared dune vegetation at the northern end.* **3B.** *Caretta caretta nesting at the margin of the semi-natural forest along the middle section of the beach.* **3C.** *Revegetation of previously cleared dune in front of housing at the southern end.* **3D.** *Extensively modified dune vegetation at the southern end of the beach.* **3E.** *Sparce vegetation screening between the road and turtle nesting habitat of the frontal dune, northern end of beach.* **3F.** *Erosion of closed forest species in the central beach section.*

## STUDY SITE

Four beaches were surveyed for turtle nesting in the Bourail district which lies approximately 160 km north of Noumea on New Caledonia's west coast. These beaches are shoreward of a wide natural break, Passe Popinée, in the barrier reef that lies along the southwestern coast of New Caledonia.

There is a marine protected area over these coastal waters (Figure 1A). However, judging by the behavior of the general public, only minimal heed is paid to the regulations. However, some members of the local community have a well established concern for marine turtle conservation as is evidenced by the car-park sign advocating turtle friendly behaviors on the beach (Figure 1B).

**FIGURE 4.** *Impacts on the nesting habitat at La Plage de la Roche Percée.* **4A.** *Road immediately behind the nesting habitat at the northern end of the beach. Two sets of turtle nesting tracks are visible.* **4B.** *Rock wall constructed to "protect" real estate from erosion.* **4C.** *Fallen trees and exposed roots prevent turtles from accessing nesting habitat along the eroded dune at the southern end of the beach.* **4D.** *Vehicle tracks across turtle body pits and dune vegetation.*

**PLAGE DE LA ROCHE PERCÉE**

La Plage de la Roche Percée is the second largest of the Bourail beaches and is approximately 3km in length (21°37.369'S, 165°27.751'E to 21°36.855'S, 165°27.383'E). It extends northward from the mouth of the Nera River (Figure 2). The beach and the associated La Roche Percée settlement and coastal road are contained on the seaward side of a meander of the river that loops close to breaking through the dune system on the northern end of the beach. The Nera River contributes dark sediment directly to La Plage de la Roche Percée and, as a result, the sand of at la Roche Percée is darker in color than the sand on the beaches immediately to the north and south. This dark sand gets very hot during summer days and surface temperatures can be too hot for bare-foot walking.

A band of natural closed forest extends 20-30m behind the central section of the beach. The dunes have been cleared and revegetated with coconut palms and *Casuarina equisitifolia* along parts of the northern and southern ends. In the cleared areas, the frontal dune is vegetated with vines (*Ipomoea pescaprae*) and grasses (Figure 3).

La Roche Percée was first settled by Europeans in 1984 and is now occupied by approximately 30 residential sites. The beach is backed by a bitumen road about 50-100m inland of the low frontal dune (Figure 4a). There is no street lighting associated with this road. A small settlement of 'western style' homes has been built mostly on the inland side of this road. A rock wall has been built of offer "protection' from dune erosion for the road and some of the real estate on the seaward side of the road. This rock wall extends for several hundred metres and spans from below the high tide mark back to the forest margin (Figure 4b) and is located approximately mid-way along the beach, extending for several hundred meters (> 7% of beach) from 21°37.989'S, 165°27.807'E to 21°36.822'S, 165°27.726'E.

A number of the dwellings along the road have significant exterior lighting. Due to the vegetation being absent, scarce or low along the northern end, this lighting causes the beach to be lit up throughout the night. The close proximity of the road and the reduced vegetation also results in vehicle headlights intermittently shining brightly across the beach.

There is considerable evidence indicating that nest erosion is occurring at la Plage de la Roche Percée. Along sections of the southern beach, a 0.5m high erosion bank has developed and remained for at least the last two summers. This erosion bank is cutting further back into the forest with each storm season, causing the undermining of trees that now lie scattered on the beach (Figure 4c). Dune erosion is enhanced by easy vehicle access to the frontal dune at the southern end of the beach. This traffic damages the vegetation that helps stabilize the dunes. It also damages turtle nests (Figure 4d).

**PLAGE DE LA BAIE DES TORTUES**

Plage de la Baie des Tortues is approximately 0.3km long and lies between two rocky headlands (Figure 5). The dune vegetation has been modified within the remnant Araucaria forest. It is not as subject to erosion as la Plage de la Roche Percée.

A tunnel provides pedestrian access from la Roche Percée to Plage de la Baie des Tortues. However, this access is limited to very low tides.

**ILE VERTE**

Ile verte lies several kilometers off the coast from la Plage de la Roche Percée in Passe Popinée. The small island has

**FIGURE 5.** *Plage de la Baie des Tortue*

**FIGURE 6.** *View of eroded white sand beach and vegetated strand on Ile Verte.*

**FIGURE 7.** *Michelle Boyle weighing and measuring Caretta caretta eggs on the beach as they are collected from the nest by Tony Sunderland. Isobell Roy, at right, was a local resident assisting with the monitoring study.*

a white coral sand beach (Figure 6) for approximately one quarter of the island's ~200 m circumference, whilst the remainder of the shore consists of exposed beach rock and boulders. The beach is backed by a 0.5 m erosion bank within several meters of the tree line. Fallen trees along the beach indicate that this beach has been subject to nest erosion in recent years.

### LA PLAGE DE LA POE

La Plage de la Poe lies to the north of la Baie des Tortues. It is a long crescent-shaped beach with light colored sand that extends for tens of kilometers. Only the southern end of the beach is accessible by road where some vegetation has been cleared to allow for camping and the construction of a few residential dwellings.

The coast to the south of Nera River consists of rocky shore for a number of kilometres with no ready vehicle access.

## METHODS

A survey of marine turtle nesting adjacent to the village of Roche Percée was conducted during 6th - 20th January 2005. A general survey was made by foot during daylight of all accessible beaches in the area. La Plage de la Roche Percée was surveyed each night for a period of 6-8 hours around the high tide and the beach was walked daily during daylight hours. La Plage de la Baie des Tortues was visited regularly during daylight hours as weather permitted, to record nesting activity. Weather conditions during the time of the survey washed away parts of the access road rendering night surveys unsafe. Each nesting crawl was recorded irrespective of whether or not the turtle was sighted and scored for whether or not the turtle had laid.

When nesting turtle turtles were encountered, they were tagged and measured using standard methodology for the Queensland Turtle Research Project (Limpus et al. 1983). Each adult turtles was double tagged with titanium turtle tags (Stockbrands, standard size) in the axillary tagging position on each front flipper (Limpus, 1992). Curved carapace length was measured (± 0.1 cm) with a flexible tape measure from the anterior skin-carapace junction to the posterior edge of the midline junction of the two supra-pygal scutes. Each female was assessed for external damage and injuries.

A sample of clutches were counted within one hour of the turtle completing her nesting, Ten eggs per clutch were selected from top to bottom of the nest for most counted clutches. These eggs were cleaned of sand with a soft bristle brush and with the minimum of rotation before being and measured for diameter with

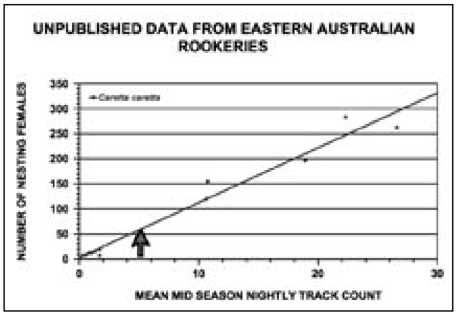


FIGURE 8. *Trend line showing the correlation between the average number of nesting crawls (tracks) per night during two weeks at mid nesting season and the size of the total nesting populations at the same rookery in the same year for eastern Australian Caretta caretta nesting beaches. Arrow denotes the size of the Roche Percée nesting population in 2004-2005. See Text for additional detail.*

vernier callipers and weighed on a digital balance (± 0.1 g) (Figure 7).

Local residents were interviewed to provide additional insights into past knowledge and issues related to turtle populations in the Bourail region.

Sand temperatures were measured at 50 cm below the beach surface using a digital thermometer (± 0.2°C).

Estimation of the size of the total seasonal nesting population based on mid-season nesting density made use of unpublished data from the Queensland Turtle Research Project: Figure 8 summarizes the relationship between the average number of nesting crawls per night during two weeks at the peak of the nesting season and the size of the total annual nesting population measured by total tagging census during months of nightly monitoring at the same rookery. This figure pools annual census data from Mon Repos, Heron Island and Fraser Island.

Genetic samples were taken from nesting female turtles during nesting observations at la Roche Perceé rookery, by means of a small skin biopsy that was removed with a sterile razor blade from the upper shoulder region. Tissue samples were stored in dimethyl sulfoxide 20% (DMSO) saturated with 5M NaCL (without EDTA), routinely used to preserve Chelonid tissue (Dutton, 1996). In the laboratory the tissue samples were removed from the DMSO, rinsed in distilled water, and minced up with a sterile scalpel blade to optimise DNA extraction. Genomic DNA was isolated from the tissue using the ammonium acetate method described by Nicholls et al. (2000).

An 1100 base pair (bp) fragment located in the control region of the mitochondrial genome was amplified with polymerase chain reaction (PCR) methodology, using the primers TCR-6 (5’-GTA CGT ACA AGT AAA ACT ACC GTA TGC C-3’) and TCR-1 (5’- GGA TCA AAC AAC CCA ACA GG -3’) (Norman et. al 1994).

PCR conditions were optimized using methods described by Cobb & Clarkson (1994). PCR amplifications were performed in a 25 l reaction volume containing, 3ng DNA template, 1x QIAGEN PCR Buffer (containing Tris-Hcl and KCl), 0.32 mM of dNTP, 4mM MgCl2, 0.20 mM of each primer (TCR1 + TCR6), and 0.5 units of Taq DNA polymerase (QIAGEN). The PCR amplification conditions were as follows: 95C for 2 mins followed by 34 cycles at 94C for 25 sec, 48C for 15 sec, 72C for 45 sec with a final extension at 72C for 5 sec. PCR amplifications included a negative (DNA free) control reaction to test for contamination.

The amplified products were electrophoresed in low-melt agarose gels and exised from 1.5% agrose gels and purified using a gel extraction kit (QIAGEN). Quantification of DNA concentrations were performed with ImageJ software (http://rsb.info.ih.gov.ij). Cycle sequencing reactions were conducted with the primers TCR1 and TCR6 in ET terminator half reactions according to manufacturers instructions and analysed in the Genetic Analysis Facility in James Cook University’s Advanced Analytical Centre, on a MegaBase 1000 (Amersham BioSciences). Resulting sequences were edited with Sequencher 4.2.2 (Gene Codes Inc), and manually aligned using Se-AL v 2.0a11. Variability at sites was verified with associated chromatograms.

# RESULTS

## ORAL HISTORY

Numerous locals were spoken to regarding the history of la Roche Percée and the local turtle populations. Comments from four groups have been included below.

**Laurence Langlois** (January 2005): a local Kanak resident whose father was a fisherman.

> According to Mr Langlois, dugong (*Dugong dugon*) and turtles (*Chelonia mydas* and *Caretta caretta*) were once numerous in the area of la Roche Percée. However, their numbers have been greatly reduced. While all species were hunted by local people, dugong and C. mydas were the preferred species. Grosse Tête (local name for *C. caretta*) egg consumption and the harvest of females when they were ashore was common by locals. 20-30 years ago an average of 6 Grosse Tête nested per night at la Roche Percée, with a maximum of 20-35 on some nights.
>
> Prior to extensive tree-felling of the surrounding mountains in 1988, ‘the beaches were whiter in color ... the water was much clearer and turtles could be seen in the water from 100m away... this is no longer the case’.

**Jean-Pierre Revercé (J-PR )** (January 2005): a local New Caledonian resident who grew up in the region and who has previously been employed as the deputy-major for the Bourail Council and as a land surveyor at the Université de la Nouvelle-Caledonie (UNC).

> '30 years ago during the peak of the nesting season 5-6 loggerheads laid clutches at la Roche Percée per night, with a maximum of 10 per night'.
>
> J-PR was commissioned through UNC during 1994-96 to conduct surveys in response to an application for sand mining of this beach. The results of this research document the erosion that has occurred at la Plage de la Roche Percée during this time. J-PR commented that his work showed that the northern end of la Plage de la Roche Percée has receded 80m and the southern end has receded 30 m in the previous couple of decades. However, it should be noted that this erosion survey was conducted over the period of time that was effected by Cyclone Betty (26-37 March 1996).

**Marile and Daniel Marteaud** (February 2005): Local residents Marile and Daniel believe from discussions that they have held with local people, that up to 300 turtle clutches were laid per day about 30 years ago. However, these reports are from indirect sources and the time frame is uncertain. At that time, the beach at la Plage de la Roche Percée was considerably wider and the forest extended some hundred of metres seaward of the current high tide mark. The coast line has been subject to long term erosion over the decades. These comments were also supported during discussions with other local peoples, including Rick Annex.

During the 2002/2003 nesting season Association pour la Sauvegarde de la Nature Neo-Caledonienne (ASNNC) conducted a turtle nesting survey at la Plage de la Roche Percée and estimated that a total of 215 clutches were laid during that season.

The general conclusions that can be drawn from all discussions that were held with local residents is that since settlement 20 years ago, the area of la Roche Percée has changed considerably. One significant change has been to the vegetation. Anecdotal reports suggest that the vegetation once extended many tens of meters behind the dunes. However, the development of western style homes and access roads, including the establishment of a road behind the frontal dunes of la plage de la Roche Percée has markedly reduced the natural vegetation. The catchment area of the Nera River surrounding la Roche Percée has also been extensively cleared for cattle grazing. In addition, there are unsubstantiated reports of sand removal from the beach (J-PR). These factors would have undoubtedly contributed to the high rate of erosion that has been witnessed over the last couple of decades and that is of considerable concern to the local residents.

There was variation among old verbal reports for estimated numbers in past *C. caretta* nesting populations at la Roche Percée. However, in general the consensus was that the *C. caretta* nesting population at la Roche Percée has declined over recent decades.

**WEATHER**

On January 7, 2005, Cyclone *Kerry* approached New Caledonia and brought substantial rain during January 7 to 16 (Figure 9). This rain caused the Nera River to flood and, on the 7th, to break across the road that connects la Roche Percee to the mainland. The water in the bay contained a high sediment load with close to zero visibility for the remainder of the survey period.

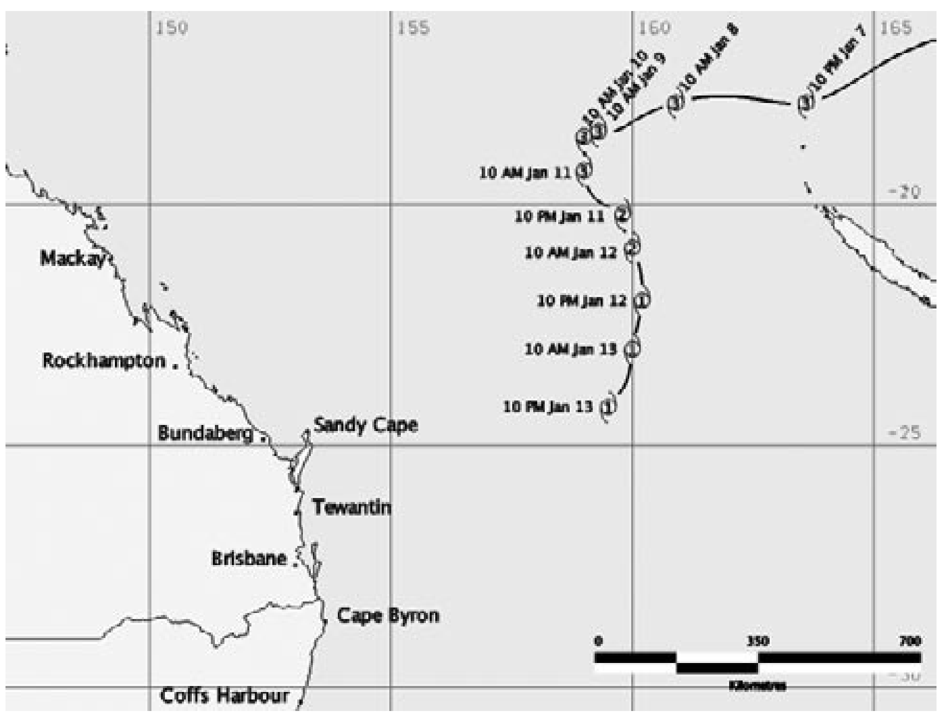


FIGURE 9. *Track of Cyclone Kerry during early January 2005 (Australian Bureau of Meteorology).*

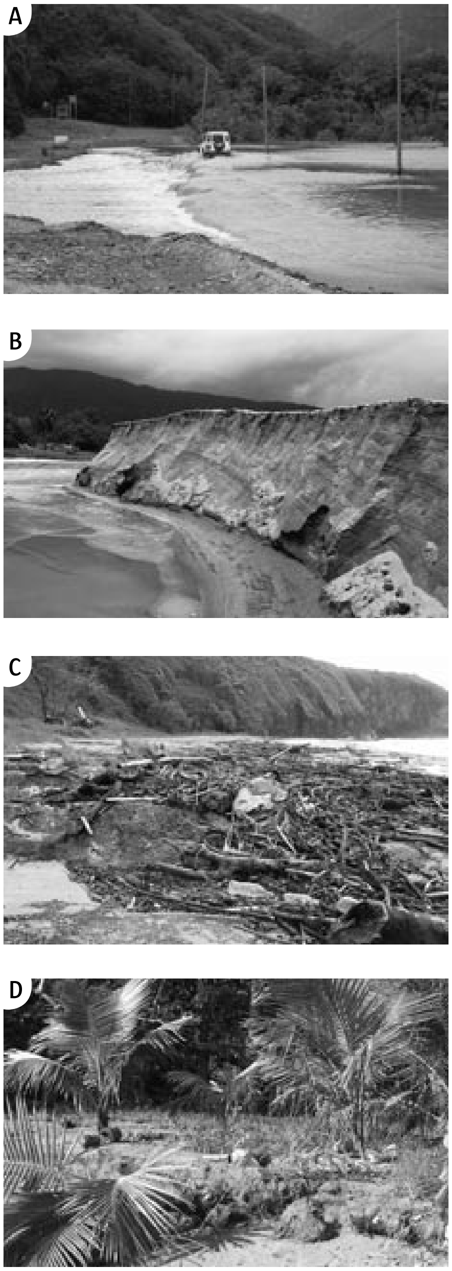

**FIGURE 10.** *Illustrations of the impact of Cyclone Kerry on the beaches in the Bourail district.* **10A.** *The Nera River cut through the road at the northern access to Roche Percée.* **10B.** *2 m erosion bank at the northern end of la Plage de la Roche Percée.* **10C.** *Flood debris accumulated on la Plage de la Baie des Tortues.* **10D.** *Erosion of vegetation on the southern end of la Plage de la Roche Percée.*

Cyclonic winds generated heavy surf on the beach at la Roche Percée. The wet conditions that occurred throughout the study period caused considerable damage to the road to Baie de Tortues. This prevented nightly observations of that beach as had been originally intented. High water levels prevented access to the Baie de Tortues via the pedestrian tunnel route.

Cyclone *Kerry* brought high rainfall that caused flooding of the Nera River. The river overflowed its backs to cut across the access road to Roche Percée at the northern end of the beach (Figure 10A), effectively leaving the village as a small island. This north river outflow eroded large volumes of sand from the northern end of the beach (Figure 10B). Large amounts debris was washed to sea from both river mouths and substantial amounts of this debris washed onto nearby beaches (Figure 10C). In some localized areas, the debris was thick enough to impede turtle access to nesting habitat. Because the cyclone center lay to the west of the main island of New Caledonia, the winds along this west coast area were not onshore. Therefore, this cyclone had minimal storm-surge impact on the beaches. There was, however, some fresh erosion of the dunes at this time (Figure 10D).

Because of the heavy rain during the cyclone, local residents did not participate in the night-time training and monitoring until after the rain had abated. Thus, we only had three nights of effective community participation in the project. Similarly, participation by members of ASNNC who had to drive up from Noumea and visits by the local media were limited to the last few days of the survey.

Table 1. Sand temperatures measured at 50 cm below the beach surface within the open sand dune nesting habitat of la Plage de la Roche Percée following Cyclone *Kerry*.

| Date January 2005 | Time (hr) | Temperature (°C) |
|---|---|---|
| 14th | 21:45 | 28.5 |
| 15th | 00:39 | 28.2 |
| 15th | 11:35 | 29.2 |
| 16th | 02:42 | 29.3 |
| 20th | 04:00 | 30.2 |

## SAND TEMPERATURES

Sand temperatures at nest depth (50 cm) were recorded within the open sand of the dune nesting habitat of la Plage de la Roche Percée after the heavy from Cyclone Kerry had ceased (Table 1). Unfortunately, these data do not provide a measure of the normal sand temperatures at nest depth for this beach. Sand temperatures will have been lowered below normal by the heavy cyclonic rain. These temperatures do, however, demonstrate the rapid rise in temperature that occurs at nest depth, following the cessation of heavy rain during the summer months. The rising temperature as the survey finished indicated that this should be a warm beach, well above the pivotal temperature (28.7°C. Limpus et al. 1985) for eastern Australian population. It is presumed that this would be a female-producing beach for *C. caretta* in New Caledonia.

## GENETICS

Thirty nesting female *C. caretta* were sampled for the genetics study. Of the 30 samples, 28 (93%) were found to be haplotype CC-P1, and 2 (7%) were found to be haplotype CC-P5 (Figure 11). No new haplotypes were discovered.

The identified haplotypes (CC-P1 & CC-P5), and the frequencies at which they occur, parallel those found throughout the east Australian rookeries. Therefore, based on the current understanding of stock structure, the New Caledonian


**FIGURE 11.** *Examples of genotypesA region of the aligned mtDNA sequences of Caretta caretta from La Roche Percee. Illustrated is the base*

and Eastern Australian nesting populations cannot be defined as separate genetic stocks. These data are being included in Michelle Boyle's PhD thesis (James Cook University) and are being prepared for peer-reviewed scientific publication.

This is an unexpected result given the approximately 1,300 km separation of the New Caledonian and eastern Australian breeding sites. The samples have been banked with other genetic samples from the Queensland Turtle Research Project and they will be made available for future analysis as new genetic analytical tools are developed.

## TURTLE BIOLOGY

Only *C. caretta* was recorded nesting on any of the beaches surveyed.

## NESTING CENSUS

### *La Plage de la Roche Percée*

During the survey period, 6-19 January, a total of 76 crawls by nesting turtles were recorded on la Plage de la Roche Percée. See Table 2 for a summary of nightly beach census scores. The mean number of *C. caretta* nesting crawls during the census period was 5.4 per night (SD = 3.4; range=1 - 13; n = 14 nights). During the same period, the mean number of clutches laid was 3.0 per night (SD = 2.1, range = 1 – 9, n = 14 nights)

Of the 76 beachings, 43 resulted in successful laying of clutches, whilst the remaining 33 were unsuccessful nesting crawls (i.e. clutches were not laid) (Table 3). This equates to a nesting success of 57%. The majority of tracks and nests were at the northern end of the beach. Throughout the survey 40 beaching by turtles were not observed, but were subsequently recorded from the tracks. These included 15 clutches laid and 25 unsuccessful nesting crawls.

### *La Plage de la Baie des Tortues*

During the survey period, January 6-19, 2005, a total of 2 crawls by nesting turtles were recorded on la Plage de la Baie des Tortues. See Table 2 for a summary of nightly beach census scores. The mean number of *C. caretta* nesting crawls during the census period was 0.14 per night (SD = 0.36; range=0 - 1; n = 14 nights). During the same period, the mean number of clutches laid was 0.14 per night (SD = 0.36; range=0 - 1; n = 14 nights).

Both these nesting crawls resulted in successful nesting, although neither turtle was observed for its nesting (Table 3).

### *Ile verte*

Ile verte was visited for one hour on January 19, 2005 during daylight hours. The entire beach was surveyed on foot and no evidence of turtle nesting crawls or body pits or hatchling tracks were identified. This was consistent with the oral reports given by J-P. Revercé.

While no turtle nesting was identified, the island was terrestrial habitat for sea kraits, Laticauda sp. (sea snakes).

### *La Plage de la Poe*

Only approximately the southern most kilometer of potential nesting habitat along la Plage de la Poe was surveyed on foot on January 6, 2005. No evidence of turtle nesting crawls or body pits or hatchling tracks were observed. This was consistent with the oral reports given by local residents (J-P. Revercé: no observed nesting. D. Marteaud: only 1 nesting turtle observed) that turtle nesting is rarely observed on this beach. In the absence of access to a suitable vehicle for driving the beach, this beach was not surveyed further.

Combining the data for all beaches, a total of 45 *C. caretta* clutches were laid in the two week period January 6-19, 2005. This is a minimum estimate of the number of female *C. caretta* nesting during one renesting interval at approximately mid-breeding season. Thirty-one of these females were tagged. The combined beaches nightly nesting attempts were 5.5 beachings per night at La Roche Percée for the same period. This period overlapped the late December – early January peak density of the *C. caretta* nesting season in Queensland (Limpus, 1985). Applying the relationship between the mean number of beachings per night at the peak of the Queensland *C. caretta* nesting season and the total nesting

Table 2. Nightly census count of *Caretta caretta* nesting crawls, clutches laid, predated and emerging, Bourail District, January 2005.

| Date | La Plage de la Roche Percée | | | | La Plage de la Baie des Tortues | | | |
|---|---|---|---|---|---|---|---|---|
| January 2005 | Tracks | Clutches | | | Tracks | Clutches | | |
| | | Laid | Predated | Emerged | | Laid | Predated | Emerged |
| Prior to arrival | NA | NA | NA | NA | 5 visible | NA | NA | NA |
| $6^{th}$ | 7 | 3 | | | 0 | 0 | | |
| $7^{th}$ | 5 | 2 | | | 0 | 0 | | |
| $8^{th}$ | 1 | 1 | | | 0 | 0 | | |
| $9^{th}$ | 5 | 2 | | | 1 | 1 | | |
| $10^{th}$ | 10 | 6 | | | 0 | 0 | | |
| $11^{th}$ | 3 | 2 | | | 1 | 1 | | |
| $12^{th}$ | 13 | 9 | | | 0 | 0 | | |
| $13^{th}$ | 10 | 3 | | | 0 | 0 | | |
| $14^{th}$ | 4 | 4 | | | 0 | 0 | | |
| $15^{th}$ | 4 | 2 | | | 0 | 0 | | |
| $16^{th}$ | 4 | 2 | | | 0 | 0 | | |
| $17^{th}$ | 3 | 2 | | | 0 | 0 | | |
| $18^{th}$ | 5 | 2 | 1 | 2 | 0 | 0 | | |
| $19^{th}$ | 2 | 2 | | | 0 | 0 | | |

Table 3. Summary of *Caretta caretta* nesting success with respect to observed and missed nesting crawls on beaches in the Bourail District, January 2005.

| | Observed | Not observed (tracks only recorded) | Total |
|---|---|---|---|
| La Plage de la Roche Percée | | | |
| Laid | 28 | 15 | 43 |
| Did not lay | 8 | 25 | 33 |
| Total beaching | 36 | 40 | 76 |
| La Plage de la Baie des Tortues | | | |
| Laid | 0 | 2 | 2 |
| Did not lay | 0 | 0 | 0 |
| Total beaching | 0 | 2 | 2 |

Table 4. Distribution of successful *Caretta caretta* nesting locations by habitat during 6-19 January 2005.

| | Under trees | In grass or vines | In bare sand |
|---|---|---|---|
| Dune crest | 0 | 4 | 35 |
| Beach slope | 0 | 1 | 3 |
| Below high tide line | NA | NA | 2 |

population for the entire season (Figure 7), the 5.5 beachings per night in the present study translates to approximately 60-70 *C. caretta* nesting on this coast for the entire 2004 – 2005 breeding season.

## NESTING BEHAVIOUR

Of the 76 recorded nesting attempts, only two occurred during daylight (3% daylight nesting attempts) and both resulted in successful laying.

Five females that were unsuccessful in a recorded nesting attempt were recorded returning for a subsequent attempt. On average, a turtle that failed to nest was most likely to return on the following night (SD = 0.71, range = 0 – 2 d, n = 5). One of these females was missing the entire right hind flipper and failed to successfully dig an egg chamber on two consecutive nights because of this damage. When she returned on the 3rd consecutive night and was again observed to be unsuccessful in digging an egg chamber, an artificial egg-chamber was dug under her while she was digging. She accepted this hole as a nest and laid 137 eggs. The remaining four females that were recorded on their return, following an unsuccessful nesting attempt, each successfully laid on their next return. Given the incomplete interception of the nesting turtles, these data are consistent with the concept that females that return to the sea following unsuccessful nesting attempts do not drop their eggs at sea, but return on subsequent nights for further nesting attempts.

The majority of the turtles (89%) laid their eggs in bare sand habitat, rather than within vegetated areas (Table 4). 4% of clutches were laid below the high tide level and should not have incubated due to flooding. Although not quantified, the significant erosion at both extremities of the beach occurred on the low density nesting areas of the beach and had minimal impact on the incubation of the clutches.

The majority of the nesting occurred on the northern side of the rock wall and in front of the area with houses. Numerous turtles came ashore in front of the rock wall and, with no beach above high tide in front of the wall, they turned back with out laying. No turtles crossed the rock wall to nest. Fewer turtles attempted to nest south of the rock wall. In this section, where turtles came ashore in front of fallen trees, they usually were unsuccessful in nesting.

## SIZE OF NESTING FEMALES

The size of nesting female *C. caretta* at la Roche Percée is summarised in Table 5 and Figure 12. The mean size of nesting females was 95.1cm CCL.

Table 5. Summary of measurements of nesting female *Caretta caretta* and their eggs, nests and hatchlings at la Roche Percée during the mid 2004-2005 breeding season.

| Parameter | Measurements | | | |
|---|---|---|---|---|
| | Mean | SD | Range | Sample size |
| Curved carapace length (cm) | 95.13 | 5.508 | 83.1 – 107.0 | 30 |
| Eggs per clutch | 113.6 | 35.37 | 60 - 186 | 13 |
| Egg diameter (cm) | 4.16 | 0.13 | 3.86 – 4.42 | 126 eggs from 13 clutches |
| Egg weight (g) | 39.48 | 3.82 | 31.3 – 47.0 | 116 eggs from 12 clutches |
| Yolkless egg per clutch | 0 | - | - | 13 |
| Multiyolked eggs per clutch | 0.08 | 0.28 | 0 - 1 | 13 |
| Nest depth, bottom (cm) | 56.3 | 4.62 | 51 – 59 | 3 |
| Hatching success (%) | 86.9 | 2.33 | 85.2 – 88.5 | 2 |
| Incubation to emergence success (%) | 81.5 | 0.47 | 81.2 – 81.8 | 2 |
| Hatchling straight carapace length (cm) | 4.39 | 0.13 | 4.19 – 4.48 | 10 hatchlings from 2 clutches |
| Hatchling weight (g) | 21.15 | 2.26 | 19.2 – 26.6 | 10 hatchlings from 2 clutches |

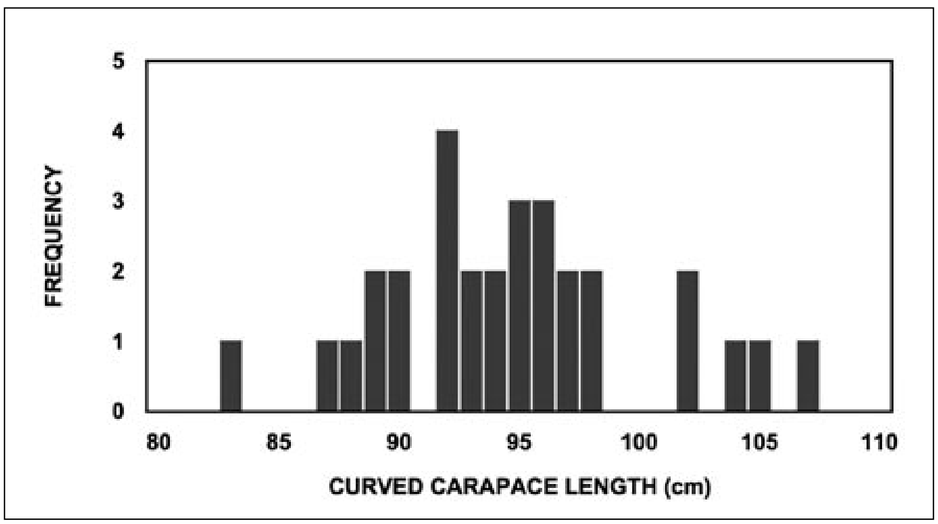


**FIGURE 12.** *Frequency distribution for size of nesting female Caretta caretta at la Roche Percée.*

These nesting *C. caretta* were recorded laying on average 113.6 eggs per clutch that were 4.16 cm in diameter and weighed 39.5 g (Table 5). No yolkless eggs were recorded in this sample of 13 clutches and only 1 multi-yolked egg (double yolked egg, diameter = 4.82 x 5.14 cm, weight = 68.9 g) was recorded.

The first hatchling emergence from nests was recorded on 18 January 2005. However, given the storm conditions of the preceding week and extensive erosion of the fore dune, there is the possibility that some clutches may have emerged on an earlier date and escaped detection. The incubation success recorded from these two clutches was: hatch success = 86.9% of eggs laid and 81.5% of eggs produced hatchlings to the beach surface (Table 5).

**FIGURE 13.** *Michelle Boyle excavating a nest to assess incubation success. Hatchlings had run from this nest during the previous night.*

**FIGURE 14.A.** *Caretta caretta hatchling*

**FIGURE 14.B.** *Caretta caretta hatchling and track.*

## HATCHLINGS

Hatchlings from the two emerged clutches measured 4.40 cm SCL and weighed 21.1 g (Table 3). These hatchlings were the typical dark brown color for the species (Figure 14a). They crawled with the typical alternating gait for hatchlings for this species (Figure 14b). All 10 hatchlings examined had the standard scale count for the species of: 1 nuchal, 5 vertebrals, 2 supra-pygals, 5/5 costals, 12/12 marginals, 3/3 post-occulars, no pre-occulars, 3/3 infra-marginals and 0 intergulars.

The post parietal scutes were variable with frequencies of: 1 with 2 scutes, 1 with 3 scutes, and 8 with 4 scales.

## INJURIES AND DISEASE

Significant injuries from both natural and anthropogenic sources were recorded for five of the nesting females:

- R24764: large healing fracture to the right side of the carapace (Figure 15a) possibly resulting from a boat-strike.
- R24771: healing shark bite to the right shoulder (Figure 15b). This bite probably occurred during courtship.
- Two females were each missing almost 100% of the right hind flipper: R24359, R24369. These turtles had difficulty in preparing their egg chambers.
- R24361: missing the left marginal rim of the carapace equivalent to the area of the posterior four left marginal scutes; completely healed.

None of the 30 nesting females had external fibropapilloma tumours.

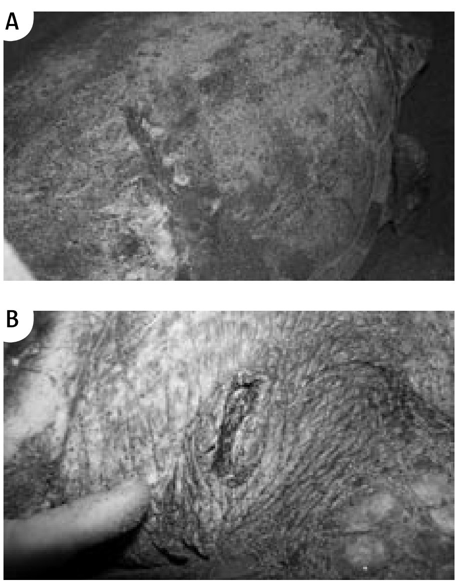


**FIGURE 15.** *Recent injuries to nesting female Caretta caretta.* **15A.** *Healing fracture in carapace of R24764.* **15B.** *Healing recent shark bite to the shoulder of R24771.*

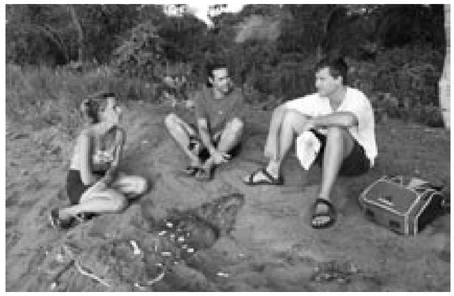

**FIGURE 16A.** *Dog-predated Caretta caretta clutch. Tony Sunderland discussing dog predation issues with local residents, Claudia and Eric.*

**FIGURE 16B.** *Two of the regularly observed dogs that were free-ranging on la Plage de la Roche Percée.*

## HARVEST AND PREDATION

People removed at least one nesting female, R24771, from the beach after she had laid her clutch and before she had returned to the sea on 16 January. She was presumably killed. Multiple local folks reported that at least two other nesting females had been similarly taken from the beach earlier during the nesting season, including one at Christmas. This represents a harvest of at least 5% of the season's total nesting population.

Free-ranging dogs were plentiful on the beach throughout the day and night during the survey period (Figure 16). While they were not recorded to harass the nesting turtles, at least one clutch of eggs was observed destroyed by dogs. Local residents reported that numerous clutches of eggs have been destroyed by dogs at la Roche Percée each summer.

Based on reports from local residents, a small number of eggs appear to be eaten by people from the district. No human removal of eggs was observed during the survey period.

Ghost crabs, *Ocypode cordimana*, were abundant along the beach. These crabs were large enough to prey on turtle hatchlings. While hatchling predation was not observed, these crabs were seen preying on frogs and bivalves along the beach.

## TRAINING AND EDUCATION

This project could not have succeeded without the assistance and support of J-Louis d'Auzon, President of Association pour la Sauvegarde de la Nature Neo-Caledonienne and other members of the Association. Before the team traveled to Bourail, J-Louis organized for the team to spend half a day at the Noumea Aquarium assisting the staff with tagging of their turtles in preparation for their release. A discussion session explaining the function of the present study occurred at that time.

As was expected following the preliminary February 2004 visit to the site, the local residents were enthusiastic towards participation in the project and being trained in turtle monitoring methods. However, Cyclone *Kerry* dampened their enthusiasm. As a result, local folks only participated in the field work during the last few nights. Through out the study, locals participated on five nights with 1 – 15 persons per night.

A public education night was held in the outdoor dining area of the village hotel on January 18, 2005 (Figure 17). Two local folks, Isabell Roy and Ingrid Vallejo-Torres, assisted Michelle in preparation of the slide presentation

FIGURE 17. *Public education: An illustrated talk on turtle biology and the current research project was given to local residents and media in the lounge of L'Hotel de la Roche Percée.*

Table 6. Capture history of Green turtle, *Chelonia mydas*, tag number T91659.

| Date | Location | Capture history |
|---|---|---|
| Dec 1984 – Jan 1985 | Heron Island, southern Great Barrier Reef | Ashore for nesting<br>• Curved carapace length (CCL) = 109.5cm |
| Dec 1989 – Jan 1990 | Heron Island, southern Great Barrier Reef | Ashore for nesting<br>• CCL = 110.5cm<br>• Remigration interval = 5yr |
| Dec 1995 – Jan 1996 | Heron Island, southern Great Barrier Reef | Ashore for nesting<br>• CCL = 112.5cm<br>• Remigration interval = 6yr |
| March 2005 | Tiari, north of Pouebo, western New Caledonia | Captured in seagrass habitat.<br>• Killed and eaten |

so that it was presented in French and also facilitated the answering of questions following the presentation. Approximately 50 persons attended this slide presentation on sea turtle biology and conservation. The talk also served to acquaint the broader local community with the purpose of the study.

A full kit, including datasheets, tag applicators, tags, measuring tapes, helmet and head spot, was left with J-Louis to facilitate continued monitoring of the area. In addition, electronic copies were also left with these folks of: 1) powerpoint presentation prepared for the Public education night, and 2) copies of our data sheets.

Turtle tags used for this study were chosen to be integrated with the existing ASNNC turtle tagging project in New Caledonia, rather than introduce tags with an Australian address for this short term study. This was facilitated by J-Louis. A full copy of all data from this project will be lodged with ASNNC.

The team has maintained an ongoing communication with the local folks. This has lead to at least one new reporting of a tagged turtle captured by a fisherman. It was an Australian tagged green turtle that was captured and eaten in northern New Caledonia (Table 6).

Loggerheads (*C. caretta*) in the size range of "about 70 to 85 centimeters long" are regularly encountered foraging in the reefs, channels and sea grass areas to the north of Bourail. They occur there all year round. Up until May 2005, no tagged *C. caretta* had been seen.

Following the visit to the Aquarium and the education night, the project was aired on local TV news broadcasts. The project was also reported in the local news paper.

## MANAGEMENT ISSUES

A range of human activities was negatively impacting both the nesting habitat and the nesting turtles, their eggs and hatchlings.

### *Erosion*

The erosion of the beach in recent years has threatened housing and the adjacent road. This is a continuing problem. The local government has responded by depositing rocks along approximately 7% of the beach. The rocks extend to below the high tide mark and prevent turtles from accessing the nesting habitat along this portion of the beach. While this rock wall appears to have placed within the most preferred nesting habitat for La Roche Percée, no turtles successfully laid along the section of the beach with the rock wall during the time of the survey.

The continuing erosion of the beach is causing concern among local residents and local government. Some residents are advocating for this rock wall to be significantly extended. If this occurs it will further decrease the amount of suitable nesting habitat for the turtles.

The least stable areas occur at both ends of the beach. This was particularly evident on the southern end of the beach during Cyclone Kerry. During the time of the survey a sand cliff formed that was unsurmountable by nesting turtles. As a result turtles were returning to the water, without successfully laying in this section of the beach.

We consider that beach erosion and the proposed extension of the rock wall pose a significant threat to the viability of this turtle nesting population.

### *Housing and traffic lighting*

There was intense lighting of the beach area from housing and from traffic headlights on the northern end. The house lighting that was of concern was primarily the external lights. There were strong outside security lights that remained on throughout the night with at least two houses near the northern end of the beach. This lighting caused the beach to be brightly illuminated and was strong enough to impair the night vision of the research team. While there was little evidence of turtles returning without laying because of this lights, there remains the concern that new females recruiting to the nesting population will avoid using brightly illuminated beaches. The long-term decline in nesting turtle numbers in response to increased illumination of beaches has been observed at others rookeries and is a distinct possibility here at Bourail.

Because the survey did not occur during the primary hatchling emergence period, the effect that this lighting would have on hatchling orientation was not documented. Changes to the light horizons that occur with passing traffic were relatively intermittent and should not significantly impair hatchling orientation under current traffic densities. This can be expected to change with increased development and tourist visitation to the district.

### *Vehicles on dunes*

Vehicles have access to the nesting habitat at the southern end of the beach. Vehicle traffic on the beach is damaging nests where vehicle tracks occur over nesting sites and is retarding vegetation growth. Where vehicle damage to dune vegetation is excessive, there is the increased risk of beach erosion.

### *Dogs*

There is a large dog population within the La Roche Percée community. Many of these dogs are free to roam the nesting beach. Residents reported that dogs often dug into nests and destroyed developed eggs on a regular basis.

### *Boating*

There were no reports of turtle strandings that could be attributed to boat strike. The quiet waters of the Bay offshore from the nesting beach will be the inter-nesting habitat used during the summer months by the females, while they are preparing their successive clutches for laying. During the survey most boats departed the boat ramp (at the entrance of the river mouth) and headed directly out to the reef. While very little motorboat activity was observed in the Bay, jet skis were observed travelling back and forth and at speed in the bay during the survey period. This activity would be disturbing to any turtles using these shallow waters.

### *Poaching*

During the survey, one nesting female was removed from the beach by humans. Local informants reported nesting turtles being removed from the beach at a rate of approximately 2-3 per year. This has not been validated. There was one report of eggs being removed from a nest. The traditional inhabitants of the area, Kanak people, appear to have a greater desire to utilize the turtles and eggs as food than the folks of European origin.

## DISCUSSION

Within the Pacific Ocean region, *C. caretta* breeding is restricted to the western margin (Figure 18). In the North Pacific, nesting only occurs within Japan (Kamezaki et al. 2003). In the South Pacific, nesting is rarely encountered outside of eastern Australia (south Queensland and northern New South Wales), New Caledonia and Vanuatu (Limpus and Limpus, 2003). In contrast with the well known eastern Australian nesting population (Limpus, 1985), the nesting distribution in New Caledonia and Vanuatu remains incompletely described. With about 60-70 nesting females annually, the Bourail District *C. caretta* nesting population is the largest currently known within New Caledonia. In the absence of more comprehensive surveys, Roche Percée is identified as a suitable index beach for on going monitoring the population status of *C. caretta* within New Caledonia. This assessment is based on the combination of the size of the annual nesting population and the accessibility of this mainland nesting beach for ongoing monitoring, even under adverse weather conditions.

Based on the results of the present study, the *C. caretta* nesting populations of New Caledonia and eastern Australia should be regarded as forming a single management unit. Allowing for the small sample size of the population at Roche Percée, the size of nesting females, the number of eggs per clutch, the size and weight of the eggs and the size and weight of hatchlings (Table 5), this representative New Caledonian nesting population is very similar to the respective parameters measured at eastern Australian rookeries (Limpus, 1985). This similarity in reproductive parameters is what would be expected from rookeries within a single genetic stock. Until more comprehensive data area available from the New Caledonian rookeries, it is recommended that values derived at the Australian *C. caretta* rookeries be used to describe the relevant reproductive biology at the New Caledonian rookeries.

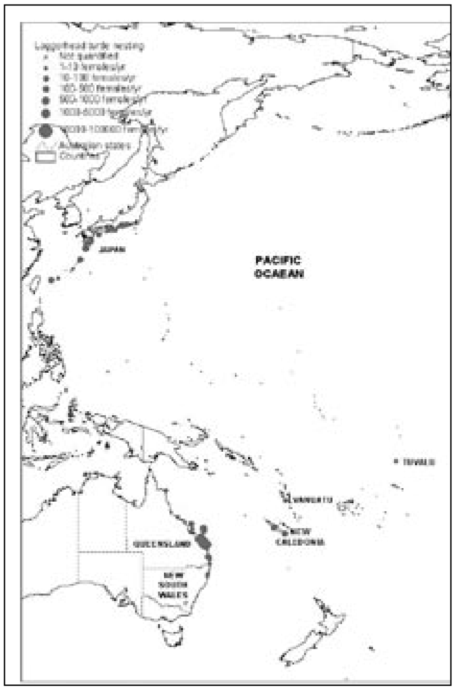


**FIGURE 18.** *Distribution of loggerhead turtle, Caretta caretta, nesting within the Pacific Ocean region (Source Limpus and Limpus, 2003). Dots denote nesting sites.*

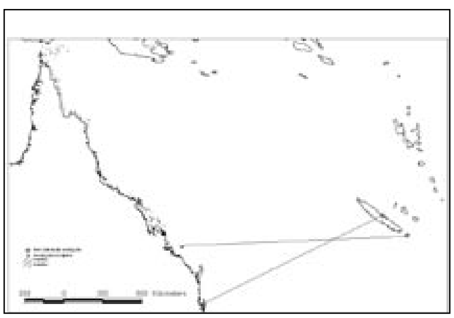

**FIGURE 19.** *Identified foraging areas for two adult female Caretta caretta that bred in New Caledonia. Crosses denote nesting sites. Dots denote feeding sites.*

Migration data are available from only two New Caledonian nesting females to link the nesting populations to their dispersed foraging areas (Limpus, 1994; Limpus and Limpus, 2001). Both females migrated from feeding areas in eastern Australia to New Caledonian rookeries (Figure 19) and subsequently returned, each to the same feeding area from which she began her breeding migration.

It can be assumed that the *C. caretta* that foraging in New Caledonian coastal in areas, like off Bourail (see above) and Ile des Pines (Beloff, 1997) will include turtles that breed both at the Australian rookeries (Limpus and Limpus, 2003) and at New Caledonian rookeries.

Again, until data are specifically available from a wider range of foraging areas, it is recommended that the demographic parameters described for the species in eastern Australian foraging areas and the associated demographic modelling (Chaloupka, 2003) be applied for investigating the potential responses of the New Caledonian populations to anthropogenic impacts and their potential responses to management options.

There are some discrepancies among the reports from local informants: Laurence Langlois recollected that 20-30 years ago an average of 6 Grosse Tête nested per night at la Roche Percée, with a maximum of 20-35 on some nights. This is similar to estimates provided by Jean-Pierre Revercé, also a local man who grew up in the region, who suggests that around 30 years ago, during the peak of the nesting season, 5-6 loggerheads laid clutches at la Roche Percée per night, and at the most 10 per night. Other reports claim that nesting loggerheads once numbered in the hundreds on any given night within the breeding season. However, the general consensus was that there had been a decline in the amount of nesting that occurs annually on the Bourail District beaches over recent decades.

A decline in the New Caledonian nesting population would be consistent with the substantive declines in *C. caretta* breeding recorded at the sites where monitoring has occurred elsewhere in the Pacific Ocean basin. It would be appropriate then for steps to be taken to improve the conservation outlook for *C. caretta* in New Caledonia. In particular, at nesting beaches, such as those in the Bourail District, there are a number of actions that can be taken by the local community that will contribute to improving reproductive success for the species:

- Reduce erosion and increase the stability of the dunes that are the nesting habitat:
  - planting of suitable vegetation that will stabilize the beach;
  - excluding vehicle traffic from the frontal dunes. This action would reduce loss of eggs due to being run over in the nests.
- Extension of the existing rock wall as a solution to erosion should be avoided.
- Dense vegetation should be planted along the dunes. While this will contribute to reduced erosion of the dunes, it also will provide the beach with protection from lighting.
- Where possible, it is recommended that a 1.5km darkness zone be maintained around these nesting beaches. Dark beaches are the preferred management option for maintaining sustainable turtle populations. Altered light horizons resulting from the continued expansion of housing development within this community can be minimized via the use of appropriate turtle-friendly lighting including:
  - Low pressure sodium vapor lights should be used where road lighting is required along roads and for external lighting of buildings;
  - Security lighting visibly from the beach should be turned on by proximity sensors rather than being turned on continuously throughout the night;
  - Intermittent slowly flashing lights can be used to mark walking tracks.

- It is recommended that vehicle traffic be kept from access to the turtle nesting habitat of the frontal dunes of these beaches. This has already been achieved in some sections of beach through the use of a line of closely placed large rocks to obstruct vehicle access (Figure 3e).
- Turtle nesting would benefit from restricting boating activity to defined navigation channels while limiting boat speed within the waters immediately off the nesting beaches. While boating activity does not appear to be a pressing management issue at present, it can be expected to increase with increased development of the area and increased tourist visitation.
- Local residents should be encouraged to manage the dog population to prevent them from wandering the dunes throughout the night.
- Local laws relating to harvest of turtles should be enforced. If the local Kanak people are permitted to harvest turtles and/or eggs, then the following general principals can be applied to ensure that the harvest can be sustainable:
  - At least 70% of the clutches of eggs should produce hatchlings. The loss of eggs to dog predation, to erosion and to human harvest need to be collectively regulated to ensure that sufficient hatchlings are produced.
  - The harvest of nesting females should not exceed 10% of the annual recruitment rate to the nesting population. Based on eastern Australian populations, this would translate to no more than 10% of 30% = 3% of the total annual nesting population, i.e. about a maximum of 2 adult females annually.
  - The management of a sustainable level of take should be addressed by the Kanak elders.

These issues need to be addressed by an education campaign directed to both the local residents and the local government.

## ACKNOWLEDGEMENTS

This project was conducted as part of the Queensland Turtle Research Project. It was funded in part by a grant from the Western Pacific Regional Fisheries Management Council (Contract No. 04-WPC-030). The project could not have achieved without the invaluable assistance of the Association pour la Sauvegarde de la Nature Neo-Caledonienne and in particular the President, J-Louis d'Auzon. Marile and Daniel Marteaud provided assistance with accommodations. Numerous local residents provided oral background information on the region and its turtles and assisted with the beach studies. This assistance is acknowledged and appreciated.

## REFERENCES

Beloff, P. (1997). Report on the Isle des Pines marine turtle survey (21st December 1996 to 5th January 1997. Unpublished Report to Association Pour La Sauvegarde De La Nature Neo-Caledonienne. Pp. 1-10.

Chaloupka, M. (2003). Stochastic simulation modeling of loggerhead population dynamics given exposure to competing mortality risks in the western South Pacific. In: Bolten, A. B. and Witherington, B. E. Biology and Conservation of Loggerhead Turtles. Pp. 274-294. (Smithsonian Institution Press: Washington, D. C.)

Cobb, B. D. and Clarkson, J. M. (1994). A Simple Procedure for Optimizing the Polymerase Chain-Reaction (Pcr) Using Modified Taguchi Methods. *Nucleic Acids Research* 22(18): 3801-3805.

Dutton, P. H. (1996). Methods for collection and preservation of samples for sea tutle genetic studies. Proceedings of the International Symposium on Sea Turtle Conservation Genetics, Miami, Florida, NOAA.

Kamezaki, N., Matsuzawa, Y., Abe, M., Asakawa, H., Fujii, T., Goto, K., Hagino, S., Hayami, M., Ishii, M., Iwamoto, T., Kamata, T., Kato, H., Kodama, J., Kondo, Y., Miyawaki, I., Mizobuchi, K., Nakamura, Y., Nakashima, Y., Naruse, H., Ohmuta, K., Samejima, M., Suganuma, H., Takeshita, H., Tanaka, T., Toji, T., Uematsu, M., Yamamoto, A., Yamato, T. and Wakabayashi, I. (2003). Loggerhead turtles nesting in Japan. In "Biology and Conservation of Loggerhead Turtles." (Eds. Bolten, A. B. and Witherington, B. E.) Pp. 210-217. (Smithsonian Institution Press: Washington, D. C.).

Limpus, C. J. (1985). A study of the loggerhead turtle, *Caretta caretta*, in eastern Australia. PhD Thesis, Zoology Department, University of Queensland.

Limpus, C. J. (1992). Estimation of tag loss in marine turtle research. *Wildlife Research* 19: 457-69.

Limpus, C. J. (1994). Marine turtles: ancient mariners in distress. *Air Sea Rescue Journal* 12(2): 99-113.

Limpus, C. J. (in press). "A biological review of Australian marine turtles. i. Loggerhead Turtle, *Caretta caretta* (Linneaus)." (Queensland Environmental Protection Agency: Brisbane).

Limpus, C. J. and Limpus, D. J. (2001). The loggerhead turtle, *Caretta caretta*, in Queensland: breeding migrations and fidelity to a warm temperate feeding area. *Chelonian Conservation and Biology* 4(1): 142-153.

Limpus, C. J. and Limpus, D. J. (2003). The loggerhead turtle, *Caretta caretta*, in the equatorial and southwest Pacific Ocean: a species in decline. In "Biology and Conservation of Loggerhead Turtles." (Eds. Bolten, A. B. and Witherington, B. E.) Pp. 199-209. (Smithsonian Institution Press: Washington, D. C.).

Limpus, C. J.; Reed, P. C., and Miller, J. D. (1985). Temperature dependent sex determination in Queensland sea turtles: intraspecific variation in *Caretta caretta*. In: Biology of Australian Frogs and Reptiles. (Grigg, G., Shine, R. and Ehmann, H., Eds.) Pp. 343-51. (Surrey Beatly and Sons: Sydney.)

Limpus, C. J., Parmenter, C. J., Baker, V. and Fleay, A. (1983). The Crab Island sea turtle rookery in north eastern Gulf of Carpentaria. *Australian Wildlife Research* 10: 173-84.

Nicholls, J. A., Double, M. C., Rowell, D. M. and Magrath, R. D. (2000). The evolution of cooperative and pair breeding in thornbills Acanthiza (Pardalotidae). *Journal of Avian Biology* 31(2): 165-176.

Norman, J. A., Moritz, C. and Limpus, C. J. (1994). Mitochondrial-DNA control region polymorphisms – genetic-markers for ecological-studies of marine turtles. *Molecular Ecology* 3(4): 363-373.

# Appendix 1:
# North Pacific Loggerhead Turtle – Threat Mix

**RISK MATRIX: THREATS RANKED (1-4)**
**1** = High threat level; high importance to take action
**2** = Medium threat level
**3** = Low threat level; low importance to take action
**4** = No threat level (not applicable)
**Unk** = unknown threat (but could potentially be a threat, once more is known)

High level threats versus medium level threats ranked and/or prioritized based on tasks that are within reason to implement given available monetary resources.

| THREAT | ADULTS | JUVENILES | HATCHLINGS | EGGS |
|---|---|---|---|---|
| **Threats to Nesting Beaches** | | | | |
| Direct harvest (humans) | 4 | 4 | 4 | 4 |
| Coastal construction (disruption of nesting & hatching activities) | 1 | 4 | 4 | 2 |
| Nest predation by domestic, native and/or feral animals | 4 | 4 | 3 | 3[a] |
| Artificial lighting | 2.5 | 4 | 2.5 | 4 |
| Data deficiencies (nesting activity, identify nesting beaches, determine and monitor trends, nesting beach origins, define stock boundaries, genetics) | 3 | 4 | 3 | 3 |
| **Threats to Nesting Habitat** | | | | |
| Degradation due to erosion-control measures, jetties, breakwaters | 1 | 4 | 4 | 1 |
| Sand removal & mining practices | 2.5 | 4 | 4 | 2.5 |
| Vehicular driving/ Foot traffic | 2 | 4 | 1.5 | 1.5 |
| Degradation by upland, coastal erosion, siltation (mining), river armoring, dams | 1 | 4 | 4 | 1 |
| Ceremonial purposes[b] | 4 | 4 | 1 | 4 |
| Global warming* (increasing sand temperature, sea level rise) | 2 | 4 | 4 | 2 |
| Typhoon | 1.5 | 4 | 4 | 1.5 |

| THREAT | ADULTS | JUVENILES | HATCHLINGS | EGGS |
|---|---|---|---|---|
| **Threats to turtles in marine habitats** | | | | |
| Direct harvest | 1[c] | 1 | 4 | 4 |
| Data deficiencies (distribution, abundance, migration, growth rates, survivorship, threats on foraging grounds) | 2 | 2 | 4 | 4 |
| Entanglement and ingestion of marine debris | 2 | 2 | 3 | 4 |
| Boat collisions | 3 | 3 | 4 | 4 |
| ***Incidental take in Fisheries*** | | | | |
| Longline | 1 | 1 | 4 | 4 |
| Purse seine | 3 | 3 | 4 | 4 |
| Trawl | 1 | 1 | 4 | 4 |
| Gillnet | 1 | 1 | 4 | 4 |
| Pound nets/traps/pots | 3 | 3 | 4 | 4 |
| FADs | 3 | 3 | 4 | 4 |
| Hook and line | 3 | 3 | 4 | 4 |
| ***Other*** | | | | |
| Disease | 3 | 3 | 4 | 4 |
| Predation | 3 | 3 | 4 | 4 |
| **Threats to marine habitat** | | | | |
| Data deficiencies (identification of important foraging habitat) | 1.5 | 1.5 | 4 | 4 |
| Degradation of reefs by boating, diving, human use activities | 2 (Unk) | 4 | 4 | 4 |
| Degradation by coastal erosion, siltation, including mining, logging, pollution | 3 | 3 | 4 | 4 |
| Degradation of pelagic habitat by oil trans-shipment[d]* | 2.5 | 2.5 | 4 | 4 |
| Bioaccumulation of heavy metals through prey ingestion* | Unk | Unk | 4 | 4 |
| Commercial red crab fishery[e] | Unk | Unk | 4 | 4 |

[a] Depending on the beach, egg predation by ghost crabs and ants takes place. In addition, a raccoon, introduced from the U.S., may prey on eggs and hatchlings – this may be an emerging issue.

[b] In Hamamatsu (Shizuoka Prefecture), an NGO relocates eggs to hatchery and holds loggerhead hatchlings longer than normal after they hatch to be released en masse on a set calendar day, for the purpose of educating and attracting tourists and local media. Hatchlings are released during the day, after spending their frenzy period in a tank. Threat is therefore high for hatchlings in this area only.

[c] There is minimal direct harvest by 3-4 communities in Japan of non-nesting loggerheads of minimum size of 70 cm. This is likely decreasing due to education and outreach efforts. The direct harvest of loggerheads off Baja California, Mexico is still occurring at high levels and is the primary reason this threat is ranked "high." Few adults are taken - mainly juveniles and subadults.

[d] There are proposals for installation of several Liquid Natural Gas facilities off southern California and Baja California, Mexico. This is an emerging issue.

[e] While this fishery is currently non-existent, if a commercial fishery for pelagic red crabs does emerge, this could have serious impacts on loggerheads foraging off Baja California, since this is one of their primary food sources.

* emerging issue

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