SUCCESSFUL CONSERVATION STRATEGIES FOR SEA TURTLES

Achievements and Challenges

Maria Monica Lara Uc
Juan M. Rguez-Baron
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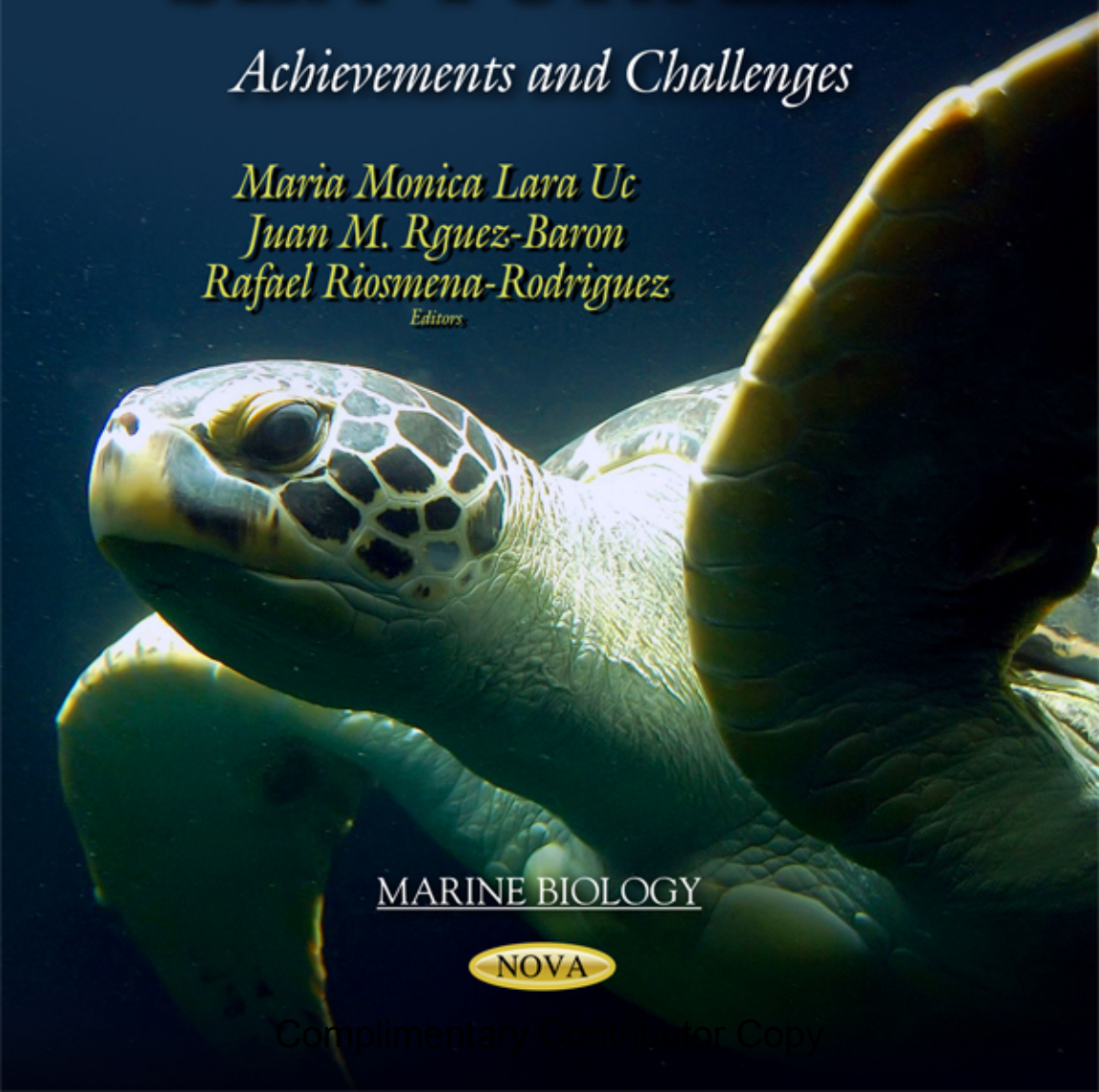
Editors



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MARIA MONICA LARA UC
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EDITORS

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PREFACE

After decades of research, monitoring, and analysis, we still have so much to learn about sea turtles. As reptiles, they are environmentally sensitive animals and thus can sense acute changes in their habitat. This rudimentary tactic of ectothermic animals has possibly conceded to the survival of sea turtle populations over millions of years. They have endured cooling and warming of the earth. The habitats they depend have endured fierce hurricanes and erosion. Now the question remains if sea turtle populations and their habitats will survive the challenges and pressures that humans place on the world.

The anthology of research presented in this text book is diverse and yet so interconnected. We cannot work to conserve wildlife populations without a fundamental understanding of habitat or the range of changes that individuals within a population can tolerate. Sea turtles are no exception. Changes in migration patterns due to climate change, diversity of food sources between species, acute habitat selection for nesting, mutations in genetics, and differences in anatomy, physiology, and biochemistry between species and even individuals make the study of sea turtles dynamic and challenging.

Sea turtles face human threats as well as natural threats. Unregulated and expansive coastal development provokes accelerated erosion of nesting beaches resulting in habitat loss and indirect consequences such as lighting which can disorient hatchlings. Accidental catch in fishing nets and longlines, direct poaching of eggs and individuals, and oil spills, pose a cumulative, negative impact on a global scale. These human threats should initiate a collaborative approach to sea turtle conservation. However, when the hunger and competition for funding is so aggressive in an economically depressed world, it appears that groups are fighting for more than territory and

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publication rights. Competition is overcome when researchers contribute to sharing data and information such as the work that presented here in this textbook.

While the next generation is consumed by technology through cell phones, computers, tablets, and other electronic devices, we have the responsibility to translate what we know from mechanical research and conservation into the technological world. New scientists and old will appreciate the diversity of efforts to study sea turtles from this work anthology and learn to apply these results through their successes and failures into new forms of research. The next generation is tasked with continuing our work presented herein by modifying our methods, expanding our hypotheses, and revising our results into applicable uses for the conservation of these endangered species.

However, our efforts will be lost if we cannot work together to find solutions to protect marine turtle habitat. With only 1-3% of our entire oceans protected, we have a long way to go. Habitat protection leads to healthy sea turtle populations and better conservation efforts. Yet, to understand which habitats are needed to protect, further research and analysis is needed to identify priority habitats and gain a more complete fundamental understanding of in-water habitat use. On behalf of all researchers, we can achieve conservation of marine turtles when we all work together through data sharing and outreach, such as the following examples of excellent coordination of research.

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Chapter 1

HISTORY, SCIENCE AND CONSERVATION OF SEA TURTLES IN CHILE

Carlos A. Canales Cerro and Rocío E. Álvarez Varas
ONG Qarapara Tortugas Marinas, Chile

ABSTRACT

It is possible to recognize the presence of sea turtles in Chile since the Cretaceous with fossil registry in the south of the country. In addition, pictographies and petroglyphs exist, in both continental and insular territory. This evidences the interaction between sea turtles and man since early times in history, either for consumption or cultural reasons. Later on, from the first observations made by J.I. Molina in 1782 until the present time, numerous studies have been conducted, that cover from simple descriptions to more complex population, environmental and fisheries studies. These investigations have helped define the presence of four species in the country (*Chelonia mydas, Caretta caretta, Lepidochelys olivacea* and *Dermochelys coriacea*), aspects of their ecology, population health and threats, all of which have promoted the development of legislation and local conservation projects. Due to the growing interest emerging in this country, there are diverse organizations and institutions dedicated to increase and spread the knowledge of these Chelonians. However there is still a long way to go in relation to sea turtle conservation in Chile. Nowadays, it is necessary to complete the classification process of the species, at the same time generate systematic scientific information and projects adapted to the local and national realities, while integrating community participation. This will lay the groundwork to formulate and implement appropriate management and conservation plans for these threatened species in our country.

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INTRODUCTION

Popular knowledge regarding sea turtles in Chile, even among the scientific community, is scarce. Their presence on our coasts is still unknown for some or is believed to be sporadic or of accidental nature. However, evidence exists that the presence of sea turtles along the Chilean coasts, both continental and insular, dates back to prehistoric times and that their interaction with man begins before the Spanish colonization.

This chapter seeks to point out the importance of the Chilean territory in historic and biological terms for, at least, the four sea turtle species nowadays described along Chilean coasts.

HISTORY BEFORE THE HISTORY

The paleontological register of marine Chelonids in Chile dates from the Cretaceous period. One of these fossils is a jaw found in Lirquén, province of Concepción (Biobío Region, center-south of Chile), in the upper section of the Quiriquina formation, Campaniano-Maastrichtiano (36º42'11"S; 72º58'20"W). It is an incomplete jaw that does not possess the joint of both branches nor the anterior end of the symphysis (Figure 1). This piece is considered to belong to a specimen of the *Osteopygis* genus. The species of this genus dates back to the Superior Cretaceous of North America, thereby the finding of this jaw in southern Chile, increases the geographic distribution for this taxa (Gasparini & Biro-Bagoczky, 1986).

The piece identified with code Q/377 (Figure 1) is kept in the Paleontological Museum of the Geosciences Department of Concepción University, located in Concepción city (Biobío Region) (Gasparini & Biro-Bagoczky, 1986).

Furthermore, Quiriquina Island and the neighboring coasts hold one of the richest deposits of cretaceous marine herpeto fauna of South America. On this island, turtles of great size have been registered on rocks that date from the same time as the previously mentioned jaw, but in this case these ancient remains haven't been extracted (Fuenzalida, 1956; Gasparini, 1979).

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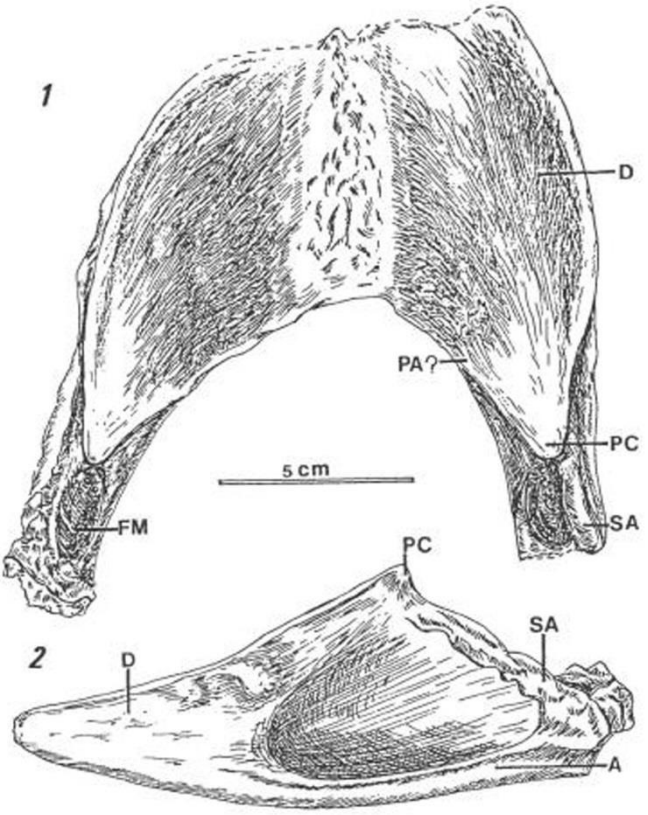

Figure 1. Incomplete *Osteopygis sp.* jaw (Q/377). 1. Dorsal view; 2. Lateral view. A. Angular; D. Dental; FM. *Fossa Meckelli*; PA?. Pre-articular; PC. Coronoid process; SA. Suranfular. (Figure extracted from Gasparini & Biro-Bagoczky, 1986).

The first registers of interaction between humans and sea turtles in continental Chile date back to the last millennium of the pre Hispanic cultural sequence, and are found in El Medano (24°49'17"S; 70°30'31"W). This is a remote ravine located in the northern coast of the country, stretching from the coastal mountain range (over 2000 m.a.s.l) down to the coastal plain (1200 m.a.s.l). This ravine contains more than a thousand red rupestrian paintings with marine and terrestrial images. Several shapes and forms can be observed, like fish, cetaceans, turtles and sea lions among the marine animals, either solitary or in groups. It is also possible to identify fishing and collective hunting scenes of sea lions for their skins, besides the hunting of terrestrial

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species. These images are found in more than 200 painted panels located along the first half of the 10 Km. extension of this ravine. This pictographic site was reported for the first time by Augusto Capdeville in 1923 and map referenced in 1956 by a relative of his (Berenguer, 2009). On the basis of these images, it is presumed in the literature that some of the specimens of sea turtles represented would correspond to *Dermochelys coriacea* (Figure 2) (Berenguer, 2009).

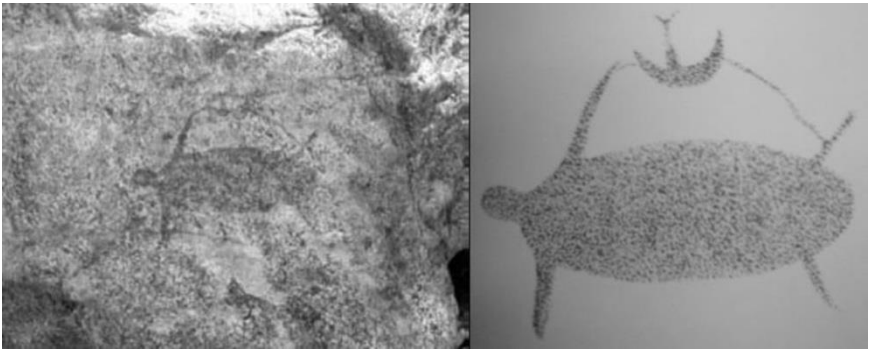

Figure 2. Canoe trawling a Leatherback Turtle (*D. coriacea*). Left: photograph taken by J. Berenguer (Berenguer, 2009). Right: illustration of the rupestrial painting.

In addition, one kilometer from the San Ramón (25°23'02"S; 70°26'40"W) ravine, located south of El Medano ravine, there is another site of pictographies with representations of *changas* (sea lion skin rafts) trawling cetaceans, fish and turtles, among other animals (Rojas-Muñoz, 2005).

As part of insular Chile, in Rapa Nui (Easter Island; 27º07'10"S; 109º21'17"W), historic registers can be found that show the ancestral interaction between Rapanui people and sea turtles. Osseous remains of these animals have been found near some of the oldest human artifacts dated in this place (Hunt and Lipo, 2006). Furthermore, their presence in myths, legends and historic literature of the island, show the importance of these species in this Polynesian culture. Sea turtles have been incorporated in rupestrian Rapanui art (Museo Chileno de Arte Precolombino, 2012), evident in images observed in the different petroglyphs situated around the island (Figure 3). In the same way, these animals are also present in Rongo Rongo tablet writings, which repeat the signs depicted on the petroglyphs and symbolize the Pleiades (Rjabchikov, 2001).

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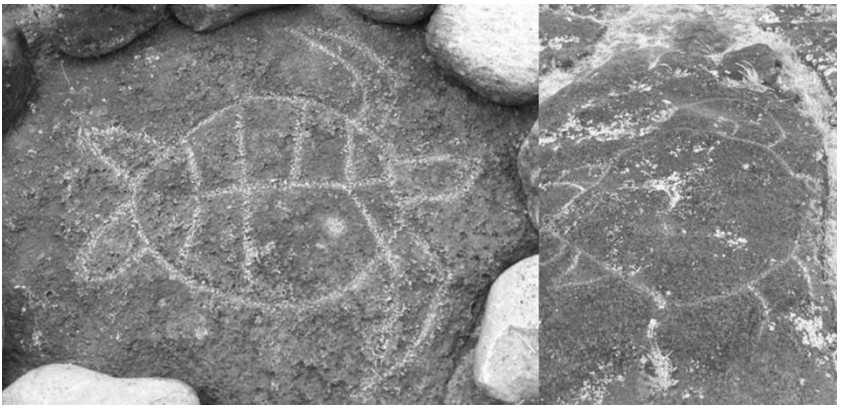

Figure 3. Sea turtle petroglyphs in Rapa Nui (Easter Island) (Photographs: Carolina Cuevas Martínez).

As well as in other Polynesian islands, there are registers of the socio-cultural context around which feeding on these species developed in Rapa Nui, where traditional law restricted sea turtle meals solely to kings and priests (Woodrom, 2010). The story tells that in Hanga Ho'onu (Sea Turtle Bay, known nowadays as La Perousse Bay), the locals waited with their harpoons until sunset, observing the arrival of the turtles from stone towers (Campbell, 1999; Thompson, 1891). Even though there is scarce information about the techniques used for capturing these animals on the island, Ayres (1979) reports the use of a special net to capture turtles called "*kupenga honu*" and the manufacturing of diverse types of hooks that could be used with the same purpose.

STUDIES SINCE THE BEGINNINGS AND NATURAL HISTORY

Among the first scientific references about sea turtles in the Pacific American coast, is one from Chile, described by Abate Juan Ignacio Molina, in his publication Saggio *Sulla Storia Naturale de Chile del Signor Abate Giovani, Ignazio Molina* (1782). This work was later translated into Spanish in 1787 with the title *Compendium de la historia geográfica, Natural y Civil del Reino de Chile.* Here, Molina refers to this animal group with the following phrase: "The coriaceous turtle inhabits the sea", without any clear idea of what led him to make this affirmation (Donoso-Barros & Cardenas, 1962; Frazier & Salas, 1982).

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After the J.I. Molina statement, the presence of Chelonids in Chile is uncertain, as mentioned by Claudio Gay in an 1848 publication where he points out: “in Chile there are no sea turtles of any species”. This was asseverated after not having any actual evidence of their presence on these coasts (Frazier & Salas, 1982).

Dr. R.A. Philippi, former director of the National Natural History Museum of Chile (NNHM), was another naturalist who worked and provided important data about sea turtles in Chile. In 1887 he was the first to conduct detailed studies about this animal group, not only in the country, but also throughout the South American western coasts (Frazier & Salas, 1982).

After the observation made by Molina, in which he refers only to the presence of *Testudo coriacea* (present synonymity of *Dermochelys coriacea*), Dr. R.A Philippi mentions these animals in 1899, within the University of Chile annals, in a publication that compiled the data obtained during his studies. Philippi observed specimens from Iquique, Tocopilla, Valparaíso, Quinteros and Chiloe island (north, center and south of Chile), from which he determined some as new species, underlining that they had only been detected 20 years before the publication that is referenced here (Philippi, 1899). However, the asseveration of their “recent” presence on Chilean coasts could have been influenced by the difficulty to see these animals in their environment.

Philippi (1899) in his publication begins with a differentiation of the three sea turtle genera that could be found in Chile and on this basis described new species. The genera were: *Dermatochelys* or *Sphargis* (present synonymity of *Dermochelys*), *Chelonia* and *Thalassochelys* (present synonymity of *Chelonia*/*Caretta* and *Lepidochelys* respectively*)*. Until then, the only species known by the naturalists of the time in Chilean waters was *Sphargis coriacea*, which extended from Iquique (20ºS) to Chiloé (42ºS). In the same way the author makes reference to another species that corresponds to the same genus, *Sphargis augusta*. It differs from *S. coriacea* by the author because of morphological variables that nowadays are considered just variability among individuals. This species’ holotype is in the National Natural History Museum (specimen MNHN 1515).

Chelonia lata, is another species described for the first time by R.A. Philippi on the basis of the new specimens collected in Chilean waters. The holotype of this species is found in the NNHM collection (specimen MNHN 1510). Of this species, two carapaces have been in the museum collection since 1889. These carapaces were found to be different than *Chelonia mydas* by the descriptor, reason why he exhibited them under the name of *C. lata*.

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In 1896, a complete specimen arrived, as a gift to the museum from Ortiz de Zárate. With this specimen Philippi convinced himself that it was a different species because of the phenotypic variations that could be observed, which led towards what nowadays is known as the subspecies *Chelonia mydas agassizii* (controversial among specialists that describe it as a morphotype). *Thalassochelys tarapacana* (MNHN 1511) and *Thalassochelys controversa* (MNHN 1512) also were described by Philippi and nowadays both are considered as *C. caretta*.

Additionally, an anecdotic natural history fact is mentioned that refers to nesting turtles on the Chiloé island coasts (42°S) located in Southern Chile. Given that this is an exceptional case in the country, the author is textually quoted in his 1899 publication:

> "Mr. S. C. Hambleton, natural history teacher of the Ancud Lyceum, has written me the following on the 8th of April of 1895:
>
> -Gay says that chelonians do not exist in Chile and this seems to be the general idea, but I am convinced that this is a mistake.
>
> One of the lyceum students, that takes a lot of interest in these matters, stayed one summer on the western coast of Chiloé, at a spot called Cucao, near the Huillinco lake, with his father that was washing gold there. He told me that a sea turtle species is found there in great numbers and the Indians that live in the south told him they came out onto the coasts and laid their eggs on the sand in great abundance.
>
> They gave him information about the way the eggs were laid, their shape and size, shell, etc., knowledge they couldn't have had without actually seeing them, and I have motive to believe that the youngster has told me the truth, and if this is the truth, we could say that Chile has at least one kind of turtle.-
>
> I wrote immediately to mister Hambleton begging him to try to obtain more information, because it seems unlikely that sea turtles lay eggs on a coast as cold and rainy as this, but until today I haven't received any communication from mister Hambleton" (Philippi, 1899).

This would be the only supposed registry that exists of nesting sea turtles in Chile, even though it is common for them to come out on beaches along the country. There is no actual registry of nesting behavior to date. On the other hand, Carr (1952) suggests that if this anecdotal information turns out to be real, the nesting species should be *Caretta caretta* due to its distribution.

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Furthermore, a record exists of a female with eggs captured in front of the Chilean coasts, an event that will be recounted later on in this chapter.

The last publication of Dr. Philippi on sea turtles in Chile, was written in german in 1901.This was similar to the one published in 1889, but with some variations in the morphological measurements of the specimens that he described and name spelling, which weren't taken into account at the time (Frazier & Salas, 1982).

By 1908, Garman makes the first "scientific" reference regarding the presence of Chelonians in Rapa Nui island, mentioning five species (*Dermochelys schlegelii, Caretta olivacea, Chelonia japonica, Chelonia depressa* and *Eretmochelys squamosa*). Nevertheless, it is clear he did not observe any specimen from the island, based on what is mentioned in the following phrase:

> "To give an approximately complete idea of Easter Island's herpetology it is necessary to consider and provisionally introduce into our species list a number of sea turtles and one sea serpent that have their distribution range between Polynesia and the tropical and temperate portions of the Pacific and Indian Oceans, but up to date have not been collected or are known firsthand by scientists" (Garman's translation, 1908, extracted from Frazier & Salas, 1982).

In more recent times, Yañez (1951), submitted one of the most complete studies to that date, where he collected and mentioned the synonymities reported by other authors, including Philippi's reports. Herewith, he puts in order and updates the confusing taxonomic situation of the time, as well as scientific names and common names. Yañez makes reference to *Chelonia mydas* as a "relatively common" species from Coquimbo (30°S) to the north; however he mentions that *Dermochelys coriacea* is probably the most frequent species across the country, given that it is the most captured and known, being present from Chiloé (42°S) to the north. In addition, he recognizes *Lepidochelys* as a different genus than *Caretta*, reidentifying the previously observed specimens by Philippi.

The first concrete evidence of the presence of *Caretta* genus along the Chilean coasts, as well as in other South American Pacific coasts, can be found in Maria Codoceo's 1956 publication, in her NNHM Guide. Here, besides referring to the preserved specimens of that collection, she widely alludes to a living sea turtle specimen of this genus captured in the open sea in front of the Coquimbo (29ºS) coast. This specimen was donated to the old museum aquarium by teacher Carlos Muñoz on October 10th, 1956. In addition

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to this reference, Donoso-Barros (1961), discusses the presence of *Caretta caretta gigas*, mentioning it as relatively frequent in the Chilean northern coasts, and even as "an excellent dish".

Donoso-Barros in his work "Chilean Reptiles" (1966a), presents a summary of a number of studies published to that date, giving detailed information for every species, including their distribution within the country. *Chelonia mydas agassizii*, is located in bays and near island beaches, with a common distribution from Valparaiso (33°S) to the north, but also with some sightings south to Chiloé (42ºS). *Lepidochelys olivacea*, can be found from Antofagasta (24°S) to the north, with occasional sightings from Valparaiso (33ºS) and is mentioned as relatively frequent in Chile. *Eretmochelys imbricata*, is not mentioned as an inhabitant of Chilean waters, however it is mentioned for Rapa Nui because Garman (1908) had stated it previously.

In 1970 Donoso-Barros, published the Chilean Herpetological Catalog, incorporating complementary information to his previous publications. Within the most remarkable data, he confirmed the extension of the distribution range of *Dermochelys coriacea* to Chiloé, besides being the first one that refers to nesting sea turtles in Chile as "very unlikely". The distribution of *Lepidochelys olivacea* was also extended as far as Talcahuano (37°S).

In the same decade, Guzmán & Campodonico (1973) present the southernmost known sighting of *C. mydas agassizii*, at Desolación Island (52°S) in the Magallanes province. This specimen was observed from a National Petroleum Company (ENAP, from the Spanish abbreviation) craft, entangled in algae (*Macrocystis pyrifera)* fronds. The specimen is nowadays kept in the Patagonia Institute collection.

Mann in 1982, among other information, shows the first data about sea turtles in the Juan Fernández archipelago, mentioning the observation of 15 turtle carapaces and reports of islanders about their "appearance" between October and February. The carapaces came from specimens found on the coasts of the islands and from bycatch.

In 2003, González and collaborators published the capture of a gravid Olive Ridley (*Lepidochelys olivacea*). The specimen was captured in July of 2000 in the Laraquete coast (37º09' S; 73º11'W), near Concepción city, Biobío Region. This was a female with the long curve carapace measurement of 65 cm and the carapace width of 57 cm. It contained 96 eggs in the oviduct, in their final development stage (22.8 ± 4.1 mm) (González et al. 2003). However, this finding does not imply the existence of nesting beaches on Chilean coasts, given that Chelonids are capable of retaining eggs for long periods before laying. Other turtles with eggs inside have been found in distant

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coasts from their nesting beaches, as is the case of a Leatherback Turtle spotted in New Jersey (González et al. 2003).

Other important studies referred to the sea turtle collection of the National Natural History Museum, as well as observations of these species along the Chilean coasts, are those of Quijada (1916), Mann (1949), Donoso-Barros (1961, 1965a, b, 1966b), Pequeño (1967), Bahamonde (1972), Formas (1976), Marquez (1976), Frazier (1985), Ibarra-Vidal & Ortiz (1990) and Marambio (2007).

On the other hand, some studies referred to aspects of the ecology and health of Chelonids in Chilean coasts have also been conducted. González and collaborators (2000), provide the first data on epibionts. Their work details what was found on the carapaces of *Chelonia mydas* specimens from Laraquete (37ºS), southern Chile. They described cirripedians, hydrozoans and bryozoans. Miranda & Moreno (2002) refer to *Lepidochelys olivacea* found on the coast of the Biobío Region (center-south of Chile) during the years 2001 and 2002. The epibionts that were localized on the carapace, flippers and cloaca, mainly belonged to crustaceans and hydrozoans. Of the first group, the species *Lepas anatifera*, *Verruca laevigata*, *Balanus laevis* and *Planes cyaneus* were recognized; they are all common species for Pacific Ocean waters (Miranda & Moreno, 2002). Later, Brito (2007) reports the finding of *Planes cyaneus* associated to *L. olivacea* to the west of San Antonio (33°S) and in Matanza beach (33°S). Finally, López (2007) performs epibiont studies on those found on *Chelonia mydas* from Salado bay (27°41'08"S; 71°00'32"W), Atacama Region (northern Chile). She identified mollusks and crustaceans. Of the molluscs, only one species was identified as belonging to the *Crepidulla* genus. Of the crustaceans, two species belonged to the Gammaridae family, one species to the Aoridae family and one to the Talitridae family. As stated by Miranda & Moreno (2002), the species identified by López (2007) are common for the Pacific Ocean and the Chilean coasts.

In 2009 Álvarez-Varas conducted a study that determined heavy metal levels in the blood of Green turtles (*C. mydas*). She compared two feeding grounds with different levels of anthropic intervention in the north of Chile: Constitución cove (23°24'S; 70°35'W, a small fishermen’s bay with little human activity) and the Fishing Port of Antofagasta (23°35'S; 70°23'W, one of the main fishing ports in Chile). The results of this study indicated that the average values of copper (Cu), lead (Pb) and mercury (Hg) were 2.8 µg/g, 0.7 µg/g y 0.07 µg/g respectively. There weren’t significant differences between age stages (juveniles and adults) in any locality; however lead had higher

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concentrations in Constitución cove and mercury in Antofagasta. This is coherent with the environmental contaminant behavior, which moves with the wind and marine currents, so pollution in this kind of ecosystem does not reflect the presence of only one contamination source. The documented levels in this study were between 6 and 20 times greater than the ones reported in the blood of sea turtles from other parts of the world. These findings were attributed to the natural high levels of metals in the north of Chile and the historical mining and industry activity in the region. The high metal levels with an ecotoxicological importance found in Green turtle's blood suggest an elevated exposure to these elements and therefore a potential threat to those populations of this portion of the Southeastern Pacific Ocean.

Finally, we can't leave aside the report by Guerra and collaborators (2007), regarding the attacks and depredation of sea turtles by sea lions (*Otaria flavescens*) in the Mejillones locality, Antofagasta Region. In southern Mejillones bay (23°15'S; 70º30'W) it was possible to observe a permanent congregation of more than 20 Green turtle specimens, which were attracted by hot water originated from a thermal power plant belonging to Edelnor Company. Since 2007 continuous attacks were registered from sea lions against sea turtles in that area (primarily neck and flipper tearing), leading to a decrease and finally a local extinction of that population. Nowadays the presence of sea turtles in Mejillones bay is occasional and generally the sea lions continue to attack them once they enter the bay (Carlos Guerra, personal communication). It is believed that the documented attacks respond primarily to two causes: first to territorial conflicts due to unnatural sea turtle congregations and secondly to a decrease of available food for *O. flavescens*, either from anthropic origin (fishermen discards) or natural (schools of fish) (Guerra et al. 2007).

BYCATCH

Traditionally, swordfish (*Xiphias gladius*; known locally as Albacora) fishing in Chile was performed locally and through the use of harpoons. However, with an increasing market, since 1980 artisanal fishermen modified their techniques with longer trips and the use of gill nets and longlines. These are used at night with small submersible chemical lights as fish attractors (Frazier & Brito, 1990; Eckert & Sarti, 1997). By 1987 the annual fishing effort was of 4.777 nights at sea, six years later in 1993, the annual fishing effort was about 40.692 nights at sea, turning Chile into one of the countries

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with higher levels of fishing in South America (Eckert & Sarti, 1997). These changes brought along trapping other species in the nets, including the sea turtles species *D. coriacea*, *C. caretta* and *C. mydas*.

One of the first studies regarding bycatch of sea turtles in Chile was conducted by Frazier & Brito in 1990 in San Antonio (33°S), where captures of *D. coriacea* were estimated. These captures occurred primarily between January and July, and were absent between August and December, which coincides with the increase of bycatch in general during the swordfish season (Frazier & Brito, 1990). In this study, it was estimated that around 250 Leatherback turtles were incidentally captured. However, it was not a systematic study and the statistical analysis was not strong, therefore the given values could be overestimated.

With the exception of San Antonio, Chilean ports didn't usually incorporate sea turtle incidental catch in their fishing statistics. San Antonio represented approx. 28-32% of total national gill net fishing. Therefore, in the 1990s, if every port presented similar percentages (assumption with no basis), the annual turtle bycatch could have been higher than 830 specimens, with 80% of the incidentally captured animals found dead (Eckert & Sarti, 1997). However, this publication drags along the overestimation of the previous study conducted by Frazier & Brito (1990), besides assuming that the fishing effort is the same. Accordingly then, the number of incidental sea turtle catches in Chile would probably also be overestimated.

A more recently published study conducted between 2001 and 2005 (Donoso & Dutton, 2010), including 94% of the total number of hooks used in longline swordfish fishing (10.604.059 hooks), revealed that *D. coriacea* was the most captured species, with 284 specimens and only two deaths between those years. Secondly was *C. caretta* with 59 captured specimens, without any deaths, and finally *C. mydas* with only five living specimens in the same period. Despite differences with previous studies and the low catch rate of *D. coriacea*, the authors mentioned that impacts of this type of fishery could be significant when combined with other types of fisheries and threats in the region. Mortalities of Chelonids along the Chilean coast could also affect nesting populations of Mexico and Costa Rica (Eckert & Sarti, 1997; Dutton et al. 1999; Godley et al. 2007), besides populations that feed in Australia and New Caledonia, which use Chilean waters as part of their migration route (Boyle et al. 2009).

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LEGISLATION AND CONSERVATION

The 18th century marks an increasing extraction demand for native vertebrates in Chile, with a strong emphasis on marine animals (Iriarte, 1999). Thereby, with the purpose of regulating this activity, a number of laws, regulations and norms were promulgated.

In 1929 Hunting Law N° 4.602 was enacted, the oldest legislation of this kind in Latin American. This legal body is the first one to protect wild fauna in a general way, both terrestrial and marine. Also it includes a specific article that refers to the marine environment, specifically Title II "Hunting at Sea". However, this refers mainly to aspects of whaling.

In 1991 the General Law of Fishing and Aquaculture N°18.892 was passed, and although it didn't have articles referring to the protection or regulation of marine vertebrates, it possessed the legal attributes to enable those measures.

After multiple modifications to the existing law, in March of 1993 a new version of Hunting Law N°4.602 was promulgated, called Supreme Act N°133. In it, the species to be regulated were defined for the first time by the General Law of Fishing and Aquaculture (N°18.892), including marine mammals (cetaceans, pinnipeds and otters), marine birds (penguins) and marine reptiles (turtles). So, for the first time, sea turtles are considered by a national legislation in order to control their extraction.

In 1995 Supreme Act N°225 is promulgated, and it establishes the prohibition of extraction of almost every marine vertebrate for 30 years, among which are included all sea turtles species. Nevertheless, the Fishing Undersecretaryship (Subsecretaría de Pesca) may authorize the capture of specimens for captivity with recreational, exhibition, cultural or research purposes.

In 1996 a new Hunting Law was created (N°19.473), which increases the fines including prison penalties for those who commercialize threatened species. This includes species present in The Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES) and/or The Convention on the Conservation of Migratory Species of Wild Animals (CMS), as the case of the four sea turtles species registered in Chile.

In May of 2005, Supreme Act Nº 75 was promulgated, which established a new process of species classification according to its conservation status, applying IUCN criteria. Nowadays, this process is handled by public services, academic institution members and it also considers citizen participation.

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Although diverse taxa have been classified, sea turtles have not yet entered the classification process.

In relation to international regulations, Chile has signed at least 10 conventions and international treaties to promote the conservation and sustainable use of native marine vertebrates (Iriarte, 1999). In Table 1 the main international obligations that the country has adopted and that consider sea turtles and their habitats are mentioned.

Table 1. Main conventions and treaties adopted by Chile, for the conservation and sustainable use that consider sea turtles and their habitats

Name of the Agreement	**Date of subscription and Act that ratifies it**
Regulation for the Maritime Hunting Tasks in the South Pacific Waters.	D.S. N° 432 of 1954
Convention for the Protection of the Fauna, Flora and Natural Scenic Beauty of America	D.S. N° 531 of 1967
Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES)	D.L. N° 873 of 1975
Convention Concerning the Protection of the World Cultural and Natural Heritage	D.L. N° 259 of 1980
Conservation of migratory species (Bonn Convention or CMS)	D.S. N° 868 of 1981
Convention on Biological Diversity (CBD)	D.S. N° 1.963 of 1995
Inter-American Convention for the Protection and Conservation of Sea Turtles (IAC)	D.S. N° 114 of 2010

Nowadays poaching of birds, cetaceans and marine reptiles is scarce, being primarily part of bycatch. However, there are still isolated events of slaughtering some specimens of sea turtles for consumption and using their remains in handcraft, which are mainly sanctioned through fines without strong penalties. Among examples that made headlines causing public outcry, is the event that occurred in January of 2009 in San Antonio (central Chile), where a witness reported to have found an Olive Ridley in the kitchen of a Chinese restaurant. It is believed that it was going to be prepared as a dish. The owner of the restaurant was summoned to declare in court to receive the corresponding sanction. Another recent case took place in Arica (northern Chile) on November of 2013, where a local couple found a beached Green turtle and decided to dismember it to make a lamp with the carapace. Through witnesses' accusations, representatives of the maritime government arrived

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and confiscated the carcass, letting the wrongdoers go. Due to this, a mass campaign in the media was carried out to relocate the transgressors, who finally turned themselves in and confessed before the Environmental Crime Squad of the Investigative Police. Ultimately the couple was freed after having to pay an undisclosed fine that could be maximum US$2,000.

Conservation of sea turtles in Chile is led by government institutions in charge of their welfare and care. Among them are the Fishing Undersecretaryship (Subsecretaría de Pesca), the National Fishing and Aquaculture Service (Sernapesca) and the Environment Ministry. These take upon the creation of regulations and control actions for both fisheries and citizens across the country.

Regarding conservation in insular Chile, despite evidence that capture and consumption of sea turtles in Rapa Nui was common 30 to 40 years ago, nowadays these customs have been replaced by their use in tourism (Álvarez-Varas et al. 2012), which is the main economic activity of the island (Moreno & Zurob, 2013). Currently the Rapanui people respect these charismatic animals, consider them to be beneficial for their development, and their consumption is rejected by the local community.

Nowadays sea turtles constitute an intrinsic part of the natural environment of Rapa Nui and are commonly observed in small fishermen coves, where they are normally fed by people. According to a study conducted in 2011 (Álvarez-Varas et al. 2012), the presence of this species has a positive connotation for the local community, and they are perceived as a tourist attraction that must be preserved. These animals are part of their contemporary art, represented in the works of painters, artisans and sculptors, reflecting a tight cultural bond. Some commercial constructions have sea turtles represented on their facades (Figure 4). These animals also constitute icons that are personified in the *Tapati*, a yearly traditional festival since the mid 20th century and is the greatest exhibition of Rapanui culture to foreign visitors (Ramírez, 2010).

Regarding conservation in continental Chile, there are a number of organizations dedicated to study and promote the protection of sea turtles (Table 2). The majority are located in the north of the country as that is where most feeding grounds for marine Chelonids have been identified.

Tortumar, is a research group that belongs to the Arturo Prat University and has its activities on the coasts of Arica, northern Chile. This organization has generated multiple research, among them, “The characterization of the local sites where the Black turtle (*C. mydas agassizi*) inhabits, for the development of future conservation plans with the Regional Government”

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Figure 4. Sea turtle representation on a modern construction. Left: Chilean Army facade placard. Right: Hanga Piko bay facade. (Photographs: Rocío Álvarez-Varas).

Table 2. Activities of Chilean organizations that promote sea turtle conservation

Name	Location	Characteristics
Tortumar, Programa de Conservación de Tortugas Marinas de Arica-Chile	Arica-Parinacota Region, northern Chile	Belonging to University Arturo Prat. Research, Rehabilitation and Environmental Education.
NGO Tortuga Verde Arica	Arica-Parinacota Region, northern Chile	Formed by the local community, including local fishermen.
Centro Regional de Estudios y Educación Ambiental(CREA)	Antofagasta Region, northern Chile	Members of the University of Antofagasta. Research, Rehabilitation and Environmental Education.
Museo Municipal de Ciencias Naturales y Arqueología de San Antonio	San Antonio, Valparaiso Region, central Chile	Environmental education and Fisheries Observer.
Sea Turtles Chile	Throughout all of Chile	Sea turtle information network in Chile
NGO Pacífico Laud Chile	Throughout all of Chile	Fishing Research, Training.
NGO Qarapara, Tortugas Marinas Chile	Atacama Region, northern Chile and Easter Island.	Research, Conservation, Rescue and Rehabilitation Consulting and Environmental Education.

NGO Tortuga Verde Arica is also based in the same city, and integrated by local people including artisanal fishermen. This community takes upon an important role regarding the dissemination of information and environmental education for the local community.

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The Centro Regional de Estudios y Educación Ambiental (CREA), belonging to the University of Antofagasta, is located in Antofagasta. They have generated much research on sea turtles present in the Antofagasta Region besides managing a rehabilitation center with several years of experience. Thereby, it has been the school for multiple professionals that dedicate their work to the study and conservation of sea turtles.

Since 1988 José Luis Brito and his team, from the Municipal Museum of Natural Science and Archaeology of San Antonio, work with the San Antonio's cove fishermen, among other localities. There, they gather information regarding bycatch, including sea turtles. During past years, they have conducted rehabilitation of specimens; some non survivors are now part of the museum collection.

Sea Turtles Chile, integrated by a group of volunteers, takes upon the role of disseminating information through social networks and delivering news referring to Chelonids, including beached specimens, rescue actions and promoting charity events for their conservation.

The NGO Pacífico Laúd, working with the Fishing Promotion Institute (IFOP, from the Spanish abbreviation), carry out observations from fishing boats all over the country. Their work has delivered valuable information on the impact of fisheries on sea turtles in Chilean waters.

Qarapara Sea Turtles Chile is a NGO dedicated to research and conservation of sea turtles and their habitats in Chile. Nowadays their research team is developing studies in the north of the country where the southernmost feeding ground of *C. mydas* in the Southeast Pacific Ocean is located. The project is titled "Knowing and Protecting the Sea Turtles of Salado Bay, Atacama Region" and it is financed by the Chilean government and supported by foreign institutions. Here, the NGO works with local fishermen and children from public schools of the neighboring areas, promoting the understanding and building awareness towards sea turtle conservation and marine ecosystems.

CONCLUSION

All these studies have generated important information on sea turtles in Chile and also have increased interest in them and their value as a natural richness or tourist attraction. Their presence from the northernmost point of the country (18°S) to Desolation Island (52ºS) in the extreme south, exposes them to a number of adverse factors, especially anthropogenic threats such as

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pollution and bycatch. Although during the last years there have been important efforts in terms of research and environmental education regarding sea turtles and their ecosystems, these have been conducted in a disjointed and non consistent way throughout time. Therefore there is still a long way to go in relation to sea turtle conservation in Chile. Nowadays, it is necessary to complete the classification process of the species, at the same time generate systematic scientific information and projects adapted to the local and national realities, while integrating community participation. This will lay the groundwork to formulate and implement appropriate management and conservation plans for these threatened species in our country.

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Chapter 2

THE ROLE OF RESIDENTS, TOURISTS AND STUDENTS IN MARINE TURTLE CONSERVATION

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ABSTRACT

In the southern Pacific region of the Baja California Peninsula *Lepidochelys olivacea* is the primary nester in the region, followed by *Chelonia mydas (agassizii)* and *Dermochelys coriacea.* For these species, this region serves as the northern extent of their nesting range. However, as climate change provokes nesting behavior further north, this region in 10-25 years may be considered primary nesting beaches for *D. coriacea*. Yet, coastal development and traditional sun and beach tourism is competing for nesting habitat. Rather than fighting coastal growth, we are integrating the local community into current ongoing monitoring and conservation efforts in a way to build a model for conservation tourism as a means to safeguard coastal biodiversity and marine turtle nesting habitat. By incorporating residents, tourists, and students in nest monitoring and hatchling release activities, we can effectively reduce poaching, raise awareness, and increase research funding through coordination with the local community. This chapter analyzes the challenges and solutions to marine turtle conservation by introducing the

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success of environmental education programs and future advancement of expanding in-situ nest monitoring responsibilities to tourism companies and coastal development communities.

INTRODUCTION

Most marine turtle conservation groups in México use nest relocation activities as the primary method of nest protection. In terms of the total number of nests protected annually, it can be a successful conservation tool because of illegal poaching, feral dog predation, and hurricane damage. However, this methodology potentially reduces the hatching success rate per nest and potentially reduces hatching fitness due to extensive human manipulation. Rather, in-situ nest monitoring practices, where nests are marked and protected in the location where the female deposits eggs, is the preferred methodology for achieving a higher hatchling rate (90-100%). However, habitat loss, non-native and native predation, and illegal poaching are significant factors that pose grave challenges to in-situ nest monitoring.

In the southern Pacific region of the Baja California Peninsula, *Lepidochelys olivacea* is the primary nesting species of the region, followed by *Chelonia mydas (agassizii*)[1] and *Dermochelys coriacea*. As climate change provokes advances in nesting behavior further north, these beaches will be critical for conservation efforts especially for *D. coriacea*. The majority of conservation efforts in México, rely on nest relocation to protective corrals as a common practice of marine turtle nest monitoring and conservation. Especially for *L. olivacea*, the least endangered species, in-situ monitoring can be a positive conservation tool with proper education and participation from the local community. However, while SEMARNAT, the federal Secretary of the Environment in México, encourages more in-situ nest monitoring, they continue to permit unregulated coastal development within sea turtle nesting range, owing to habitat loss and making in-situ nest monitoring difficult.

Possibly the greatest long-term threat to marine turtle conservation is the onslaught of coastal developments and associated coastal tourism activities. The proximity of México to the United States and Canada makes it an exceptional tourist destination for the beautiful coastline and outdoor activities. However, the increase in tourism and the second home trend have provoked unregulated expansion of existing tourist destinations and creation of

[1] This species is still under taxonomic review to be determine if the Pacific population is a separate species or a subspecies of *Chelonia mydas*.

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the mega all-inclusive resorts along the coast. Coastal development and associated beach activities threaten habitat through direct loss, increased erosion, future need for seawalls, lighting pollution, and direct impact from desalination plants.

Effects of Traditional Tourism on Marine Turtles

"Tourism is the answer". This is a claim on the main webpage of FONATUR for the failing Mexican economy. FONATUR which is organized under the National Secretary of Tourism, is the institution responsible for the planning and development of sustainable tourism projects that have a national socioeconomic impact. In Spanish, FONATUR stands for Fondo Nacional de Fomento al Turismo; translated in English, it is the National Fund for Forming Tourism. The world´s largest, expanding industry in terms of international trade is tourism, so it makes sense that this institution promotes foreign investment and training in the tourism sector. According to the website, FONATUR claims that, "Mexico is the world's 8th most visited country and ranks in 12th place in terms of foreign revenue earnings from tourism; in both categories, it is the leader in Latin America."

FONATUR focuses on six main tourism development regions, all located within coastal ecosystems. A major draw to México is the unique cultural and ecological diversity and high level of species endemism. México ranks 5th in terms of biodiversity habitat compared to other countries around the world (Valdez et al, 2006). Yet, once these tourism destinations are fully developed, the same biodiversity that is driving the tourism will be destroyed, and there with it, the tourism industry, sending the Mexican economy back into the negative. As México attempts to follow in the global trend of sustainable development, it is failing miserably in the implementation of this goal.

The Los Cabos region became a tourism destination in 1976 and thus has become the third most *Integrally Planned Resorts* boasted by FONATUR. Possibly due to the proximity to California and other west coast states, the Los Cabos region attracts large numbers of high-end tourists. Yet, vacation tourism is not the only economic driver.

More common is the trend of seasonal foreign residents whereby wealthy U.S. and Canadian residents have second homes in the region which they use for a portion of the year. In most nesting beaches in México, in-situ nest monitoring is not a feasible method of marine turtle conservation. For example, the Los Cabos corridor, a linear stretch of coastline and an important

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nesting ground, approximately 40 kilometers long, is heavily developed for coastal tourism (Figure 1).

Figure 1. The Los Cabos Corridor, built in protected marine turtle nesting habitat continues to grow and is a prime example of unregulated coastal development occurring in Mexico.

Over the last decade, this region experienced an average annual growth rate of approximately 10% (Ganster et al. 2012), resulting in one of the highest growth rates affecting sea turtle nesting habitat (Pombo et al. 2008). As a result, the Los Cabos government began Cabo Tortugas, a nest monitoring group that coordinates with coastal hotels built within or adjacent to nesting habitat. Golf courses are often included in these mega resort development plans, especially in tourism destinations. México is ranked as the number two golf destination in the world, Los Cabos being a focal point with 15% of the total number of golf courses located in this region.

Due to the large volume of water required for golf courses combined with limited available water, new tourism development plans are now required to include a desalination plant. However, the thought that desalination plants can provide a solution for the lack of water resources and invariably have no adverse effect on the environment is erroneous. In the case of Los Cabos, a large capacity desalination plant was built in 2005 and began operation in 2006.

Desalination plants like many coastal infrastructures, have the potential to modify sand humidity and temperatures, thus altering conditions for deposition. Figure 2 shows a false crawl at an outtake value in the survey area. At the same outtake valve, a female laid a nest that was later washed away due to the pressure of forced water that altered the morphology of the beach (figure 3). Changes in morphology at the same desalination plant can be

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observed on a constant basis as in this photo where the water pressure at the outtake valve created a lagoon in the tide line (figure 4).

Figure 2. The poorly constructed desalination plant in Los Cabos, Mexico attracts female sea turtles to nest in dangerous zones by creating false humidity and temperature regimes.

Figure 3. Nests erode rapidly in the area of the desalination plant which creates non-viable artificial habitat.

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Figure 4. Desalination plants create pools of highly saline water with high concentrations of chemicals negatively altering the beach morphology.

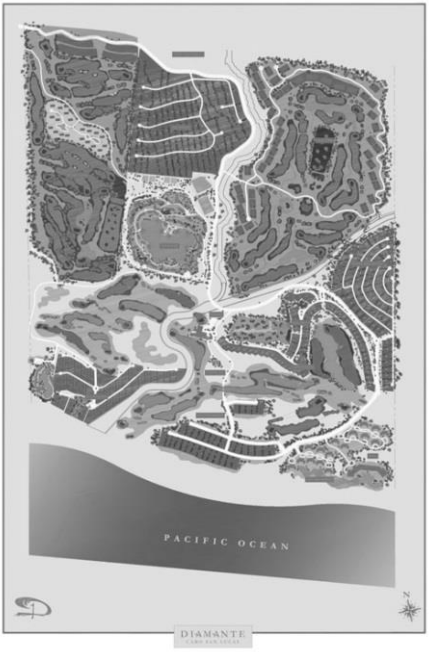

Figure 5. Coastal developments such as the mega resort, Diamonte Beach Club is a major threat habitat loss of marine turtle nesting beaches.

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Sustainable Development Concept

The idea behind sustainable development is often identified as, "A relationship between development and the respect to natural resources". The concept requires a sense of responsibility in reference to human actions, whereby the consequences are extended to future generations. Particularly in México, the recent sustainable development idea has become a governmental panacea and encouraged as a marketing tool to coastal developers. Yet, this concept is still lacking a true understanding and effective execution as evidenced by the continuation of traditional coastal development design and omission of implementing environmental protection laws.

Due to the negative impacts to marine turtle nesting habitat by the Diamante Resort (see Case Study Above) and potential future impacts from other proposed resorts within the 21.5 km monitoring area, ProFaunaBaja, a small research society, (figure 6) has recently teamed up with ASUPMATOMA A.C., a Mexican environmental non-profit, (figure 7) to offer assistance in scientific investigation design and habitat protection. ASUPMATOMA A.C. (The Association for the Protection of Marine Turtles and the Environment) has been collecting nesting data for over 18 years, yet only reports the total number of nests relocated and the total number of hatchlings successfully released.

Figure 6. ProFaunaBaja operates a training program for high school and university students in coastal field studies. www.ProFaunaBaja.org.

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Figure 7. ASUPMATOMA is the longest running marine turtle nest monitoring group in the Baja Peninsula.

To determine the response of nesting species to climate change and coastal development, ProFaunaBaja and ASUPMATOMA A.C. together began investigating beach morphology and nest distribution and density in 2012. This data serves to provide a platform for developing region-specific criteria of best practices for safeguarding marine turtle nesting grounds.

Another significant challenge of in-situ monitoring, for example, is the presence and lack of enforcement against poaching. While the federal government placed a ban on hunting a significant threat, mainly in part to lack of law enforcement and resources (Mancini et al. 2012). ASUPMATOMA A.C. has made formal complaints to the Mexican environmental law enforcement agency, (PROFEPA, acronym in Spanish) with few successful results. However, it is difficult to catch a poacher, because the authorities are required to witness the act in order for the poacher to be captured. Since ASUPMATOMA A.C. began monitoring Playa El Suspiro, many poaching events have been witnessed. Yet, despite numerous attempts to report poachers, an increase in poaching activity ensues.

Playa El Suspiro has public access beach which potentially facilitates access for poachers. In contrast, other areas of the nesting beach are very isolated which creates difficult and dangerous situations for monitoring when poachers are present. Poachers are very good at absconding themselves and their camp in remote areas and hidden caves carved out by granite rock that geologically creates the towering coastal dunes. This elusiveness and seclusion coupled with the lack of law enforcement and lack of authorization by ASUPMATOMA A.C. to act legally, poachers are very successful. However, SWOT (The State of the World´s Sea Turtles), an organization who maintains sea turtle data from around the world, concluded that a physical presence is an effective deterrent against illegal poaching from successful areas which have increased monitoring and research. At El Suspiro, because of nightly patrols,

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many times per night, in 2013, for example, a known poacher was arrested by local officials (figure 8). An official report was filed by ASUPMATOMA to the local law enforcement which resulted in the arrest showing photos of the hidden cave full of cooking materials, jugs of water, condiments like salt to preserve the meat, the remaining sea turtle carapace, and a bag of eggs (figure 9).

Figure 8. ASUPMATOMA biologists successfully arrested a poacher after finding his cave.

Figure 9. An occurrence along remote areas of nesting beaches in Mexico. Poachers gain more money for selling sea turtle meat and eggs than fishermen which provokes a malicious cycle.

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In México universities, limited science majors and tourism-type majors are kept in separate departments. In this structure, crossover curriculum and overlapping concepts are disconnected which prevents effective development of conservation-based tourism programs. For example, at the University of Baja California Sur (UABCS), alterative tourism programs are housed in the economics department, which limits the available ecological principals in the course curriculum to fully comprehend and implement a sustainable ecotourism niche market. Yet, the marine and coastal biology department in contrast is one of the top programs in the country, but lacks a connection to the human dimension. So it makes sense that there should exist a significant correlation between the two programs to produce biologists with a conscience of socioeconomic threats to the marine and coastal resources, and produce ecotourism majors with ecological principals to bring conscience, sustainable tourism to the region.

In 2013, ASUPMATOMA and ProFaunaBaja offered field workshops to marine biology students in which they reviewed the problems from the desalination plant and impending mega development, Diamante and other developments along the coast. In 2014, ProFaunaBaja will offer a classroom based workshop at the university which will bring together students from both programs: Marine Biology and Alternative Tourism to consider economic tourism opportunities in conservation biology and ways to increase local community participation in conservation efforts in the protection of endangered species habitat protection.

Sea Turtle Nest Monitoring

Over 10 groups in the state of Baja California Sur are monitoring sections of beaches for nesting marine turtles. The oldest group in the peninsula, ASUPMATOMA A.C., currently monitors approximately 21 kilometers of nesting beach in the Los Cabos region, separated into two distinct field stations or “camps”. ASUPMATOMA relocates on average 1100 nests annually and less than 100 nests are monitored in-situ. They operate a patrol season from July until November, and maintain the corral from July until January.

ASUPMATOMA A.C. invests approximately 750,000 pesos annually, an equivalent to approximately $62,500 U.S. This budget encompasses administration costs, regular maintenance and repairs of ATVs, room and board for six biologists and rotating volunteers, operating permit costs, and

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office administration overhead. ASUPMATOMA A.C. staffs three biologists at each camp for the duration of the season, with a lead biologist in charge of daily camp operations. Biologists undergo a rigorous training in June and are responsible for marine turtle nest monitoring and relocation as well as environmental education duties for school groups and tourists. The annual volunteer brigade members are trained in August and serve at least 2 times per month for 4 months to support activities. Each season, the organization hosts a festival to raise awareness of the activities and funds for the following season.

The patrol area that ASUPMATOMA monitors is separated into two camps: El Suspiro and San Cristobal. El Suspiro is approximately 16.5 km in length and ranges from 60 to 400meters (m) wide with coastal dunes ranging from 30 to 200 m high. San Cristobal, the first marine turtle monitoring camp established in the region, is approximately 5 km in length, 50–150m wide and coastal dunes ranging 10 to 80m high. San Cristobal is accessed through a private ranch, partially owned by the president of ASUPMATOMA. Comparatively, El Suspiro is privately owned and contains the FONATUR Integrally Planned Resort, Diamante Beach Club and Resort, which is adversely affecting the nesting beach (see above).

Local Community Involvement

ASUPMATOMA A.C. has provided over 800 environmental education workshops, organized three sea turtle festivals, and numerous projects to local schools and the general public. For example, ASUPMATOMA, A.C. alone has attended over 230 schools from three different cities.

As a way to increase in-situ monitoring, ProFaunaBaja a local research group in coordination with ASUPMTOMA, began incorporating tourists into research projects and monitoring. Biologists digitally record nest distribution and beach morphology using handheld GPS units. Nest coordinates are digitally recorded before they are relocated and plotted on a map using ArcGIS software, provided by the University of Baja California Sur, México (UABCS).

This research began in 2012 as a pilot program with Ecology Project International who contributed transportation and food while at camp, a GPS, and monthly 3-day workshops for over 150 local high school students. In 2013, full project financing was realized through a grant from the Rufford Small Grants Conservation Fund (figure 10), which provided eight undergraduate students from UABCS a chance to learn and participate in

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guided research at the field stations (figure 11). The objective of the research is to identify areas that can be targeted to increase in-situ nest monitoring practices within the ASUPMATOMA nest monitoring areas.

Students from UABCS formulated studies correlating wind velocity with nightly nest counts. This will enable ASUPMATOMA to better predict high number of nests based on wind patterns. Another study that evolved at UABCS is a comparison of hatchling success between in-situ nests and relocated nests. The hypothesis that in-situ nests have a higher success rate is being investigated through percentages of hatching through an analysis of the previous 5 years of data including 2013. A third important study that one of the Columbian students developed is an analysis of the percentage of nests predated by fly and beetle larva in relocated nests for the past 15 years. This will help biologists determine a pattern of predation overtime.

Figure 10. Rufford Small Grants Conservation Fund from London, England provides funding for scientific research in developing countries and is a primary funder of ProFaunaBaja.

Figure 11. Undergraduate students from the University of Baja California Sur (UABCS) in Mexico participate with biologists from ProFaunaBaja to learn about sea turtle conservation.

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During overnight adventures, "voluntourists" participate in all aspects of data collection with the biologists and feel a special relationship and honor in the conservation of marine turtles (figure 13). Compared to the common release events, overnight guests learn in depth about the ecology and conservation of marine turtles. "Voluntourists" leave with a sense of ownership in the conservation efforts since the package includes a nest adoption and certificate of completion, further owning to the profound experience (figure 14).

Figure 13. VolunTourists with Todos Santos Eco Adventures watch a female laying eggs. They will relocate the nest to a protective hatchery.

Figure 14. TOSEA voluntourists are awarded a certificate with their experience they will never forget.

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In 2014, the company plans to double or triple this tourism-generated fund, and in fact, before the end of the 2013 nesting season, TOSEA already received paid reservations for the upcoming season. TOSEA is recognized as a major supporter of research studies for ProFaunaBaja and ASUPMATOMA. For example, the owner of TOSEA financed over 50% of the cost to attend the 2014 International Sea Turtle Symposium for both authors of this chapter to present their research findings and network with international researchers to advance their field station and participation in the international sea turtle conservation community. TOSEA will be highlighted as a positive example in the Model for Conservation Tourism as mentioned above that will be published online through a joint effort between ProFaunaBaja and UABCS.

Volunteer Monitoring

Some portions of the Baja California Sur peninsula are still not protected nor monitored by any marine turtle nesting group where there is known nesting activity. In particular, Hacienda Migriño Estates, Rancho Migriño, and Elias Calles are residential communities with incidental reported nesting activity. However, given the struggles for funding the current operation on an annual basis, it would cost extra resources and efforts to generate enough funds to expand the ASUPMATOMA monitoring area. Interested residents in these communities will be offered a training program through ProFaunaBaja to monitor nesting activity.

Nest protection will be in the form of in-situ protection, by which coastal residents will mark off nests and record the dates of deposition and hatching and record the coordinates with their own personal GPS units. We will collect the notebooks of data once the season is complete and cleans nests to determine hatching success rate.

In these same areas, local tourism companies offer All-Terrain Vehicle (ATV) tours on the beach and coastal dunes on beaches where there are no sea turtle monitoring groups and the area is unprotected. ATV tours can have devastating effects on the coastal ecosystems and sea turtle nesting habitat and coastal biodiversity. Camacho et al. (2008) reported that ATV use shows a significant impact on the beach-dune morphology by removing vegetation and dune stability, thereby potentially affecting sea turtle nesting activity.

In 2015, ProFaunaBaja will be encouraging ATV tours to participate in an in-situ nest monitoring project through permission with SEMARNAT. Permission from SEMARNAT will also help us address a legal schedule of

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allowed ATV tours compared to a closed time to allow female turtles and hatchlings the seclusion they require. After signing a Memorandum of Understanding, ATV companies will be obligated to survey the beach in the morning for sea turtle tracks before any tours begin. When a nest is discovered, these companies, using their own resources, will mark off nests and number them.

A nesting log will be kept by the company. The benefit to these companies is that tour guides will have an added component to their tours to show to clients as they pass along the beach. In return, if clients want to know more about sea turtles, a brochure will be available to tourists after their ATV tour which includes information about sea turtles, ASUPMATOMA, and a card to Adopt-A-Nest. The MOU agreement has four major beneficial aspects: (1) promote the ATV company as a friend of an environmental organization, (2) provides an added component to their tours, (3) assist scientists obtain more nesting data for analysis without expending resources, and (4) potentially provides funding and raises awareness. By providing annual training and creating agreements with these groups, ProFaunaBaja aims to promote in-situ nest protection through cooperative tourism practices.

Participating ATV companies will be provided a training workshop at the start of the marine turtle nesting season for *L. olivacea*. Each company will sign a MOU based upon the example template from Choi & Eckerd (2008) which will include an understanding of the survey procedure, obligation to abide by conservation measures and provide data to scientists, abide by a schedule of tour operations, and a promise to raise awareness and promote marine turtle education with their clients during tours.

The activity schedule will revise the timing of tours so there is no effect of marine turtle nesting or in-situ nest hatching, such as night tours, which will reduce the light pollution and hopefully encourage more females to nest on these beaches, if that is a factor. At this point, there is no nesting data on these beaches, so there is not a baseline to compare.

The ATV idea is similar to the idea of incorporating coastal residents. Unless we have full government backing and law enforcement efforts, removing all coastal development and ATV tour operators from nesting beaches is just simply not a reality. Instead, with the development that already exists and is occupied, we can encourage positive participation from residents and raise awareness while not expending our resources. Rather, we can use these businesses and residences to gain resources.

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CONCLUSION

Nest monitoring can be an event that the local community can participate which opens opportunities for biologists to help raise awareness for conservation, educate, and promote conservation tourism development. By combining research efforts with environmental education and awareness, the local community can serve as an integral conservation tool for not only marine turtle populations, but also for maintaining coastal biodiversity and coastal ecosystem stability.

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Chapter 3

BIOLOGICAL MONITORING OF SEA TURTLES ON NESTING BEACHES: DATASETS AND BASIC EVALUATIONS

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ABSTRACT

Monitoring is a key tool for conservation and recovery of wild endangered species. The spatiotemporal continuity and the sturdiness of the databases is crucial for basic ecological and biological assessments, for tracing and better knowing the populations of interest and their habitat. Frequently, assessments on topics such as spatial distribution and population trends become a challenge for migratory species like sea turtles, with different life stages that depend on particular ecosystems to develop and accomplish their life cycle. In southeast Mexico several

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efforts to standardize the recording of biological monitoring on nesting beaches have been done, aimed at consolidating basic long-term databases. Occasionally, the quantitative analyses of these databases do not contemplate basic technical and statistical aspects for a robust knowledge of the populations of interest. The objective of this chapter is to present proposals of key data analysis for conservation and decision making on sea turtle populations and their nesting habitats. It is aimed to offer alternatives for technical strengthening of groups working on sea turtle nesting beaches, based on national and regional standardized directives to generate the needed ecological and biological knowledge.

INTRODUCTION

Sea turtles are a biological group with a wide range of distribution around the world. To be migratory species they establish connectivity between various marine, coastal and terrestrial ecosystems through its complex life cycle and intricate trophic networks. They are successful Mesozoic fauna representatives, who have survived catastrophic processes throughout its existence from the Earth, maintaining a genetic resilience during its evolution.

Up until the 1970s when sea turtles represented a fishing resource, their populations were decimated almost to the edge of extinction, and some species were notably reduced to their lowest numbers by placing them in critical danger of extinction according to the International Union for Conservation of Nature (IUCN, 2014), as in the case of the leatherbacks (*Dermochelys coriacea*), the Kemp´s Ridley (*Lepidochelys kempii*) and the hawksbill (*Eretmochelys imbricata*). Another species that suffered a massive extraction, that was even industrialized, was the olive Ridley turtle (*Lepidochelys olivacea*), which had their populations violated, particularly on beaches of abundance (Frazier, 1982).

There is a permanent ban on the extractive use of products and by-products from any species of sea turtle in Mexico since 1990. However, overfishing that occurred in past decades increased the degree of differential vulnerability of different species, which is currently increased by different ill-conceived sources of pressure in coastal tourism and urban development, erosion of beaches, and bad fishing practices, among others.

The National Program for the Conservation of Sea Turtles in Mexico has existed for more than four decades making various efforts for protection, research and management of the populations of sea turtles and their habitats. One of the primary components of this program has been the biological monitoring and surveillance of the nesting beaches of these reptiles.

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Biological monitoring is performed by numerous instances of the three orders of Government, as well as by universities, individuals and organizations of civil society, and responds to the primary need of preserving and recovering populations of these species. This activity allows maintaining the ecological role of turtles in marine and coastal areas, the same environments that provide various environmental services directly and indirectly to human populations.

It is a task that requires a big investment of human, material, and financial resources, which should be kept continuously in the long-term at sites subject to monitoring, to thus obtain reliable results. Such efforts at nesting beaches should be accompanied by working with the local coastal communities, among other key components.

Quantitative monitoring of various population parameters that give the same operators the information necessary for the measurement of the success of the initiatives carried out, is also necessary for the identification of new requirements and strategic adaptations that maximize the positive impact actions, which help contain historical and emerging threats faced by the populations of sea turtles and their habitats. This is critical for the sea turtles to complete their life cycle.

The efforts of conservation and research on diverse populations of sea turtles and their habitats around the world have, as a strategic objective; generating information that would serve as a tool for decision-making at different levels of management for the recovery of the species. Such task implies that the awareness of the populations of sea turtles and their habitats be transferred to decision makers.

There are some regional proposals for integration and global management of information about these reptiles, such as the Wider Caribbean Sea Turtle Conservation Network (WIDECAST, www.widecast.org), that is a regional coalition of experts who deal directly with sea turtle research, management and conservation issues. The State of the World´s Sea Turtles (SWOT, www.seaturtlestatus.org) is a partnership between international actors for the conservation of sea turtles, and the Ocean Biogeographic Information System - Spatial Ecological Analysis of Megavertebrate Populations (OBIS-SEAMAP, http://seamap.env.duke.edu/) it is an initiative for the knowledge of the distribution and ecology of mega vertebrates.

Other alternatives for transfer of knowledge about the sea turtles are various documents published by international financial institutions, which have served as the basis for numerous research and conservation programs. Examples of this are: "Techniques for Research and Management for the Conservation of Sea Turtles, Spanish version" published in 2000 by the Sea

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Turtle Specialist Group of the IUCN (Marine Turtle Specialist Group, IUCN), and more recently appeared in "Standard Minimum of Data for the Monitoring of Beaches of Nesting of Sea Turtles" (Minimum Data Standards for Sea Turtle Nesting Beach Monitoring, SWOT Scientific Advisory Board, 2011). Both briefs address technical aspects of the collection and analysis of data for different stages of life of sea turtles and their critical habitats. With these manuals the level of proposals and multidisciplinary analysis of various programs of conservation in Mexico are substantially raised.

Regarding the work of data collection and biological monitoring in Mexico, they have been through various initiatives such as the Program for the Recovery of Priority Species (PREP, 2000, for its acronyms in in Spanish) published by the then Ministry of Environment Resources Natural and Fishing; Program of Conservation of Species at Risk (PROCER, 2007, for its acronyms in Spanish), which is currently in force through the Programs of Action for the Conservation of Species (PACE) of the different species of sea turtles in Mexico, implemented by the National Commission of Natural Protected Areas (CONANP, for its acronyms in Spanish) as well as more recently the Mexican official standard NOM-162-SEMARNAT-2012.

A large amount of information on the status of the populations of sea turtles and their habitats, as well as some definitions and indications of what is desirable, is summarized in these documents for the monitoring of populations and their habitats. There is a document of Mexican origin that addresses alternatives for quantitative analysis of data derived from the regulated and strengthened biological monitoring, which has been done for many years on the national nesting beaches, that can provide an assessment of the basic and advanced population indicators required for these turtles at this stage of the conservation program.

PURPOSE

Addressing the lack of information that exists about the quantitative analysis of data coming from the biological monitoring of sea turtles on Mexican beaches, the purpose of this chapter is to present proposals for basic analysis statistically supported, in order to maximize the generation of knowledge, early diagnosis and the transfer of substantial information for decision-making.

The content is aimed at the technical strengthening of the groups dedicated to conservation on marine turtle nesting beaches. The alternatives of analysis

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are aligned with the needs of biological and ecological information required to make progress in the recovery of these species in danger of extinction. Once the information is generated, it can be incorporated into regional and national guidelines for the conservation of sea turtles.

1. Census of Sea Turtle Nests

One of the indicators is the abundance and density of female turtles' nesting places, as well as the populations of these individuals, which are discovered by censuses of nests on beach. Knowledge and monitoring of the patterns of spatial distribution and temporal activity of nesting is basic information that serves to adapt strategies for the conservation of their populations and their habitats, as well as for the evaluation and diagnosis of alterations caused by different sources of pressure, in addition to providing knowledge about the conditions favored by sea turtles to lay their eggs (Bjorndal y Bolten 1992; Chaloupka 2001; Weishampel et al. 2003; Tiwari et al. 2005; Pike et al. 2006; Weishampel et al. 2006; Pike 2009; Weishampel et al. 2010).

Specifically, the spatial distribution of the nests along the beach provides information on critical areas for conservation, given the high densities and abundance of nesting activity. This can enable proposals for the zoning of the beach, in order to maximize the efficiency of the efforts of monitoring and surveillance of the different sections of the beach. It can even evaluate the feasibility of performing various activities and use of habitats, which may include observation of females during the nesting process, given the protection of the areas where the highest abundance values are recorded or core zones (Jackson et al. 2008; Sims et al. 2008; Whiting et al. 2013).

Strategy of Census

On beaches where systematic work with sea turtles has not been formalized, and the abundance and temporality of the nesting of the present species is not known, a survey is recommended that covers as much data as possible during the entire nesting season. This will allow knowledge of the basic data such as the start and end date of the nesting activity, nesting time, monthly peak of abundance, and area of beach where there is nesting. This information will help to plan or run different protocols or levels of monitoring for a program of work in the field and collection of data in a systematic way,

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depending on available resources and/or knowledge needs. This information represents an approximation of the reproductive activity in the portion of attended beach, which can be delimited artificially or naturally.

In the case of beaches where there is systematic monitoring, the possibility of carrying out a population census based on the number of nests and the species arriving at these (Schroeder and Murphy 2000), the effort in time and space should be the same between periods studied, taking into account the times of beginning and end of the nesting season, number of persons and equipment similar to cover the monitoring, the desirable being the count of at least 95% of the nests on the portion of the beach being monitored.

In addition to counting the nests, you must register the conditions under which they were registered, recording any disturbance to them such as predation, flooding and poaching (Figure 1).

The representation of the percentages of the total number of nests recorded by station on the beaches of interest and its variation through the years by areas, beacons, or stations, is a simple analysis that provides valuable information about the movements made by breeding females in response to stability, availability, and integrity of the substrate of nesting (Guzman and Garcia 2014; Figure 2).

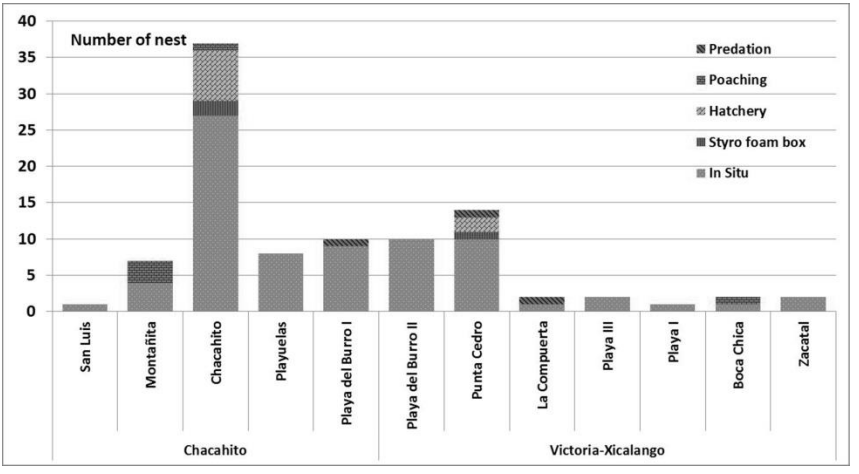

Figure 1. Representation of the total number of nests by use (management: hatchery, styrofoam box and in situ) and destination (evaluation of success) of *E. imbricata*, including successful and lost (predation and poaching) of the Program of Conservation of Sea Turtles in two beaches with their respective stations in Laguna de Terminus, Campeche, Mexico, during 2012.

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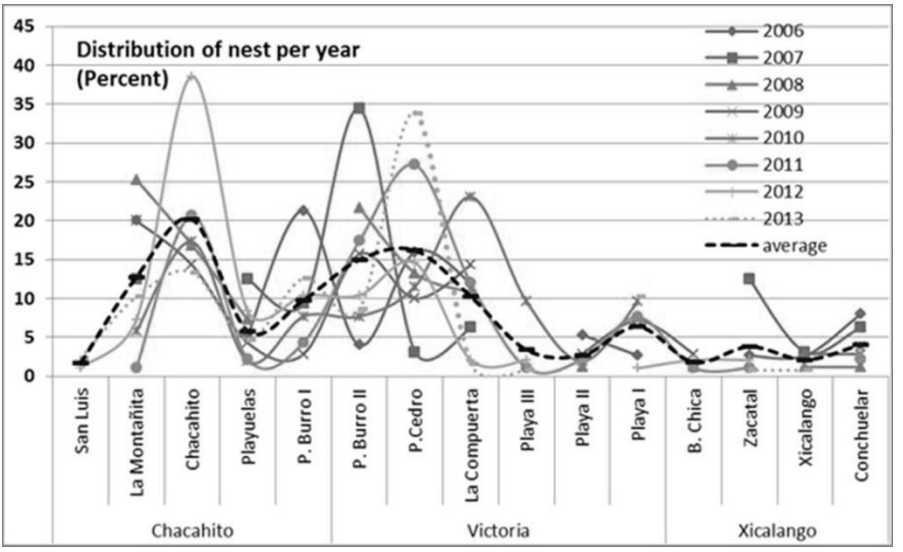

Figure 2. Annual percentage distribution of nests of *E. imbricata* by sampling stations at three beaches in Laguna de Terminos, Campeche, Mexico, in the period 2006-2013.

This analysis provides information on the areas of beach with greater abundance and densities, and therefore the critical areas for the conservation of nests. Similarly, the representation of the values recorded in different reproductive seasons enables the evaluation of spatial and temporal patterns of abundance of nests on the beach and correlates them with events in specific areas and years. At the same time, it allows monitoring aspects of density of nests on beaches with areas little nesting. Females usually nest in areas with the highest densities. Potentially they may be forced to migrate to nearby beach segments and lower abundance when beaches conditions deteriorate in one and improve on the other (Figure 2).

From annual data of all events of nests of the species subject to monitoring and by an arrangement over time, it is possible to represent variations in the abundance of nests, and thus behavior of long-term trends. Figure 3 shows the function that best conformed to the number of nests at the time, obtaining an exponential for *Chelonia mydas* and one linear for *Eretmochelys imbricata*. In the equation that defines the trend line, the coefficient of (x) represents the slope or rate of change of the time series, indicating the magnitude of the trend, either positive or negative. This kind of information gives values of indicators on trends in the activity of nesting on

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the beaches, and in an indirect way and with high uncertainty, the population of nesting individuals of these species in the area of monitoring.

2. Estimation of Population Parameters Based on the Number of Nests

The estimation of fecundity of females of a given species can be obtained by calculating the average number of eggs laid in all the reported nests of these females (Miller 1997). The basic calculation of fertility *in situ* nests represents the result of the count of all occurrences of cleaning or checking the nest, in addition this allows evaluating the success of hatching, emergencies and survival of hatchlings. The parameters that should be recorded include the number of living hatchlings, eggshells; fry hatching, eggs not hatching and non-viable eggs, as well as the deaths of embryos and hatchlings.

Thus, fertility is calculated as follows:

$$Fecundidad\ promedio = \frac{\sum total\ de\ huevos\ en\ nidos\ revisados}{\#\ de\ nidos\ revisados} \quad (1)$$

And the revised total of eggs in nests are estimated as:

$$Total\ huevos\ en\ nidos\ revisados = \#cascarones + HSDEA + HCDEA + CEV + CEM \quad (2)$$

Where:
EOEDA = eggs without embryonic development apparent
EWEDA = eggs with embryonic development apparent
HEA= hatchlings emerging alive
HED = hatchlings emerging dead

Another important parameter that is more specific than the previous ones to determine a typical female fecundity, is obtained from the average count of eggs from the nests of the same female in all or the vast majority of its successive nesting (by applying equation 1 for that specific group of female nests in particular). This is done by tracking the particular label (mark) on their subsequent returns, which for this purpose is the nesting period in days. For this calculation it is preferable to record females with the number of nestings above the estimated frequency of average nesting, avoiding underestimations as much as possible.

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On the other hand, the frequency of nesting females per season can be estimated through recapturing and marking individuals in a population marked to saturation. With this you can get the observed frequency of nesting (OFN), which corresponds to the females that were actually observed on the nesting beach; as well as the estimated frequency of nesting (EFN), which corresponds to the females recorded on the nesting beach on more than one occasion, but the period of time between records is greater than the period in average days between nesting of this population (interesting period), suggesting that they nested once more but were not observed nesting.

The interesting period required for the calculation of the EFN can be estimated based on the tracking of all nesting made by a representative of the population number of females in the study, and estimating the average and the mode of the number of days elapsed between a nesting and another one. This interesting period will allow estimating the EFN females of this same population with a greater support.

For the calculation of frequencies, it is suggested to implement marking to saturation on the beach, ensuring that at least more than 70% of all females that arrive during the season are marked. In this sense, all females found nesting on the beach should be marked with some sort of identifier (mark metal, plastic or electronic).

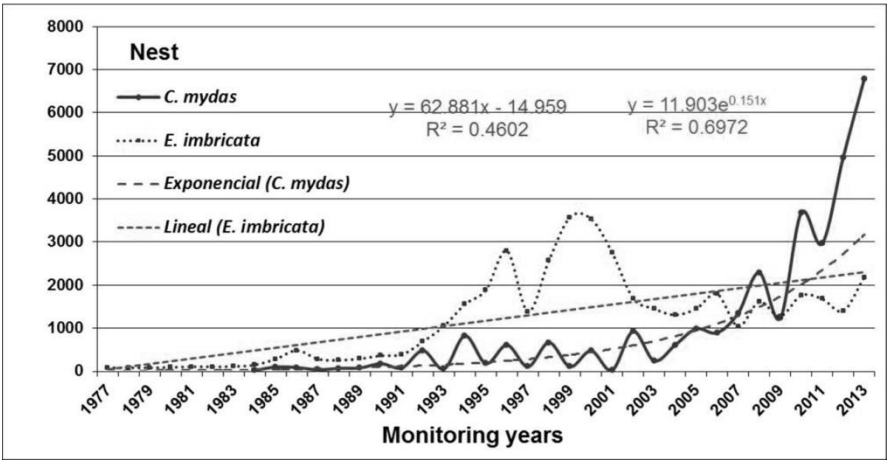

Figure 3. Variation trends of nesting of *C. mydas* and *E. imbricata* in Campeche, Mexico beaches; in the period 1977-2013.

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At the time of their encounter, if the female does not show evidence of having been registered previously on another beach (a female with no mark or evidence scar on the fins or drilling in post-marginals shields in the case of the hawksbill), it could be considered that such female is a neophyte or first timer. The possibility of erroneously identifying a female as a neophyte when it is not has been estimated at around 3% on beaches where there has been regular and significant effort of tagging nesting females for more than one decade (Gonzalez-G. 2007).

All the females that are located on the beach with evidence of having been registered previously on that same beach or any other will be considered as remigrants. The percentage composition of neophytes and remigrants registered in a particular breeding season on a nesting beach has been shown to influence the number of nests deposited that same year, since often females remigrants deposited on average a higher number of nests than the neophytes (Beggs et al. 2007; Cuevas et al. 2007; Guzmán et al. 2008).

The remigratory period is the span of time between breeding seasons for nesting by the same female. Frequently, this period is reported in years.

The weighted average of this reproductive period can be calculated with records of the females in each breeding season and identifying those which boast nesting records in more than one season. The period of time between reproductive seasons and such records will be the remigratory period of the female, and for a set of females of the same population a weighted average may be estimated.

This method of calculation is exemplified in Table 1 for an analysis of six reproductive season time windows. The first column represents the interval in years between successive records of registered nesting females (remigratory period); the second column (n) corresponds to the number of females in this population who presented the period corresponding to its rank in the first column. The third column represents the annual percentages per interval, its mean, the percentage of analyzed total females who presented one and another remigratory period, allowing identification of patterns of their reproductive behavior. This third column divides the amount of returns within a given range of years between the sums of the column and so on. The fourth column is obtained by multiplying the interval in years by the number of returns (n), which also obtains the sum considering the entire analyzed period. Finally the weighted average is obtained by dividing the total of the sum of the weighted between the total of the sum of column (n) events.

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Table 1. Remigration weighted average for two species of sea turtles in Campeche, Mexico, estimates for an interval of 6 years

Interval in years	*Species*					
	Eretmochelys imbricata			*Chelonia mydas*		
	Number of returns (n)	Annual percentages per interval	Weighted	Number of returns (n)	Annual percentages per interval	Weighted
1	31	5.40%	31	12	3%	12
2	171	29.79%	342	102	22%	204
3	170	29.62%	510	180	39%	540
4	94	16.38%	376	90	19%	360
5	67	11.67%	335	50	11%	250
6	41	7.14%	246	28	6%	168
∑	**574**	**100%**	**1,840**	**462**	**100%**	**1,534**
Weighted average	**3.21**			**3.32**		

Cuevas et al. (2006) y González-G. (2007) estimated for the index beaches of *e. imbricata* in Yucatan and Quintana Roo, remigratory periods by 2 year periods (> 30% of their scanned records), followed by a period of 3 years (< 25% of their records). Richardson et al. (2006) in Antigua reported an average period of 2.55 years and Beggs et al. (2007) in Barbados, from 2.73 years. In the case of Campeche, Guzman and Garcia (2014; unpublished data), found that for the turtle *E. imbricata* returns or remigration intervals are shorter compared to *C. mydas*. It should be noted that this value varies depending on the period of years included in the calculation (Table 2).

As shown in some examples and equations in this chapter, many of the basic reproductive parameters of nesting female turtles can be obtained with simple arithmetic equations without the need for complex statistical programs. For the calculation of some of these parameters, a final summary of the section is presented as alternatives to use the formulas shown in Table 3.

Table 4 presents some results of reproductive parameters of two species of sea turtles to the beach of Isla Aguada in Campeche. To use them as part of a population assessment, these estimates should be made annually in order to detect variations and changes within populations, and therefore promote adaptive management. It is recommended that these estimates are accompanied by basic statistics (such as measures of central tendency and dispersion) or according to the statistical requirements of the case.

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Table 2. Remigratory period in years, weighted mean for two species of female sea turtles in Campeche, Mexico

Interval in years	*Eretmochelys imbricata*	*Chelonia mydas*
3	2.37	2.57
4	2.70	2.91
5	2.99	3.15
6	3.21	3.32
7	3.37	3.46
8	3.58	3.54
9	3.73	3.68
10	3.76	3.75
13	4.01	3.85
16		3.89

Table 3. Formulas to calculate the main reproductive parameters in sea turtles

Parameter	Formula o Definition
Relative fecundity	Average of eggs of all the nests by species in a breeding season, by nesting beach.
Female fecundity	Average of eggs of several events of nesting of a same female who has been identified by a mark.
Incubation period in days	Date of emergence of hatchlings - date of egg laying
Percentage of emergency	(Number of live or dead hatchlings were found outside the nest / total number of incubated eggs) * 100
Percentage of brake-eggs	((Number of shells + number of brake-eggs hatching) / (total of incubated eggs)) * 100
Percentage of survivor	((Number of living hatching + brake-eggs hatching live) / (total of incubated eggs)) * 100
Percentage of recruitment to the sea	(Number of hatchlings released and entered the sea / total number of incubated eggs) * 100
Percentage of viability of eggs	(Number of eggs with any signs of apparent development / total number of incubated eggs) * 100
Inter nesting period in days	Average time between successive nesting of a same female of a given species in a specific area.
Period of remigration in years (weighted)	Average time passing females of a species to return turtle nesting beach after a previous nesting.
Observed Nesting Frequency (ONF)	Average verified nesting events observed in a same marked female.
Estimated Nesting Frequency (ENF)	Average verified nesting of observed events of a same marked female including intermediate nesting that could not be observed.

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Table 4. Reproductive parameters obtained in two species of sea turtles in Isla Aguada, Campeche, Mexico, during the 2013 season

Parameter	Statistician	*Eretmochelys imbricata*	*Chelonia mydas*
Curved Carapace Length nuchal-supracaudal and (Curved Carapace Length minimum) in cm (Bolten, 2000)	Average	88.9(88.5)	104.9
	Maximum	102.0(100.0)	127.0
	Minimum	73.3(73.3)	86.0
	S. D.	7.5(7.0)	5.4
	n	76(73)	814
Relative Fecundity	Medium	147	105
	Maximum	231	171
	Minimum	50	36
	S. D.	31.81	21.05
	n	185	147
Period between successive nesting (in days)	Medium	15	10
	Maximum	17	17
	Minimum	13	8
	S. D.	1.15	1.32
	n	13	429
Incubation period of nests (in days)	Medium	55	52
	Maximum	62	56
	Minimum	46	45
	S. D.	2.4	2.4
	n	159	44
Estimated Nesting Frequency ENF vs Observed Nesting Frequency (ONF)	Average	3.0(2.4)	4.4(3.69)
	Maximum	5(4)	7(7)
	Minimum	2(2)	3(2)
	S. D.	1.04(0.7)	1.09(1.42)
	n	45(10)	115(161)

S. D. = Standard deviation

Values enclosed in parentheses ( ) are the corresponding to the CCL minimum and ONF

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3. Estimate of the Number of Nesting Females

Using data from annual total records of nests, it is possible to estimate a tentative number of females who arrived at a particular Beach, considering that the population was closed, which is rarely the case. This is achieved by dividing the number of nests recorded in one year on a particular beach between the values of the estimated nesting frequency (ENF) a typical study of female nesting on the beach of interest.

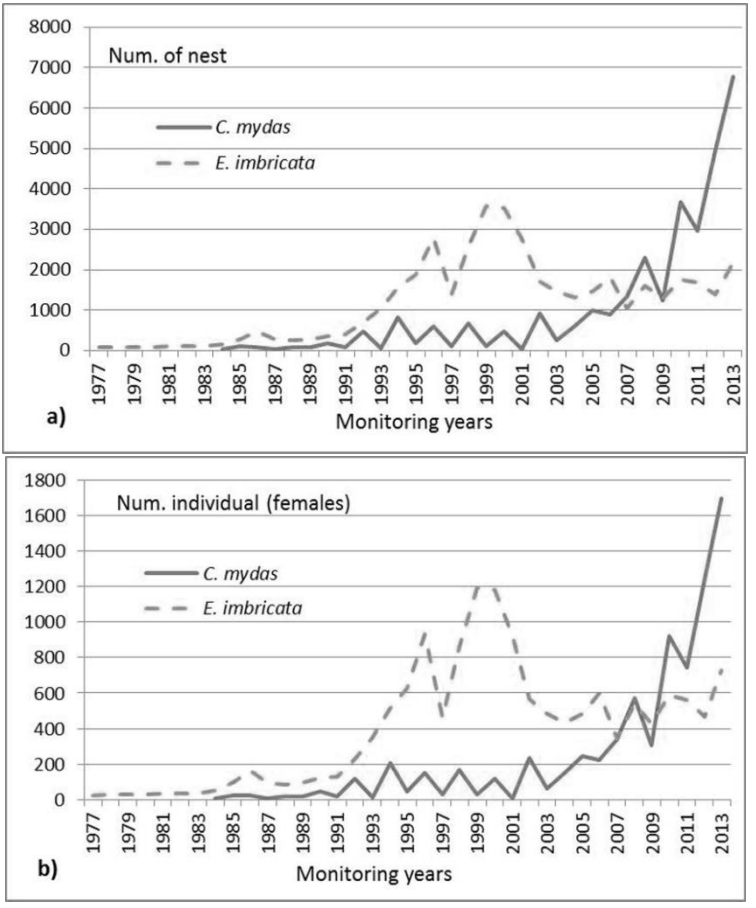

Figure 4a and b. Representation of the monitoring of long term in *C. mydas* and *E. imbricata* in the coast of Campeche, Mexico, with comparative values expressed in number of nests as value source (4a), and an estimated number of individuals as the transformed value (4b).

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For example, the estimated values of the ENF in Campeche over a little more than two decades have been averaging three nestings for females of *E. imbricata* and four for *C. mydas*. Figure 4a shows the number of nests of these species of turtles, recorded over time. The number of nests is divided between the respective FEA for each species, resulting in the estimated number of females shown in Figure 4b.

The ENF is a parameter that in the majority of cases remains similar for many years, even decades, provided that there is a significant event which could lead to radical changes in the population structure or their critical habitats for feeding and reproduction quality. Some of the variations recorded since have proportionally been the number of female remigrants or neophytes changing drastically with regard to previous years.

4. Temporal Variations in Abundance of Nesting

The remigratory period of the nesting female turtles may be in response to the great effort of reproduction in a given year, after which they must be physically recovered before addressing another reproductive event in successive years. During this period they store enough energy to afford to spend time in reproduction (Broderick et al. 2001; Mazaris et al. 2009). In terms of analysis of population data, this means that these are not the same turtles that appear consecutively every year, and makes the evaluation of changes in nesting on a particular beach across cohorts or different generations and not with the same individuals.

This hinders the interpretation about the recovery of the population over time, since there are different groups with different conditions in proportion and abundance; it is likely that some individuals come together and set points in different years. However, it is possible to reduce the wrong readings by eliminating the bias measure layers differently from the same population through the integration in the calculations of the average value of the interval of remigration by species, and in this way to correct this reproductive condition.

Occasionally, the usual reading of the variation of the number of nests per year recorded over time is not clear, especially when there is wide variability. There are alternate ways to present the same data, which can give us a better graphical representation, such as grouping them or integrating them into suitable models to determine population growth (Braun 2005).

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Data collected in Campeche in the late 1970s, resulted in the counting of 73 nests of *E. imbricata*, reported nesting of *C. mydas* until 1984. Integrating this information in decade averages for the behavior of both species on three nesting beaches, statistically significant differences were observed (P > 95% confidence) in terms of the number of nests of the first species between periods 77-80 and 81-90, 91-2000 and 2001-2010, but not between the periods 81-90 and 91-2000 and 2001-2010 and 2011-2013, and for the second species between 84-89 and 91-2000, and 91-2000 and 2001-2010, but not between the periods 2001-2010 and 2011-2013 (Figure 5).

E. imbricata presented among the 77-80 decade 91-2000, an exponential growth of a type similar to that shown by *C. mydas* the decade 91-2000 in the period 2010-2013. From the year 2001 onwards, *E. imbricata* has maintained relative stability after a sudden fall occurred in the Decade 91-2000 (Figure 5).

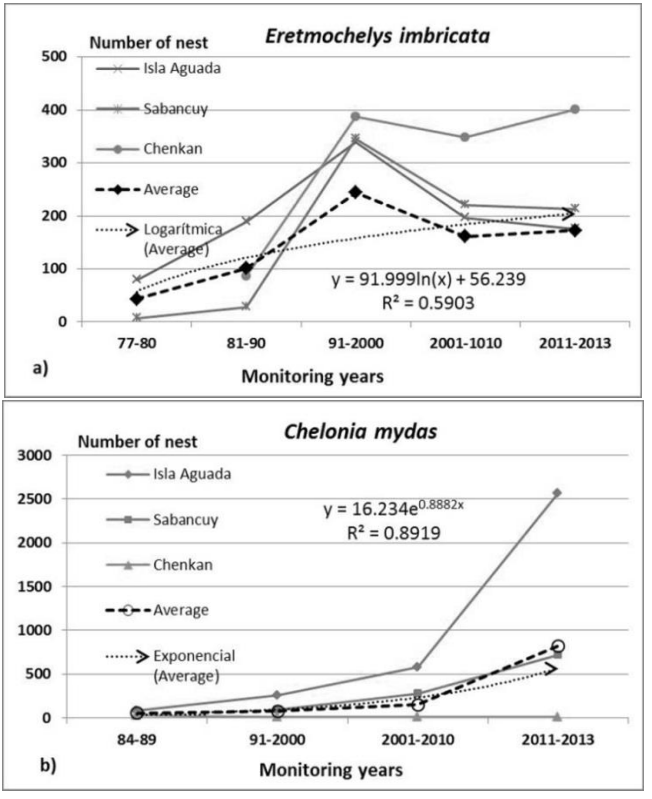

Figure 5a and b. Long-term trends of the average decadal in the number of nests recorded in *E. imbricata* and *C. mydas* at three beaches in Campeche, Mexico.

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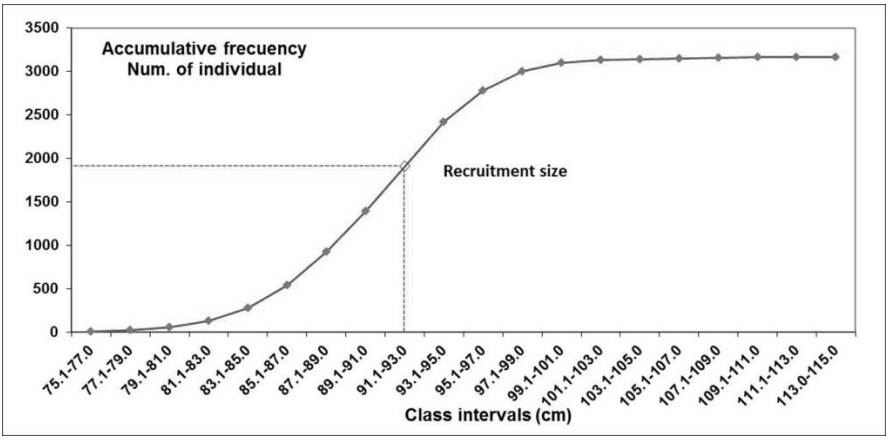

Figure 6. Distribution of accumulated frequencies of sizes and recruitment size of reproductive females of *E. imbricata* during the period 1992-2007 on Isla Aguada, Campeche, Mexico.

Logarithmic and exponential growth models adjusted for *E. imbricata* (Figure 5a) and *C. mydas* (Figure 5b), respectively through the decadal averages explained the 59 and 89% growth in the long term. The number of nests of *C. mydas* has increased on average of 139%, 202% and 541% by decade, respectively, from the first decade, a trend that in the last five years has been accentuated by an annual increase in registered nests.

5. Population and Reproductive Structure of Nesting Females

Recorded data of nesting females marked and recovered in subsequent years composed of neophytes and remigrants, can be accommodated each year by class intervals, in a frequency distribution. Different class intervals are usually tested to obtain the most suitable size groups and to provide better information. In the case of females of *E. imbricata*'s Center and South of Campeche, the interval of 2 cm, was the best statistical fit to handle the data.

Data from the distribution of frequencies, corresponding to the number of females, joined cumulatively from one year to another to get the cumulative frequency (CF). To graph the CF against the values of intervals gets a representation sigmoidal curve or polygon of accumulated frequencies. By using a definition, such as recruitment or the most common size, located at the point where a 50% cumulative percentage distribution frequency occurs,

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ranging from the smaller sizes above 75 cm, they are females who are considered early or dwarf, to the largest close to the 1.15 m, which would be theoretically representing the infinite length (L∞) of females (Figure 6).

It is noteworthy that after 1990, the average reproductive recruitment of *E. imbricata* in Campeche, Mexico ranged from the 91 to 93 cm in size, (Guzman et al., 2008), while in the report made by Marquez-M. (1990), for the same location, it ranged from 86 to 99 cm, with an average of 92.9 cm. In both cases, the values are close to 92 cm, which is the average of the carvings of recruitment, as shown in Figure 6.

Table 5 shows these values for Campeche, Yucatan and Quintana Roo, in Mexico and other points of the great Caribbean. It can be observed that with the exception of the sizes recorded for Colombia, females who reach the Yucatan Peninsula were the largest recorded in the area, and the minors were registered in Cuba.

The annual distribution of sizes of females over the years can be very variable, but at the same time be a reference to determine the high recruitment years. If one takes as reference the size average of recruitment, the distribution can skew towards the petite (1994, 77.1%; 1997, 77.7%) or large (2000, 62.1%), which can serve as a guide to interpret if certain annual cohorts dominates one or another group, and even if both are balanced, (2007, in proportion 42.1: 40.7, respectively, year in excluded the main group of the range where the likes of recruitment; Figure 7). It is possible to establish and confirm using mark-recapture data if the turtles that fall into these size categories necessarily relate to the dominance of recruits or remigrants.

Table 5. Average sizes in length curved carapace (LCC) of breeding adult females of *E. imbricata* in the greater Caribbean

Locality or Country	Interval (cm)	Average (cm)	Source
Yucatán, México.	76-114	94.4	Márquez-M., 1990.
Campeche, México.	86-99	92.9	Márquez-M., 1990.
Quintana Roo, México.	74-101	86.5	Márquez-M., 1990.
Nicaragua	62.5-87	66.5	Márquez-M., 1990.
Tortuguero, Costa Rica	72.4-94	82	Márquez-M., 1990.
Puerto Rico	67.5-85.6	77.6	Márquez-M., 1990.
Locality or Country	**Interval (cm)**	**Average (cm)**	**Source**
12 Leguas, Cuba	60-85	no data	Moncada et al., 1999.
Colombia	80-98	90.7	Márquez-M., 1990.
Guyana	80-89.9	83.8	Starbird et al., 1999.
Isla Vírgenes	84-99	no data	Márquez-M., 1990.

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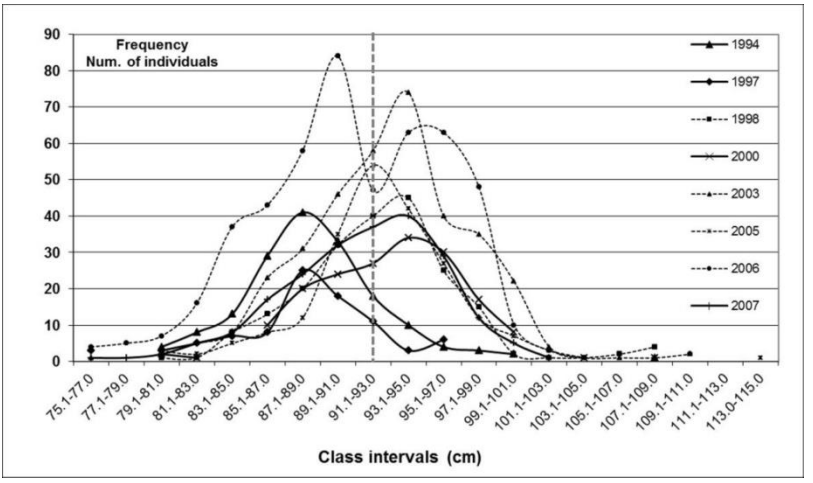

Figure 7. Annual distribution of sizes of breeding females for *E. imbricata* in Isla Aguada, Campeche, Mexico during the period 1994-2007.

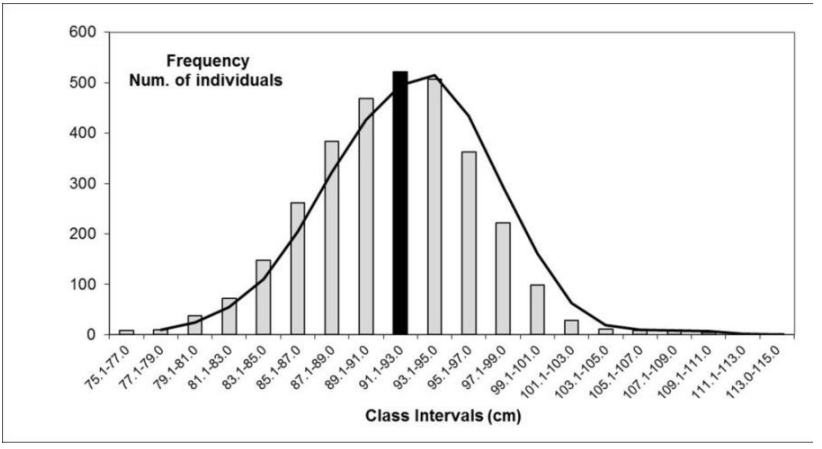

Figure 8. Frequency distribution of sizes of female recruits of *E. imbricata* during the period 1992-2007 on Isla Aguada, Campeche. Mexico. The dark column represents the mode or recruitment size (rs) of this species.

However, when a historical sum of the cumulative frequency of all sizes occurred over the 16 years here considered, you get a better picture of the population structure of the nesting turtles in Isla Aguada, Campeche

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(Figure 8). There is a distribution, which tends to normal, which is slightly skewed toward the young population due to the continuous addition of recruits. The model size range for this population coincides with the range of size of recruitment, and the distribution of sizes of breeding females in this interval, displays closeness among the measures of central tendency: the average, median and mode (Figure 8).

Based on this information, annual histograms are generated which allow tracking the emergence of different cohorts over time, and even comparatively observing variations in the size structure of breeding females with respect to other nesting beaches. For example, taking as a reference the column of the stature of recruitment, Northern Campeche is oriented towards the petite and Punta Xen large sizes, (Figure 9).

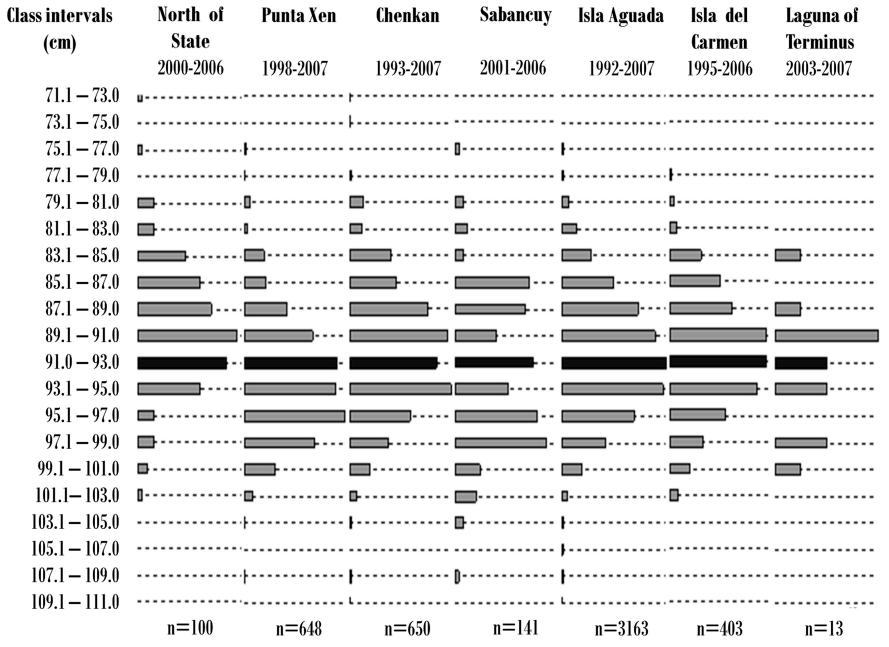

Figure 9. Frequency distribution of annual size of reproductive females of *E. imbricata*, in seven beaches of Campeche, Mexico, 1992-2007. The dark column represents the mode or recruitment size (rs) of this species.

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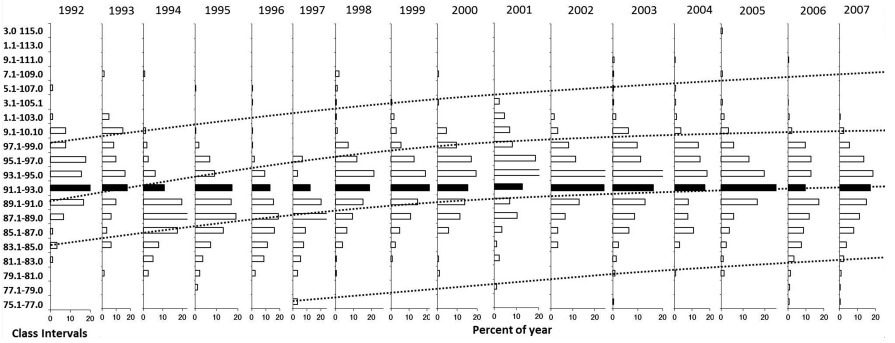

Figure 10. Monitoring of population growth from addition of annual cohorts of *E. imbricata* through time in Isla Aguada, Campeche, Mexico, 1992-2007.

It is possible to establish the particular cohort follow-up as they join and mingle with each other, then disappear over time and then reappear with larger sizes where the cohort decreases gradually in his subsequent appearances.

The behavior of a particular cohort can be followed over time in their successive nesting, as illustrated in Figure 10. The lower dotted line shows the growth trend of a cohort of small size (75.1-77.0 cm interval), which appeared in the year 1997, which is considered as year zero. It then returned to appear in 2001 (4th year), repeated in 2003 after 2 years, then in a first year in 2004, in a second year in 2006, and in 2007 repeats in a first year (Figure 10).

It may be suggested that after a break in years, in which they accumulate enough energy in the form of body fat to successfully reproduce, the turtles will be on more often, as most experienced females, and this will happen more frequently at annual intervals with sizes near or exceeding the likes of recruitment (Guzman et al. 2008), as illustrated in the second dotted line up, which represents another cohort.

Ratio of Neophytes and Remigrants

The long-term mark-recapture program of sea turtles in Campeche, Mexico, has allowed differentiated female neophytes (no marks at the time of the encounter) of the remigrants (previously marked), with an error of envelope estimation of 2.84% biased in favor of the recruits or neophytes, (Gonzalez-G., 2007), a percentage which is relatively low. Values for both species can be represented on a graph of 100% stacked, as shown in Figure 11.

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Here the annual proportions between the remigrants and the neophytes of two species of turtles shown are very variable over time, notwithstanding that the expressions in either direction were more extreme in *C. mydas*. For two species, the majority proportion was in favor of the neophytes: 25:75 in *C. mydas* and 22:78, in *E. imbricata*.

With the knowledge that on average the turtle remigrants deposited more broods than the neophytes, and for this reason the structure of the population in terms of this ratio influences the number of nests deposited in a particular year (Cuevas et al., 2006; Beggs et al. 2007; Cuevas et al., 2007; González-G., 2007), it was observed in the States of Yucatán and Campeche that in general terms, the number of *E. imbricata* nests reported from 1995 to 2007 was inversely proportional to the ratio of remigrants to neophytes registered those same years (Figure 12).

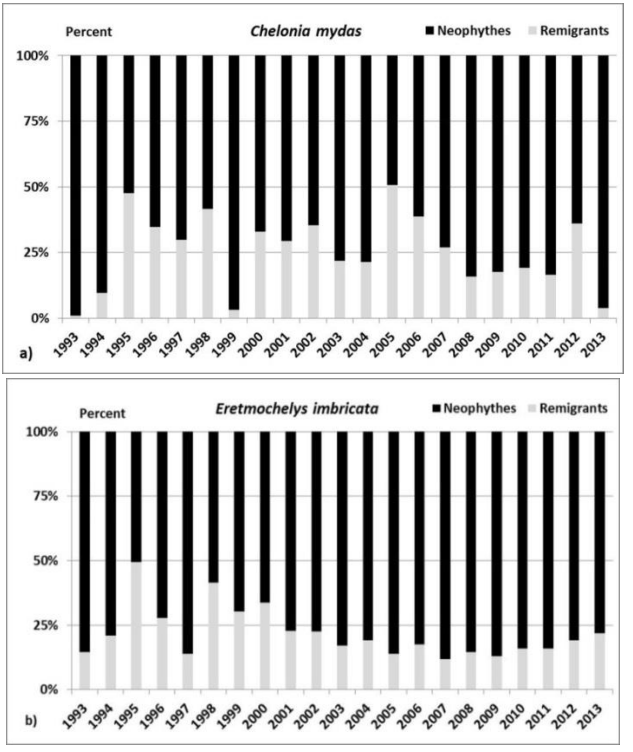

Figure 11a and b. Temporal variation between the proportion of neophytes and remigrants of females of *C. mydas* and *E. imbricata* respectively, in Isla Aguada, Campeche, Mexico in the period 1993-2013.

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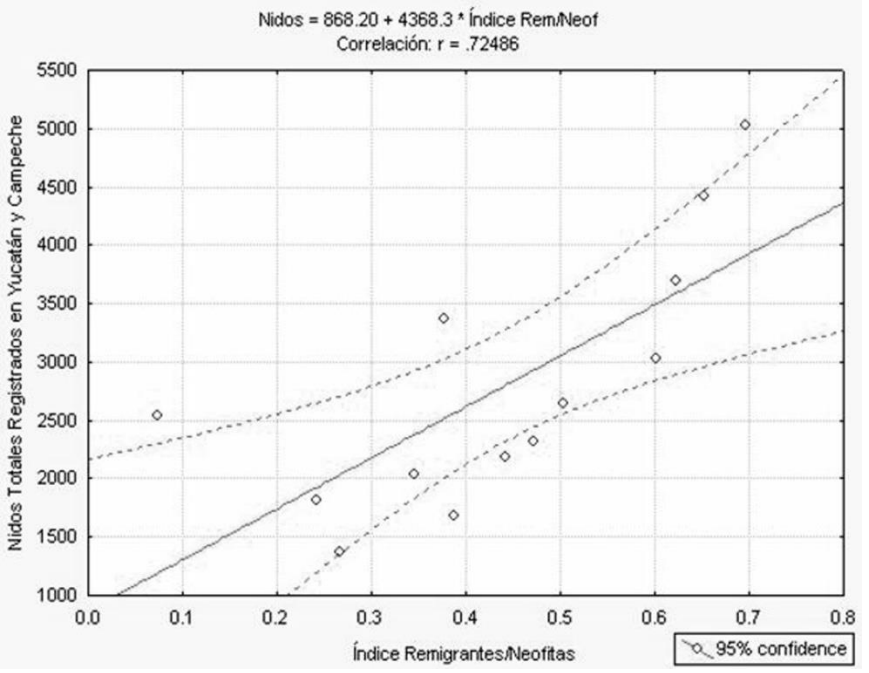

Figure 12. Linear correlation between the proportion of remigrants/neophytes and the number of total nests of hawksbill turtle (*E. imbricata*) recorded together in Yucatán and Campeche, Mexico from 1995 to 2007 (p = 0.005). Taken from Cuevas et al. 2007.

The usefulness of the above information is linked to understanding the population growth via recruitment. For example, Guzman y Garcia (2014), found that in the case of the green turtle (*C. mydas*) in Campeche, Mexico, the exponential increase of the abundance of their nesting is influenced by the proportion of annual cohorts in neophytes (R2 = 0.98, Figure 13a), and poorly related to the remigrants (R2 = 0.39, Figure. 13b). *E. imbricata* was presented a different behavior, since the correlation coefficient was similar in terms of the influence of both groups (0.89 in neophytes and 0.80 in remigrants; Figure 13c and d). It is necessary to clarify that this population of *E. imbricata* is not growing, but has remained stable for more than one decade.

The linear regressions displayed in Figure 13 can be easily obtained by typing in a program two columns of data (X and Y); the first annual values of the ratio of remigrants or neophytes, and the second with the number of nests over the years. From the regression analysis, it is possible to get the equation that defines the line of best fit between the two variables considered, as well as

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to include the value of the R^2 or coefficient of determination, which gives information about the level of fit of the model, or the degree of variation or dispersion between the two variables. The closest are the points to the home straight, the value of R^2 will be closer to one and therefore the correlation between variables X and Y will be greater; if the value of R^2 tends to zero, the points will be more dispersed and variables will have little relationship to each other.

In addition we should include the value of significance of these correlations, which is expressed as "p" and its importance lies in what provides the statistical significance of this relationship, its mean, the probability that such a relationship is merely due to random. The lower the significance; the greater the confidence level of the relationship. In biological sciences, it is more common to consider that there are statistically significant differences in less than 0.05 (Alpha = 5%).

The usefulness of the scatter chart is to show the degree of correlation between both stages of marking (neophytes and remigrants), and its importance as a component of the stock per year, either as responsible for the growth, stability or the decrease of the population of these species.

On the other hand, it is possible to track individual reproductive females marked using the outline of its successive appearances with size changes in the different years of meeting, and in this way, different patterns of remigration are observed (Figures 14 and 15). The remigrants comebacks with marks and in successive years J5951, 2-1-2; J5357, 2-2; J3313, 2-3; J2078, 3-2; J0877, 3-3, and AC949, and AH408, at 3-4, are considered within a good effort to recapture, however matches in the 4-8 years, AH408; 5-2, J2031, and 6-2, J2174, respectively, occur after long periods of time, as in the case of years 5, 6 and 8, it being evident that although these females left in intermediate years, you could spot biases in the sample due to the deficiency of exerted efforts, so the frequency of successive appearances or real remigrations could be underestimated.

Comparatively, figures 14 and 15 show different patterns of growth in body size over the years, expressed by each of the females tagged with metal markers. The trend lines denote that not all groups grow at the same rate, and suggest that in the smaller sizes, growth patterns are similar, unlike that observed in larger sizes that have different patterns of growth.

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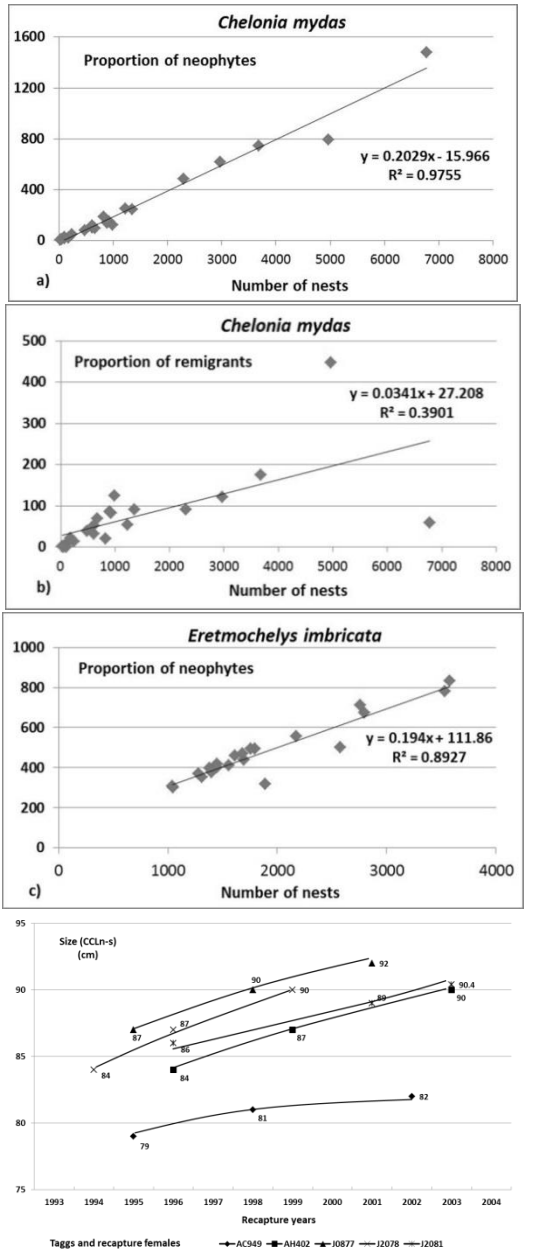

Figure 13a, b, c and d. Coefficient of correlation between the proportion of neophytes and remigrants against the abundance in number of nests in females of *E. imbricata* and *C. mydas* in Isla Aguada, Campeche, Mexico in the period 1993-2013.

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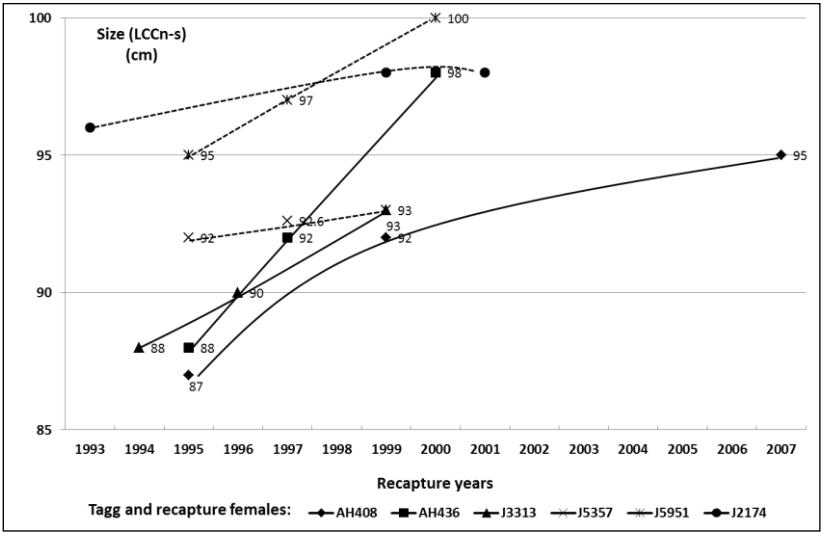

Figure 14. Monitoring of successive nesting of females of sizes small and medium of *E. imbricata* and registration of increasing sizes in Isla Aguada, Campeche, Mexico in the period 1993-2007.

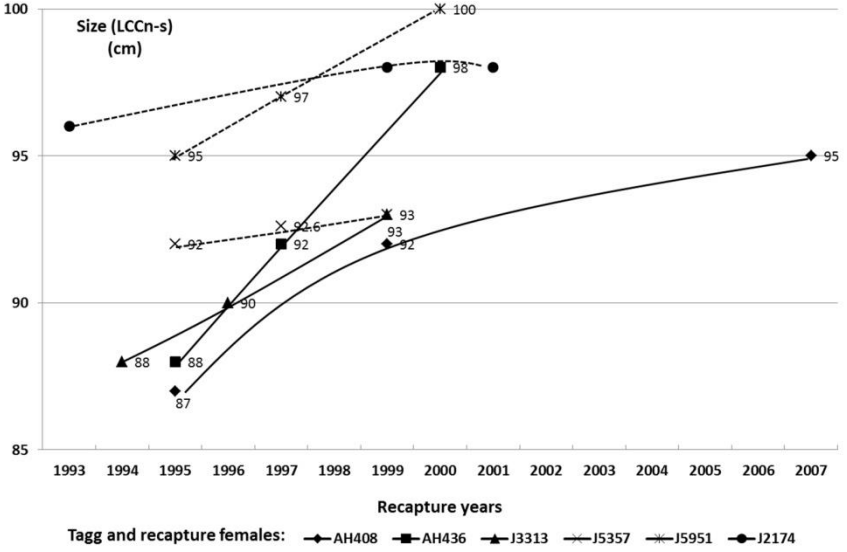

Figure 15. Monitoring of successive of large size females nesting of *E. imbricata* and registration of increasing sizes in Isla Aguada, Campeche, Mexico in the period 1993-2007.

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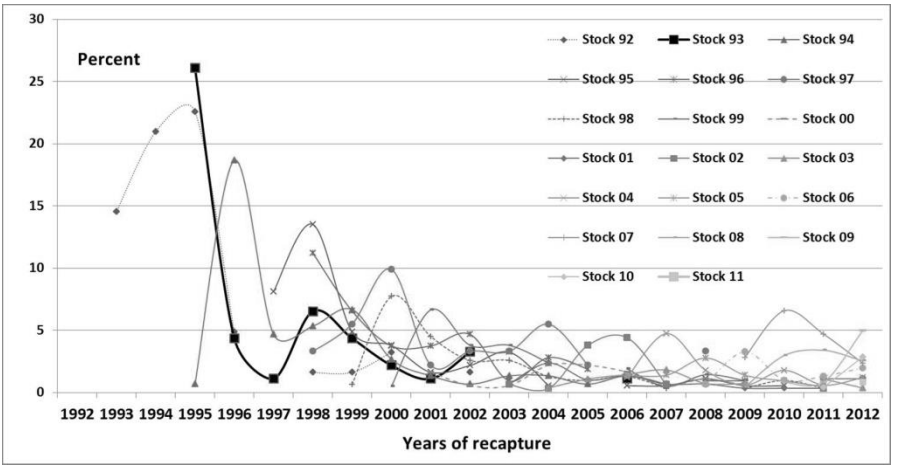

Figure 16. Percentage of recaptures of female remigrants of *E. imbricata* in Campeche, Mexico during the period 1992-2012.

Graphs of curves of decay can be built with tracking tags attached to females and their successive appearances through time, to know the proportions of recaptured females, and their interrelations with different cohorts on a beach. For example, the year 1995 recovered little more than 26% of the marks placed in 1993; While in 1996; 4.3%; 1997, 1.1%; 1998, 6.5%; 1999 4.3%; 2000, 2.2%; 2001, 1.1% and 2002, 3.3%. After this year, a break appeared again in 2006, being the last year of this appearance, with 1.1% (Figure 16). The proportions of appearance and disappearance of the cohorts through time, represent somehow, the periods of remigration of marked females.

It is evident that in the years in which the marking was implemented and during the first decade, the applied effort was intense, as one of the priorities was marking most of the turtles and sight the greatest possible number of marked females or remigrants. This explains the high percentages of recapture during these years.

At the same time you can make a sum of annual contributions from all cohorts in different years and get rates of contribution and retrieval of remigrant turtle marks per year (Figure 17). It should be noted that in the year 1997 in particular, the presence of turtles on beaches all over the State of Campeche was scarce, which influenced the low individual proportion of recoveries of turtles remigrants previously marked (Figures 16 and 17).

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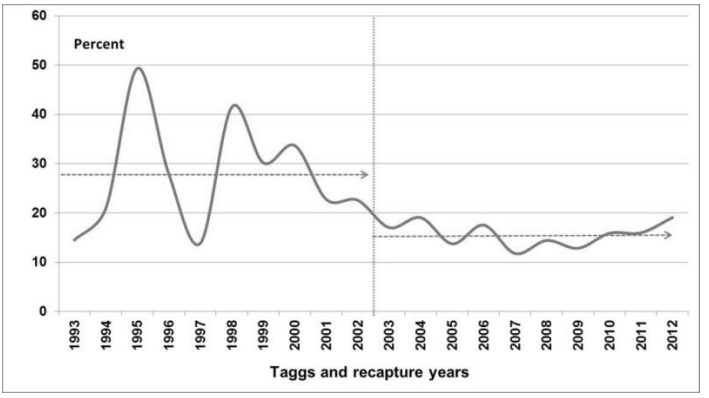

Figure 17. Cumulative percentage of recaptures of female remigrants of different cohorts of *E. imbricata* in Isla Aguada, Campeche, Mexico during the period 1993-2012. The marks recovery percentages were 28 and 16 for the first and second periods respectively.

This history of mark-recapture of females of *E. imbricata* in Isla Aguada, Campeche over the years shows that the variation shown in Figure 17 depends on two conditions, the effort applied to the annual mark-recapture, and abundances of the remigrants in particular years. Furthermore, efficiency to retrieve the marked turtles has been very variable, because the percentages of recapture in the early years and until the start of the 2000s were high, then fell and have maintained relative stability until the current time.

6. Analysis of Population Trends

If there is a good collection of data on the number of nests, as referred to in sections 1 and 2, the growth of a population of turtles can be estimated. The first step is to transform the annual number of nests by marking the corresponding number of females, as explained in section 3.

To calculate the rate of growth (lambda; ג) are placed in 2 columns, the first contains the years, and the second, the amount of females each year. To get a third column or the lambda values, the number of females of the subsequent year is divided between that of the previous year, making the first data in this column show in the year subsequent to the year of home, as described in the formula Nt = nt/nt-1, according to the procedure described by Braun (2005).

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Table 6. Example of estimation of the Lambda index (ƛ) and the coefficients (r) and (R), to 1, 2 and 3 years and the average between 2 (R1) and 3 years (R2), value approximate to the remigratory period of *E. imbricata* in Campeche, Mexico, during the period 1977-1990

year	number of females	ƛ1 Nt=nt/nt-1	r (annual) Ln(N)	R Percent	ƛ2 nt+2/nt	ƛ3 nt+3/nt	R1 (nt+2/nt)	R2 (nt+3/nt)	average (R1+R2)
1977	27								
1978	28	1.0625	0.06062462	6.25					
1979	28	0.97647059	-0.02381065	-2.35294118	1.0375		3.75		3.75
1980	32	1.14457831	0.13503628	14.4578313	1.11764706	1.1875	11.7647059	18.75	15.2573529
1981	36	1.14736842	0.13747099	14.7368421	1.31325301	1.28235294	31.3253012	28.2352941	29.7802977
1982	36	0.98165138	-0.01851905	-1.83486239	1.12631579	1.28915663	12.6315789	28.9156627	20.7736208
1983	38	1.05607477	0.05455898	5.60747664	1.03669725	1.18947368	3.66972477	18.9473684	11.3085466
1984	50	1.33628319	0.28989202	33.6283186	1.41121495	1.3853211	41.1214953	38.5321101	39.8268027
1985	96	1.90066225	0.64220238	90.0662252	2.53982301	2.68224299	153.982301	168.224299	161.1033
1986	162	1.69337979	0.52672641	69.3379791	3.21854305	4.30088496	221.854305	330.088496	275.9714
1987	95	0.58641975	-0.53371944	-41.3580247	0.99303136	1.88741722	-0.69686411	88.7417219	44.0224289
1988	86	0.90877193	-0.09566112	-9.12280702	0.53292181	0.90243902	-46.7078189	-9.75609756	-28.2319582
1989	97	1.12741313	0.11992574	12.7413127	1.0245614	0.60082305	2.45614035	-39.9176955	-18.7307776
1990	122	1.25	0.22314355	25	1.40926641	1.28070175	40.9266409	28.0701754	34.4984082
average		**1.167044116**	**0.11675929**	**16.7044116**	**1.39673126**	**1.63530121**	**39.6731258**	**63.5301213**	**49.1107852**

The data obtained in this third column, calculates the natural logarithm Ln (N) to obtain the instantaneous rates of growth (r) or annual increments, using the total average during the period considered. With N data of the column corresponding to the lambda values, it is possible to obtain proportional change (R) or values as a percentage of the rate of change per capita, which in turn gets an average of the period, which serves to estimate the rate of population growth in the years considered (Table 6).

The values of R can be graphed by species, as in figures 18 and 19 for the populations of *E. imbricata* and *C. mydas* nesting in Campeche, Mexico. In both cases two models were tested whereas the more typical remigratory periods presented by each species, occurring between 2 (R1) and 3 years (R2). It also conducted a third setting by averaging the previous two, which resulted in a similar value of the remigratory period of each species concerned in Table 1, and which corresponds to the period of 2.5 years. This value represents the expression of the female's population growth better to consider a more frequent migratory species group.

In the models presented in Figures 18 and 19, it is considered that there is a gain or population growth when the values are positive; while the negative ones denote lack of profit or growth in certain years. In *E. imbricata*, in the period 1977-2013, three pulses or important periods of population growth were presented, from 1984 to 1987; from 1991 to 1996 and from 1998 to 2001 (Figure 18), whereas for *C. mydas*, the three lines express gains and losses in even and odd-numbered years, respectively. In addition coincidences were observed between the three models for the years in which there was no growth

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(1988, 1993, 1997, 1999 and 2001). The years in which the greater population growth arose were 1990, 1992, 1994, 1998, 2002, 2006, 2008, 2012, and 2013. In a few years they only agreed on two behavior models, one of them was with one greater increase, in 1996, 2003 and 2004 (Figure 19).

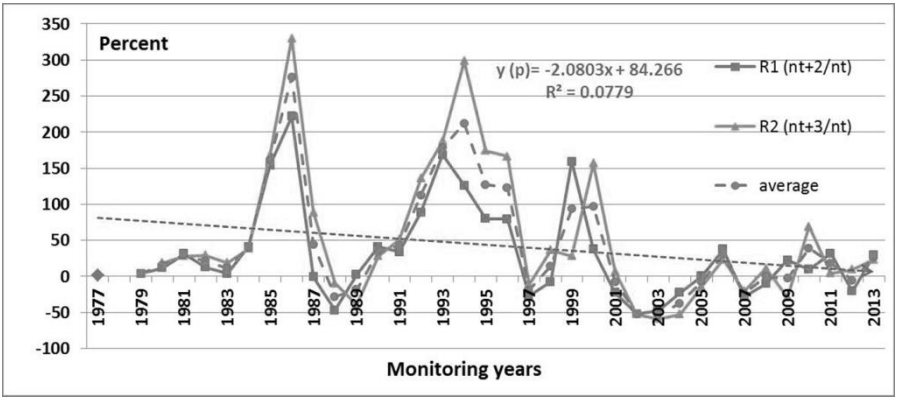

Figure 18. Proportion of change population in females of *E. imbricata* whereas remigratory periods of 2 (R1) and 3 years (R2), and the average between the two, obtained from data of the total number of nests recorded in Isla Aguada, Campeche, Mexico during the period 1977-2013.

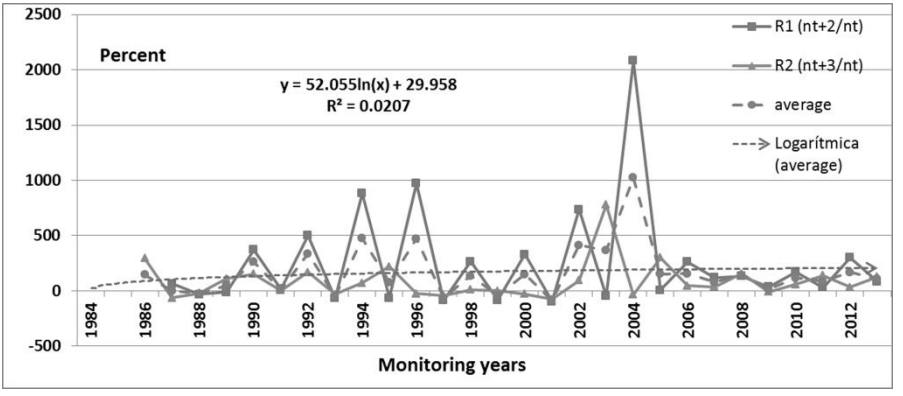

Figure 19. Proportion of change population in females of *C. mydas* whereas remigratory periods of 2 (R1) and 3 years (R3), and the average between the two, obtained from data of the total number of nests in Campeche, Mexico during the period 1984-2013.

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Although the terms of reference of a simple number of nests (Figure 3) representation and the representation of a model of growth of the same population through time (figures 18 and 19) should coincide, the results of the trends in abundance of nests and population growth are completely different in both cases. However, numerically in terms of reading indices growth models are the most appropriate, apparently not representing graphically what is observed in the field as to the abundance of females, contrasting figure 3 with 19, over all in the last 8 years.

The analysis of the growth curves of both species (Figures 18 and 19) performed by means of the coefficient of determination R^2, indicate that between the variables that represent the proportional change in both species, there is virtually no correlation.

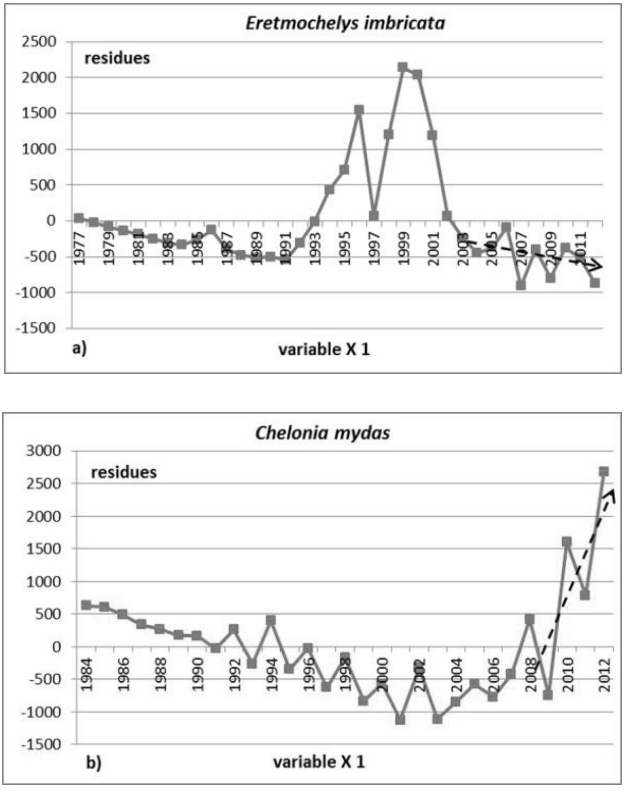

Figure 20. Analysis of residuals of populations of females of *E. imbricata* and *C. mydas*, in Campeche, Mexico, 1977-2012 periods and 1984-2012, respectively, with final trend line projection.

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One way to graphically solve this deficiency of the model is through the analysis of the residuals, which allows analyzing in more detail what actually happens with the populations. While that of *E. imbricata* maintains a downward trend in the last years of the period considered; *C. mydas* instead presents an upward trend in the past 5 years (Figure 20b).

7. Suggestions for Feedback and Adaptive Management of Monitoring and Conservation Programs

The tools available for assessing the population status of the species must be used properly considering all their assumptions and limitations. This becomes important when applied to data coming from biological monitoring oriented to conservation, as it is the case of the sea turtles. These data must be attached as close as possible to reality, as well as to analysis and interpretation, so that the monitoring remains a systematic, ongoing activity in time and space.

The changes detected in turtle populations show the influence of factors or variables that are impacting the growth trends, making it necessary to carry out corrective actions in the management of the species, as well as to increase their protection. Adaptive management should be considered permanent, since it permits an analysis of the progress of the project, in accordance with the results obtained. Adjustments arising from it will depend on the systematization, the design and the experience of prior learning, including the change of strategic lines with the recovery of populations, from direct conservation activities to simple monitoring according to the abundance of the resource.

As an example of this in Mexico, applied between 1977 and 2012, protocols were modified in 2013 by the forced entry of the NOM-162-SEMARNAT-2012, which in Campeche was concentrated in the abundance of nesting of *C. mydas* at three beaches, including Isla Aguada. This forced a change in management of preferably incubated nests in poultry, to pass to an *in situ* monitoring in an inverted proportion, from 10 to 90%, respectively.

After the first year of application of the criteria of such standard management, it was noted that in *C. mydas*, there was no significant impact in terms of loss of nests, clarifying that by 2013 there were no direct effects in the areas of Campeche nesting beaches caused by extreme weather events.

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However, the forecast should be kept through a contingency plan with protocols, depending on the environmental conditions.

This change in management is still not recommended in E. imbricata, since the downward trend. Consequently, the options offered by the law for its precautionary management, as determined through of the monitoring and analysis in the medium term; there it may be a change in strategy without risk. This is one of the possible benefits of an analytical process of multifactorial relationships.

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Data for figures 3, 4, 18, 19 and 20 come from state information is shared with credits; to figure 12, directly mentioning its source. The rest of the figures were built with data and information published in reports of the project, corresponding to the beaches of Isla Aguada, Chenkan and Laguna de Terminos.

The global nest in the State has been made possible thanks to the availability of data from the Reserva de la Biosfera Los Petenes-CONANP, Enlaces con tu Entorno AC, Secretaria de Medio Ambiente Recursos Naturales y Desarrollo Pesquero, Secretaría de Ecología, Secretaría de Medio Ambiente y Aprovechamiento Sustentable del Gobierno del Estado, Quelonios AC, Universidad Autónoma del Carmen, Universidad Autónoma del Carmen, Estación de Investigación Oceanográfica de Carmen III Región Naval-Secretaría de Marina, Marea Azul AC, Desarrollo Ecológico AC, Laguna de Términos-Delfines AC, Desarrollo Sustentable AC, Centro Regional de Investigación Pesquera Carmen and Area de Protección de Fauna Flora Laguna de Términos-CONANP.

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Pronatura Yucatán Peninsula, its managerial staff and researchers, have always driven the turtle program evaluation through the realization of meetings, training workshops and assistance in data analysis, so this effort represents a continuation of the work started.

Paty Huerta, Blanca Gonzalez, Concho, Carmen, Jaime, Felix, Javier, Valdepeña, and Xochiquetzal, among many others.

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Chapter 4

QUANTIFYING SEA TURTLE NESTING HABITAT: USING BEACH PROFILING AND NEST DISTRIBUTION AS A CONSERVATION TOOL

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ABSTRACT

In México, nest relocation is the most commonly accepted methodology of sea turtle conservation. However, due to the heightened level of manipulation, lack of proper training for volunteer monitoring groups, and limited regulation, the shift is for more in-situ nest monitoring. Especially is the case for olive Ridley species (*Lepidochelys olivacea)* which is the least endangered of all marine turtle species. Yet in-situ nest monitoring is complicated by (1) poaching, (2) dynamic Pacific coastline, (3) extreme seasonal erosion from tropical storms, (4) an onslaught of unregulated coastal developments and (5) high-impact beach activities such as ATV tours.

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The southern Pacific region of the Baja California Peninsula provides nesting habitat for *L. olivacea, Green/Black (Chelonia mydas (agassizii)*[1] and *leatherback (Dermochelys coriacea).* Habitat loss due to natural and anthropogenic reasons significantly reduces the available nesting area every season. Without an accurate analysis of the baseline habitat conditions and region-specific best management practices to protect vital coastal dunes, these northern nesting sites may be lost forever. Since the *L. olivacea* population has returned to low conservation status, this species serves as the perfect indicator species to study response to climate change effects and assess the impact of coastal development in the region.

Formally, coastal dunes and beaches were considered separate ecosystems, but since dunes serve as sand reservoirs to replenish the beach after seasonal storm erosion, especially vital in the Pacific coast, these two systems are regarded as one complex dune-beach system. Yet, as the view of dunes as a blank slate for coastal tourism development continue to exceed engineering common sense, the combination of coastal tourism development and climate change provokes an increase in erosion of nesting beaches at an alarming rate, squeezing out nesting habitat and thus compromising current conservation efforts.

This chapter (1) reviews the region –specific threats with case studies, (2) presents the results of the 2013 beach-dune profile investigations and (3) analyzes 2013 nest distribution data in relation to moving towards increased in-situ nest monitoring practices for 2014.

INTRODUCTION

Baja California is a long peninsula, over 700 kilometer (1300 miles), delineated politically by two linear states identified by north and south: Baja California Norte and Baja California Sur (Escofet & Espejel 1999). The land mass is sandwiched by the Gulf of California to the east and the Pacific Ocean to the west owing to an extensive coastline. The San Andreas Fault, which runs through Colorado Rockies, extends through the Gulf of California. This geologic process lends to the diverse coastal ecosystem of rocky shore, towering coastal dunes, mangrove lined bays and inlets, saltflats, and sandy beaches.

The physiographic features within the topographic relief along the coast are a manifestation of a complex geological past linked to the evolution of plate tectonics. Marine sediments are important in the foundation of coastal

[1] *Chelonia mydas* commonly known as the green sea turtle species is considered by some scientists in Pacific Mexico to be of a separate species or subspecies, *Chelonia agassizii* commonly known as the black sea turtle.

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dunes, of which are a vital a biotic component to successful nesting by marine turtles (SEMARNAT 2013).

Pacific Beach-Dune Ecosystem

The beach–dune system hosts an increasingly dynamic exchange of sand of which both parts of the system are dependent upon for formation (SEMARNAT 2013). The southern Pacific region of the Baja California Peninsula is characterized by dynamic coastal morphology. High energy wave forms (figure 1), strong littoral currents, high velocity local onshore winds (figure 2), and large tidal fluctuations are the main factors influencing the complex morphodynamics (Camacho-Valdez et al. 2008). For example, at transition points between sandy beach and rocky outcroppings, seasonal hide tides and strong surge from the frequent summer storms create temporary lagoons in the beach swale extending up to the coastal dunes (figure 3). These lagoons function as part of the mineral sand cycle and maintain an optimal balance of temperature and humidity in the sand.

Figure 1. High energy waves are common during the rainy season which coincides with sea turtle nesting season provoking natural erosion up to 60 meters wide in some locations.

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Figure 2. Storm surge of up to 50 meters during a tropical storm eroding a majority of the beach.

Figure 3. Temporary coastal lagoons form in the nesting area. Nests have been shown to be successful even under inundation for a period of weeks.

Sediment transport via local winds provokes alterations in both the beach and the dune through a process of erosion and accretion. These alterations are

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not immediately visible until the onset of seasonal summer tropical storms test the resilience of the system. For example, from June to December 2001, 60 meters of sand erosion was calculated through beach profiles in Cabo Falso, an area approximately 5 kilometers (km) from the center of Cabo San Lucas (Camacho-Valdez et al. 2008).

By February 2002, still only 20 meters of accumulated sand was calculated along the same profile transect. In this study area, backshore foredunes and parabolic dunes are present ranging from 10 to 100 meters in height. The strong north-westerly winds provide a means for sand transportation and dune vegetation provides an obstacle for sand allowing accumulation in the coastal dunes, which then serve as a sand reservoir to replenish the beach following storm erosion.

The dynamism of the beach-dune system coupled with climate change provokes natural erosion causing alterations of marine turtle nesting habitat which can temporarily impede nesting activity until the beach is restored by natural processes (figure 4). However, when coastal development removes the coastal dunes (figure 5), the beach cannot be replenished because the sand reservoir is lost (SEMARNAT 2013). The combination of coastal tourism development and climate change provokes an alarming rate of beach erosion, squeezing out nesting beach for marine turtles and compromising current conservation efforts (Choi & Eckert 2009).

Figure 4. Typical sand bank escarpment forms along the beach during high tides up to 6 meters high in some locations.

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It is interesting to note that the very beach the tourists and residents demand is the same beach that is eroding due to unregulated and poor engineering of construction in the coastal dunes and beaches. Along these dune-backed sandy beaches, three species of endangered marine turtles find suitable habitat to deposit eggs. By quantifying beach-dune morphology in correlation with marine turtle nest distribution, we can identify best management practices and devise a coastal management plan that will encompass conservation of all coastal dune biodiversity.

Figure 5. Example of a typical Coastal Dune Development.

Sand and Beach Tourism

In addition to erosion, inundation, and climate change, marine turtle nesting habitat is threatened from anthropogenic effects. The centerpiece of México´s tourism development is along the coast, whereas coastal dunes are the prime site for development infrastructure (figure 6). The majority of tourism occurs from traditional tourism of sun and sand, where by tourists have a negative interaction on the natural and social environments (Dean & Pesanti 2009). For example, by 2009, the growth rate of coastal hotels and resorts showed an increase of 15% (Honey & Krantz 2012). More recently

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coastal developments include houses and condominiums as the demand and trend for second homesteads are increasing abroad. In fact, a federal trust fund for tourism development, FONATUR, was set up by the Mexican government to encourage foreign investments by offering an attractive incentive package to create tourism centers with large-scale, multi-use developments (Dean & Pesanti 2009).

Figure 6. Large beach estates constructed by clearing vegetation and leveling coastal dunes.

The Los Cabos region is one of the fastest growing tourism destination centers in México, targeted by the Mexican government and funded by FONATUR (SEMARNAT 2012). The federal maritime protection zone (ZOFEMAT, the acronym in Spanish) is an area extending 20 meters from the high tide perpendicular inland. The zone is determined from the highest recorded tide line.

This zone is not intended as a tool for environmental review; yet, coastal development is based on the ZOFEMAT zone, allowing developers to construct infrastructure up to the 20 meter mark. The proximity to the U.S. and Canada and the exposure the area receives from famous celebrities, sighting Cabo in blockbuster movies and hit T.V. shows, fuels the demand and trend.

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However, all this development places significant pressure on coastal and marine resources, both indirectly and directly.

The associated tourist activities concentrated on the beach, such as recreational ATV tours, and golf courses (figure 7) reduce dune stability by removing vegetation and compact the beach sand, inhibiting the necessary dynamic movement in the system (Lizzarga-Arciniega 2001).

Figure 7. Diamonte Golf course aerial view showing non-native grass planted for green areas.

These mega-developments create direct and indirect challenges for biodiversity and marine turtle nesting. For example, the 1500 acre master planned luxury mega-development, "Diamante Beach and Golf Resort" (figure 8), located in Cabo San Lucas has adversely impacted the environment from non-native grass use for the golf greens and dredged lagoons thus impacting coastal biodiversity through habitat loss and fragmentation (figure 9). In addition, the development boasts 40 beach estate sites, each one an acre in size, located directly within marine turtle nesting habitat supposedly federally protected (figure 10).

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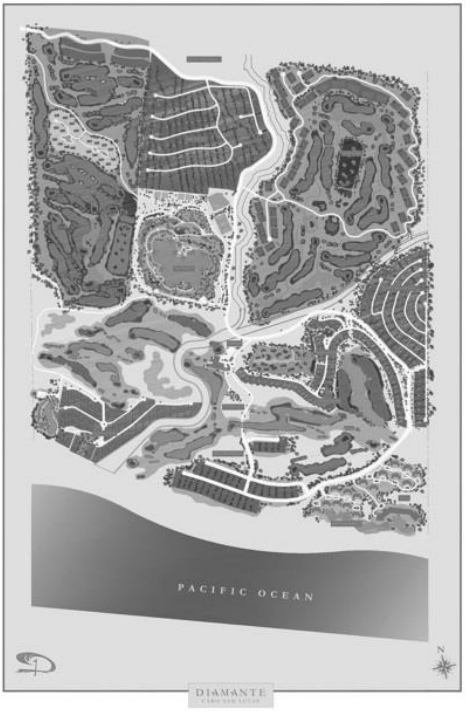

Figure 8. Diamonte Beach and Golf Resort Master Plan permitting take of over 5km^2 of priority nesting beach for *L. olivacea* species.

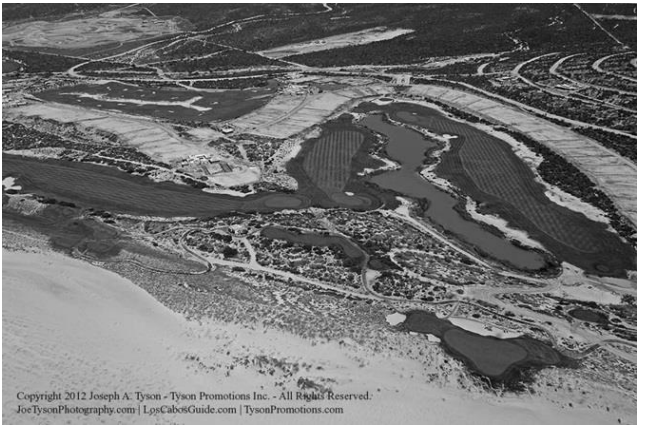

Figure 9. Diamonte Golf course using non-native grass with a dredged lagoon built into the coastal dunes.

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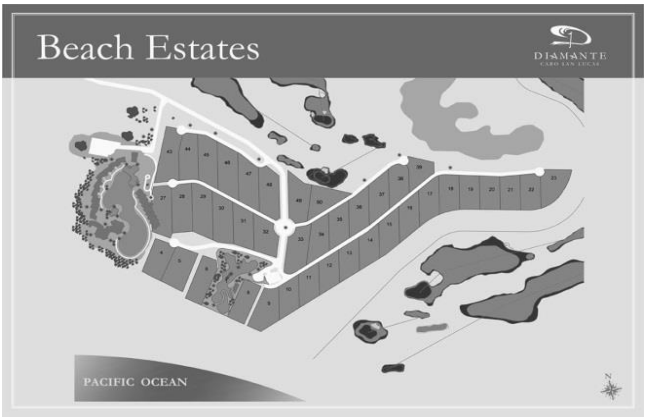

Figure 10. Diamonte beach estate lots located within sea turtle nesting habitat.

Due to the limited water resources as a consequence of building in a desert landscape, new developments are required to include a desalination plant in their plans (Pombo et al. 2008). In the case of Diamante Beach and Golf Resort, adequate environmental and engineering studies were not completed to determine the impact of the desalination plant. Only four years after installation, the outtake pipes are creating large holes in the beach, altering beach morphology (figure 11). The turbulent saline waste water flushed out from the desalination plant has resulted in erosion, causing direct loss of nests (figure 12) and loss of nesting habitat.

Overtime, coastal development, beach tourism activities and desalination plants provoke artificial beach renourishment projects after years of increasing erosion threaten the infrastructure (Mosier & Witherington, 1999). While the renourishment projects are costly to tax payers, the cost to the coastal wildlife species is more significant. For example, in Florida scientists have determined that *C. carretta* do not typically nest on a renourished beach for up to three years after due to the dramatic change in mineral, nutrient, and organic composition in the sand suitable for embryonic development. If Mexico begins to use beach renourishment as a solution to unregulated coastal development owing to excessive beach erosion, the potential loss of three years of nesting for *L. olivacea* will certainly negatively impact the past 18 years of conservation work in the state and push the population back to critically endangered status in the near future.

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Figure 11. Outtake value of the desalination plant creating artificial depressions that fill up with high saline waters, chemicals, and trash creating hazards for humans and coastal wildlife species.

Figure 12. An exposed nest due to erosion provoked by the desalination plant of Los Cabos.

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Nest Monitoring

Currently, there are five groups monitoring nesting activity in the southern Pacific coastal region of Baja California Sur, totaling over 250km, with approximately 40km lacking any monitoring group or legal protection. The oldest group, ASUPMATOMA, A.C., a Mexican non-profit organization dedicated to the preservation of the endangered marine turtles of Baja California Sur, Mexico, began work to protect the environment and develop an Environmental Education program in the Los Cabos, B.C.S. area in 1995 at Playa San Cristobal. The organization consists of a group of motivated individuals sharing the same concern about "the misuse of natural resources and the deterioration of the environment". ASUPMATOMA, A.C., legally registered by Rene Pinal, has focused on the protection, research and conservation of sea turtles and environmental education for over 18 years. The non-profit association works with three sea turtle species, primarily *L. olivacea*, and infrequently *D. coriacea* and *C. agassizii*.

In 2006, the first participatory Environmental Oversight Committee was formed which lead to the creation of a Network of biologists and volunteers for the Protection of Marine Turtles (Ganster et al. 2012). As of 2009, 103 km of beach, approximately 57.3% of beaches within the Los Cabos municipality were being monitored, but not protected against ongoing threats of poaching and habitat loss. The beaches that lack protection have an unknown density of nests, yet evident threats of coastal development pressure and tourism activities of ATV operations. In 2013, the federal Secretary of the Environment, SEMARNAT, enacted a regulation for nest monitoring operations (SEMARNAT 2013). The regulation, NOM- 162-SENMARNAT-2013, includes accepted protocol for nest relocation, hatchery design and operation, and handling marine turtles in research, and hatchling release events, especially those targeted at tourism.

The regulation states, "To maintain the integrity of the nesting habitat conditions for the survival of marine turtles, it is essential to carry out actions to prevent the destruction, fragmentation or degradation of the biological, chemical and physical conditions of the nesting habitat, such as the natural dynamics of accumulation of sand and water flows that ensure moisture salinity and temperature suitability for incubation." This new regulation has yet to be implemented since SEMARNAT continues to permit construction in marine turtle nesting habitat from Todos Santos to Cabo Falso.

Presently ASUPMATOMA, A.C. is permitted to conduct research and monitor sea turtle nesting by SEMARNAT from July to December in two

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beaches totaling 21.5 km. Rancho Punta San Cristóbal is located at Km. 111 of the Federal Highway #19, and includes 4.5 km of linear beach. René Pinal, the founder and president of ASUPMATOMA, is also the owner of the property and has committed to maintain a conservation design of construction and to protect the coastal dunes for marine turtle nesting activity. This beach is where the main facility is located that includes an educational center and focuses on a program called "Adopt a Baby Sea Turtle" which helps generate research funding. A new program was implemented by ProFaunaBaja, "Adopt a Nest" where the general public are invited to adopt a nest, in which they receive the coordinates of the nest, the hatching data, and the number of hatchlings successfully released to sea. Summer camps for local school groups and overnight tourism activities are offered here at this private beach. Playa El Suspiro, located at Km. 119, is also located on the Federal Highway #19 between Rancho Punta San Cristóbal and Cabo Falso where 16.5 km of beach are protected.

The two field stations are separated physically by a rocky beach and cliff. The difference in the morphology of the two areas is drastic. San Cristobal is much narrower and subject to frequent inundation by high tides and storm surge. In contrast, El Suspiro is characterized by towering, wide coastal dunes with granite rock caves and dune swales which have more permanent sources of water from inland arroyos and ground water influence. In terms of development threat, Rancho San Cristobal is a gated private ranch with only few single-lot residential homes constructed in the coastal scrub and dunes but many more for sale. Playa El Suspiro is located adjacent to the lighthouse of the municipality, 5 km from the center of sprawling Cabo San Lucas and 30% of the nesting beach is in development, of which includes the mega resort, Diamante and the Los Cabos desalination plant.

Annually, this group spends around $750,000 pesos on average for ATV maintenance which includes oil repairs, tire replacement, operation of monitoring facilities, gasoline, paid staff of 6 biologists, group administration, research equipment, room and board for volunteers, and materials for the hatchery, etc. Tourism activities, such as hatchling releases, overnight patrols, and adoption programs, festivals and events, and funding requests from federal programs, collectively result in a recuperation of approximately 60% of these costs. In order to assess the distribution of nests along the beaches, in 2012, we began a pilot study to digitally mark nests with GPS units before relocation to the protective hatchery (corral). In 2013, we received grant funding from the Rufford Small Grants Conservation Fund (figure 13) in which we launched a

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research project to quantify habitat conditions throughout the 21.5 km of ASUPMATOMA nesting beaches.

Figure 13. Rufford Small Grants Conservation Fund logo.

Challenges of *In-Situ* Nest Monitoring

While ASUPMATOMA formed the first monitoring group in 1995, observations of sea turtle existence in the region are documented through indigenous pictographs. For example, the now extinct groups of Pericúes and Guaycuras, painted murals of *D. coriacea* (figure 14) and remains of turtle carapace exist at archeological sites. Anthropologists conjure that sea turtles were icons of their life since turtles appear in funerary activities and arrivals of turtles translates to beliefs of abundance and longevity (Ganster et al. 2012). When missionaries and pirates invaded the region, sea turtles lost their iconic reverence and instead, became a food source. After the Mexican government declared consumption of sea turtle parts an illegal activity in 1990 (Mancini et al. 2011), officials including the President continued to feast on marine turtles on national T.V. as a symbol of social status and blatant corruption (WildCoast pers. comm.).

Still today, poachers gain profit from the black market, coxing beliefs that the eggs have aphrodisiac properties, the blood, drunken as a tonic, can cure anemia and fatigue and the fat melted into lard can remedy respiratory illnesses (Ganster et al. 2012). The black market in Baja California Sur, may not be as prevalent as other parts of México, for example Oaxaca or Michoacán, however, poaching is still obvious as recorded from the quantity of stolen nests and nesting females on an annual basis by ASUPMATOMA and other groups. For example, in El Suspiro, on average 13.5% of recorded nests are stolen annually since 1999. However, it is likely this number is actually higher because many times, the evidence of poaching is concealed by strong winds or predators. In 2013, ProFaunaBaja began mapping locations of poaching events and poaching evidence using handheld GPS units and ArcGIS software and photography resulting in one arrest (figure 15).

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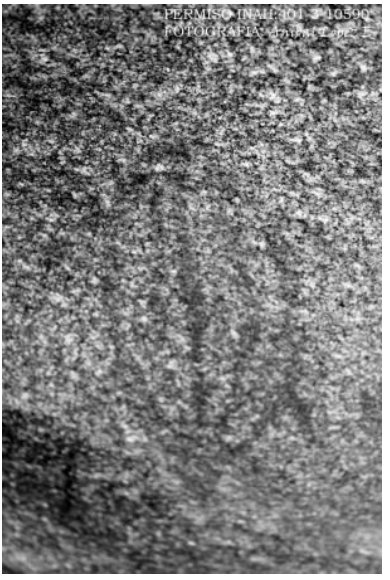

Figure 14 Indigenous pictograph over 4000 years old of a leatherback turtle discovered in the Sierra La Laguna mountain range, over 200km from any nesting beach.

Figure 15. Evidene of poaching can be found in remote areas of nesting beaches in Mexico. Poachers gain more money than fishermen provoking a malicious cycle.

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Poaching is not the only serious challenge to in-situ monitoring. Coastal development, as described above, is the primary cause of habitat loss for marine turtles and coastal biodiversity in general. In response to pressures by non-profit organizations for coastal dune protection and persistence from marine turtle groups, SEMARNAT released a document outlining management strategies and ecological criteria for coastal dune ecosystems (SEMARNAT 2013). Section 3.3 delineates the regulation of developments and activities within marine turtle habitat. While the matrix of "Do´s and Do Not´s" cites NOM- 162-SENMARNAT-2013 (NOM - federal regulation) and lists sea turtles as endangered species under NOM-059-SEMARNAT-2010, it fails miserably to promote any sort of attempt to implement these regulations or dictate the consequences once these regulations are violated. Therefore, it is unofficially bestowed upon the non-profit organizations to create scientific, objective, and measureable best management practices to safeguard marine turtle nesting with region specific conditions.

Survey Methodology

In order to obtain a fundamental understanding of the morphology of the beach-dune system and determine the response of nesting females to coastal development and climate change, we initiated a study of beach–dune profiles and analyzed nest distribution. Beach width was determined from a fixed reference point using an analog compass to orientate the surveyor perpendicular to the coast at the same angle every time. Beach profiles were recorded using an Abney level at fixed reference points comparing developed areas to non-developed areas. In El Suspiro, a total of five profile transects using the Abney level were monitored monthly from July to October. In San Cristobal, three profile transects were monitored twice in July and in September and beach width was monitored on a monthly basis using a five meter-long rope and analog compass.

In the case of nest distribution, a handheld Garmin GPS unit was used to collect nest coordinates; one GPS was issued to each field station. When biologists left for nightly patrol, nest coordinates were collected before relocation to the corral. The nest was located using a probe and the coordinates were collected from the center of the nest bed. The coordinates were uploaded into excel and transferred to ArcGIS software donated by the University of Baja California Sur. To obtain a baseline data of which to compare our preliminary beach profile data and nest distribution correlations, we calculated

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nest density from 1999 to 2012, where the total number of nests (N_t) recorded including relocated (N_p), in-situ (N_i), and lost (N_r) due to poaching or predators (N_p).

$N_t = N_r + N_i + N_p$

In the case of beach-dune profiles, a premeasured 5m rope was used to calculate the total width of the profile transect in elevation change segments. At distinct elevation change along the profile transect (designated a segment), an Abney level was used 1.5m above the sand surface to sight the horizon. The distance and the angle resulting in the Abney level was recorded for each segment then entered into a software program: Beach Profile Analysis, Version 3.2 (Grey 2000). The beach profiles extended from the edge of coastal dune vegetation to the lowest tide line.

RESULTS

Based on preliminary GPS data analysis, nesting occurs on average 76.6 meters from the highest recorded mean high tide. We used the ArcGIS layer for this tide line provided by SEMARNAT of which ZOFEMAT is a department. This nesting distance average is 56.6 meters outside the federal ZOFEMAT protection zone.

Based on the four beach profile collections, an average of 46 meters eroded from August to November in the 2013 season at El Suspiro, more than 50% outside the ZOFEMAT protection zone. From 2012 - 2013, there were seven named tropical storms that came within 50 meters or less of the coast that significantly affected the morphology of the nesting beach. Temporary lagoons over 2000 m^2 formed along the beach, all near rocky granite points along the beach.

In one of the temporary lagoon areas, in-situ nests that were not lost due to predation were recorded to have an average 90% hatching success rate, even after being completely inundated for more than seven days. A baseline data set of nest density was recorded 12% higher at San Cristobal compared to El Suspiro (figure 16).

Figure 5 illustrates a comparison of nest density between both ASUPMATOMA camps. Monitoring did not begin at El Suspiro until 1999, which explains the absence of data in the graph, however, it is important to note the density of Playa San Cristobal since the beginning in 1995 for comparison.

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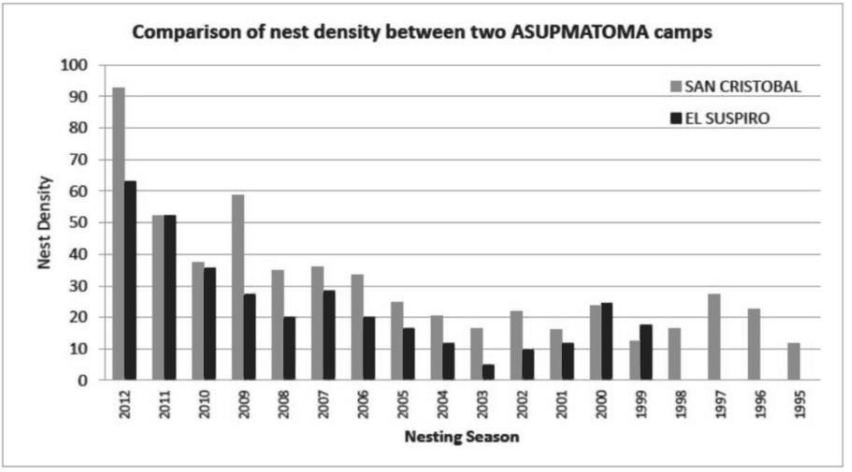

Figure 16. Nest density has steadily increased in Mexico since anti-poaching laws and increased funding for monitoring has been created by the federal government.

CONCLUSION

There were no challenges with collecting nest distribution except for days when batteries failed in the GPS. In contrast, there were many challenges with collecting beach profile data resulting from the dynamics of the Pacific coast. For example, since the sighting hole in the Abney level is very small, strong winds make reading the angle very difficult, given the slightest movement can alter that angle reading significantly.

In addition, the most prominent time to collect profile data is before, during, and after a tropical storm. However, tropical storm season is also during peak nesting season, when a limited number of staff are overworked collecting and monitoring nesting activity to have any time to collect profile data. Furthermore, after a storm, the beach erosion makes it difficult terrain to reach all areas of the beach, especially in areas of granite rock where the beach is washed away and the rock is exposed during low tide, and underwater during high tide. In these scenarios, it is recommended that a team of two students be sent to collect profile data and affix the Abney level to a stationary post that can be inserted into the sand, but easily moved. Also profile data should be collected on non-windy days when possible.

The overall higher nest density resulting at San Cristobal compared to El Suspiro is possibly due to the comparative human disturbance level between

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the two beaches. For example, El Suspiro is only 9km from Cabo San Lucas and the glow of lights from the downtown area can be seen from the tide line, potentially discouraging some females from nesting. Additionally, the construction of Diamante Beach Resort, the vibration and turbulent water from the desalination plant, the presence of shore fishing, and boating may deter females from nesting as well. Comparatively, San Cristobal has low density housing, only one or two houses that have bright lights, and very little human activity, other than our own beach patrols and a few residents.

Due to the combined results; average erosion rate of 46 meters which is more than 2x the ZOFEMAT protection zone, the lower nesting density at the more disturbed beach of El Suspiro, and the average nesting distance of 76.6m from the ZOFEMAT zone, we propose that a set-back distance for construction be legally documented to behind backdunes or 400 meters from the tide line.

We also propose that desalination plant intake and outtake tubes are constructed behind the backdunes so as not to create erosion problems and extend a minimum of 1000 meters into pelagic waters with metal screening to avoid take of marine organisms from suction. An evaluation of currents should also be analyzed before construction of intake and outtake values so as to avoid incidental take of sea turtle hatchlings. Desalination plants should not be constructed in beaches where there is wildlife nesting activity, especially sea turtles and shorebirds. If a desalination plant is to be constructed in nesting beaches, mitigation through large continuous coastal conservation easements should be imposed on the developer to protect adjacent beaches that can accommodate a high density of nests and monitoring programs should be incorporated also paid by the developer.

Developments that are considered for construction in coastal dunes should have at least a five year analysis of sea turtle nesting density and beach profiles to adequately and objectively identify construction zones and stop the use of the ZOFEMAT zone, as it is not a usable tool in the Pacific coast as proven by our results. SEMARNAT should also identify contingency for developers who violate NOM's which protect endangered species or whom ignore or abandon permitting requirements including mitigation.

These proposed recommendations are based on very dynamic beach morphology in combination with previous recommendations combining beach profile, nest density, and nest distribution data and using the observed impacts from our case study, Diamante Beach Resort and Golf course in Cabo Falso, Los Cabos, BCS, México. These recommendations, including the index below are being drafted into a model for conservation tourism created by

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ProFaunaBaja in conjunction with the University of Baja California Sur and peer-reviewed by The Center for Biological Studies of Northwest Mexico (CIBNOR), Solimar International, and the Center for Responsible Sustainable Travel (CREST).

Overtime, we can apply this data to identify high priority conservation areas by using a ranking index. For each 2km^2 of dune-beach, we can address factors of increasing threats, resulting in 10 indices, subtracting areas of rocky coastline within a linear nesting beach. The higher the ranking number, the more risk for habitat loss and population decline and the greater need for monitoring, regulation, and mitigation. A lower number signifies an high priority conservation area which is preferable for placing under conservation easement and use for mitigation purposes. This index will form the basis for making recommendations for safeguarding marine turtle nesting habitat and coastal dune biodiversity for the Pacific region of Baja California Sur where development is proposed approximately a 300 km linear coastline.

Index Category	Count
Dune-Beach Profile: ≤ 10 meters high and 20 meters wide	1
Erosion Rate: ≤ than 20 meters annually	1
Flora and fauna biodiversity greater than 10 species	1
Fishing, horseback and/or ATV tours	1
Known poaching activity	1
Minor infrastructure and/or Zoned Development (≤0.5 acre)	1
Golf Course and or Marina	1
Desalination Plant	1
Large Estate Home	1
Hotel and/or Resort	1
Total points divided by 10 (0.1 – 1)	

Recommendations

1. Given the results from this study, we recommend that all proposed coastal development projects conduct a beach-dune profile analysis for five years preceding construction to determine the appropriate set-back distance during the planning stage. Through the profile data, the maximum sand erosion deficit should be doubled to create a set-back distance for construction. This should be paid through permit fees, not directly by the deveropler to avoid corrupt data reporting.

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2. In order to prevent indirect impacts to marine turtle nesting activity, we recommend that proposed developments obtain nest distribution data for five years from a conservation organization prior to planning to determine areas for mitigation and conservation where high nest density activity is observed. This should be paid through permit fees, not directly by the developer to avoid corrupt data reporting.
3. By calculating the total number of nests, biologists conducting the environmental impact studies should identify areas of more than 15% average nest density to place under conservation and create a buffer of a minimum of 600 meter radius to protect nesting and hatching activity and promote successful nest site selection of females.
4. Coastal dunes should be protected in México from the embryonic dunes to the foredunes levels, limiting infrastructure to a minimum yet, still allowing passage of females to nest sites in the vegetated coastal dunes and to prevent the beach squeeze effect.
5. Additional studies of coastal dune biodiversity through 30 meter transects are recommended during the five years preceding construction to determine areas of high biodiversity and presence of protected flora and fauna. Coastal dune protection will ensure coastal protection of inland infrastructure, protection of tourism economy, and safeguard nesting habitat which allows for a high threshold of changes in morphology from climate change.

FUTURE STUDIES

To better understand response to climate change in nesting activity, we recommend that an analysis of nesting activity with abiotic factors such as wind velocity, sand temperature, storm frequency, and ocean currents be monitored. A continuation of beach-dune profiles correlated with nest distribution should be administered to evaluate the temporal response of nesting females to changes in beach morphology. It is possible that by analyzing nest activity with these abiotic factors, nest site selection by female turtles can help scientists predict possible shifts in coastal processes due to climate change effects and better make decisions in terms of regional planning and coastline protection for existing communities and thus prevent economic loss from costly restoration practices.

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Chapter 5

"SEA TURTLE PROTECTION NETWORK": AN INDICATOR FOR TOURIST AND ENVIRONMENTAL SUSTAINABILITY AT LOS CABOS, B.C.S.-MÉXICO

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ABSTRACT

The tourist potential of a community and its sustainability is linked to personal background and their participation on social, cultural and economic surroundings. It is also related to the management of their natural resources that support the viability on the long term of the touristic activities. Caring about our heritage strengthens our identity to promote the touristic culture in the region. It is under these assumptions that the municipality of Los Cabos (H. Ayuntamiento de Los Cabos) in Baja California Sur, throughout the Sea Turtle Protection Program started a close collaboration with tourist operators in the region to structure the "SEA TURTLE PROTECTION NETWORK".

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This chapter explores the continuous development of the "Network for the protection of sea turtles" over the past 10 years. The main goals of the network were: 1) training of security and management personnel from the hotels interested on being part of the network; 2) to protect nesting females and their nest; 3) to facilitate the interaction of academics and private sector with local and federal government responsible for the management of this natural resource and the habitats that it uses.

The Sea Turtle Protection Network work under the structure of a Municipal Committee, that is conformed by locals in representation of the community that meet on regular basis. Its members are recognized by environmental authorities as participants of activities otherwise only performed by the federal government. After more than 10 years, the network is protecting 76.6 km of beaches for the use of sea turtles and many other species, more than twice the coastline that was protected (25 km) which represents 84.08% of the protected beaches in collaboration with the municipality. A total of 71 workshops have resulted in the training of 1,879 individuals on techniques for the management and protection of sea turtles. We count with representatives of 50 companies. The joint effort of government, private sector and society have resulted in the protection of 7,220 nests in the last 10 years, with more than half a million of hatchlings. Another important set of activities are related to science, public awareness and the treatment of injured sea turtles, some of them have been successfully returned to the ocean.

The network has collaborated with authorities to prosecute poachers in possession of turtles and their products. There is a local group from tourist operators trained on management and conservation of sea turtle conservation to national and international standards, resulting on a worldwide recognition of these conservation efforts.

INTRODUCTION

Sea turtle fishing was a very important economic activity in Mexico; everything in a sea turtle can be transformed in goods for commercial purposes: their meat, eggs, skin, oil and carapace. The irrational levels of exploitation occurred between the 60's and 70's, compromising the survival of species that have been present in the planet for more than 200 million years, in addition to fisheries, the modification of nesting beaches for inadequate tourist development, pollution, and incidental by-catch and poaching, work against sea turtle conservation.

After the sustained commercial fishery of sea turtles and the intense poaching of turtle eggs at the nesting grounds worldwide, one by one the

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populations of sea turtles decreased and put on risk the survival of the various species. As a consequence, the natural history of sea turtles got modified, and a program for the conservation and protection was implemented in Mexico. Some of the actions were: a) the installation in the 60's of camps at nesting beaches for the conservation and study of that section of the population; b) laws and rules for the protection of sea turtles and their nesting grounds, the mosts importants ones are the Protection of Nesting Grounds (DOF –Diario Oficial de la Federación- January 8th 1986 "Proteccion de Zonas de Anidacion y Desove"); a total ban on consumption and possession eggs, meat or skin for all the species and subspecies of sea turtles (DOF May 31st 1990). Another management measure was the Mexican decree NOM-002PESC-1996 for the use of Turtle Excluder Devices (TED) for the shrimp trolling nets (DOF, 1996). Now-a-day, the NOM-059-ECOL-2010 (DOF, 2010), places all 7 species of sea turtles present in Mexico, olive ridley (*Lepidochelys olivacea),* kemps ridley (*Lepidochelys kempii*), leatherback (*Dermochelys coriacea*), black sea turtle or Western Pacific green sea turtle (*Chelonia agassizii*)[1], green sea turtle (*Chelonia mydas*), hawksbill (*Eretmochelys imbricata*) and loggerhead (*Caretta caretta*), as "threatened for extinction". Finally, the decree in 2013 of NOM-162-SEMARNAT-2012 for the protection, recovery and management of sea turtle populations and their nesting grounds was published.

Baja California Sur (B.C.S.) provides feeding and nesting grounds for five of the seven species of sea turtles reported for Mexico (Olguín, 1990; INE, 2000). There are reports of important feeding grounds in the B.C.S. for loggerheads or caguama (*Caretta caretta*), the black sea turtle or Western Pacific green sea turtle (*Chelonia agassizii*)[1] and hawksbill (*Eretmochelys imbricata*). Additionally, the coast of the state provides important nesting areas for olive ridley (*Lepidochelys olivacea*), leatherback (*Dermochelys coriacea*) and black sea turtle or Western Pacific green sea turtle (*Chelonia agassizii*) (Clifton et al. 1995; Márquez 1996; Briseño 2003; Tiburcio et al. 2004a; Tiburcio et al.

[1] The name and systematic of the black sea turtle or Western Pacific green sea turtle, referred as Chelonia agassizii or Ch. mydas agassizii by some authors, is still under discussion. The "Secretaria de Medio Ambiente y Recursos Naturales" (SEMARNAT) recognizes the black sea turtle as a valid species, named Chelonia agassizii, setting the number of sea turtles in Mexico on seven (INE, 2000); nevertheless some authors still consider it as a subspecies of Chelonia mydas. In consideration of this debate, we will refer to the black sea turtle as the Western Pacific Green sea turtle, Chelonia agassizii or Chelonia mydas agassizii.

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2009 and Tiburcio et al. 2010), with the highest occurrence of nesting happening in the 180 km coast line of Los Cabos' municipality (Márquez et al. 1982; Olguín 1990; Nichols 1999).

In the 70's, the commercial fishing of sea turtles in Baja California Sur, reached the highest levels, as the rest of Mexico, that brought sea turtles populations in the country near to extinction. In addition to the fragile biological situation of the sea turtles, touristic development in Los Cabos towards the end of the 70's and beginning of the 80's triggered the transformation of the nesting beaches in the southern end of the Peninsula. This development also included the migration of people from mainland with a strong tradition on turtle egg consumption that previously was a rare occurrence in the state. This increased the level of pressure over the sea turtles in the region compromising furthermore their survival.

Even tough sea turtle conservation started in Mexico in the 60's, the effort to revert the decrease tendency on sea turtles populations from B.C.S. is relatively recent on the history of sea turtle conservation in Mexico. There was some research conducted since 1960; but it is until the 90's, nearly 30 years after, that the first research studies were conducted in Baja California Sur for sea turtle protection. In 1994, the South Baja California Asociation for the Protection of Sea Turtles and Environment in Los Cabos A.C. (ASUPMATOMA because of the Spanish acronym) established the first camp for the protection of nesting olive ridleys and leatherbacks at San Cristobal beach, 4.5 km long. In this way, Los Cabos municipality became a pioneer in the protection of sea turtle nests in the BCS State (Tiburcio 2012) (Figure 1).

It is until 2000 that reports of nesting activities on beaches at San Jose del Cabo, BCS and the problems detected that affected the nesting populations of sea turtles pushed the local government from Los Cabos to start the Program for the Protection of Sea Turtles, run by the Direction for Ecology and Environment. It started with the establishment of the first camp for the protection of nesting turtles, named Don Manuel Orantes that oversees 12 km of beach. This first year, there were reports of more than 50 nest of leatherback (*Dermochelys coriaciea*) surprising locals and people in general. In the nesting season of 2000-2001 the camp was able to help hatching eggs from this species, a big success for Baja California Sur because the low beach temperatures generally prevent their development. Also there were about 400 nest of olive's ridley (*Lepidochelys olivacea*) protected during the first years, this number has been steadily increasing over the years.

Later on, there were also the first reports for the state of Black Sea turtles (*Chelonia* agassizii) nesting in the area (Tiburcio et al. 2004a).

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Figure 1. Los Cabos Municipality, Baja California Sur.

It was previously believed that this species came only to feed in the region that is why this discovery was very important. During the first three years, Don Manuel Orantes camp was consolidated, increasing to 32 km in the year 2001 the protected coastline and the number of nests reported by the community, increasing every year, which required assistance to protect the nests and the females. This was a clear evidence of the achievements of awareness actions.

Before this situation and with only 3 staff working for the Sea Turtle Protection Program at the camp, the idea that additional help was needed become evident to increase the length of the protected area and the increase of the calls from the community asking for support to protect the nests and the females.

Touristic potential of a community and its sustainability are linked to community involvement, background formation, culture, economy and social participation, but more important to the management of the natural heritage to

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ensure the long-term viability of this sector's activity. On the other hand, the protection of the heritage strengths the identity and connection of the community and promotes the touristic attraction of the region. In 2003, the idea to create the network with the participation of the private sector, mainly Hotels, in the conservation of sea turtle started; the idea was to support its work with scientific information, to follow current legislation and to train participants, all in coordination with the different levels of government.

This is how the third of six conservation lines was defined for the Sea Turtle Protection Program in Los Cabos Municipality, listed below:

- Surveillance and protection of both females and nest (Don Manuel Orantes sea turtle nesting camp)
- Culture and Scientific communication to achieve Environmental Sustainability
- *Community involvement (Sea Turtle Protection Network)*
- Research
- Bird Protection
- Tourism as an strategy for conservation

"SEA TURTLE PROTECTION NETWORK"

The encounter between the development and the coastal areas in the Municipality of Los Cabos, B.C.S. has resulted in the transformation and degradation of the beaches due to the increase of buildings and hotels. Sea turtles are one of the most affected species since man-made structures block the way to nesting females, compact the sand, and modify natural sand movement, affecting the life cycle of the different species. Additionally, the use of the beach to install tables, umbrellas, for recreational uses such as ball games, fire pits, parties and the constant traffic of tourist, increase habitat lost for nesting, nest destruction and newborn deaths. In summary, unplanned coastal development, tourism mainly, can be detrimental for sea turtle nesting grounds and their populations. Ironically, sea turtles are highly appreciated as touristic attraction both by local and international travellers; this is why designing of hotels that are environmentally friendly, sustainable and that follow environmental regulation need to be promoted.

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It is important to note that there are tourist destinations in Mexico where the private sector (tourist operators) are responsible for sea turtle’s conservation efforts. They install hatcheries or other strategies to increase survival, but that at the same time attract tourist to their establishments. Nevertheless, many of them are not based on scientific information and are not connected to other conservation efforts, which result on different methods to collect information. This creates problems to share information with consequences on the group’s goal of conservation for the nesting areas.

The success of a conservation program is measured in terms of mitigation of anthropogenic origin, number of community members that participate to solve environmental problems and understanding the origin of them, their magnitude, consequences and actions that they need to take to decrease, stop or solve some of the impacts to sea turtle nesting grounds. Unfortunately, most conservation programs do not achieve their goals because they are mostly short term and do not include all sectors. Most of the time they only consider some scientist, small groups or NGOs dedicated to conservation activities with an environmentalist focus, mainly due to current tendencies, love for nature or to get some economic benefits. On the other hand there is no standardized methodology to collect scientific data to allow a deeper understanding of sea turtle populations and their threats, at the same time that sustains scientifically specific conservation actions for the different areas. It has become an additional threat to sea turtles the establishment of conservation programs without scientifically designed methodologies, inadequate management practices and protection goals other than the well being of the sea turtles.

Considering the problems described previously and the interest of the hotels for the conservation of sea turtles, the local government at Los Cabos, Baja California Sur, Mexico proposed the creation of the “Hotel’s Sea Turtle Protection Network at Los Cabos’ Touristic Corredor” of 32 km of length, under the umbrella of the government Program for the Protection of Sea Turtles. There was still some apprehension of the initiative, hotel operators believed that they were going to be asked for money and federal agencies believed hoteliers will use the conservation wrongly, a common problem in other regions. The network has adapted over the time to changes on legislation, the length of protected beaches to 76.36 km, and the variety of participants (hotels, marinas, condos, veterinarians, NGOs, research institutions, government agencies, etc.). It is officially known as "Red para la Protección de la Tortuga Marina en el Municipio de Los Cabos" or “LA RED” (*the network*), with a logo that depicts sea turtles and Cabo San Lucas rocky arch, both considered as natural heritage of Los Cabos municipality (Figure 2).

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The main goal is to include all the private sector (mostly hotels) to participate voluntarily to address some of the problems that endangered the survival of the sea turtle species in the region.

Figure 2. Logo for the "Sea Turtle Protection Network at Los Cabos Municipality". Also known as "La Red" (*the network*).

Actions and activities must be supported by scientific information and the work needs to be in collaboration of federal and local authorities.

Therefore, this project has a strong legal framework, includes all different community sectors, and has a good working relation with the three levels of government and strong scientific bases.

THE COMPLEXITY OF THE RELATIONS THAT INTEGRATE THE PROTECTION NETWORK

After we presented the idea of integrating a network and its goals, the Committee of Security Managers from the Hotels in Los Cabos adopted the program, because they considered that the actions to protect sea turtles were a need within their responsibilities, since there were already many reports of guests on encounters with sea turtles that they were not sure how to address.

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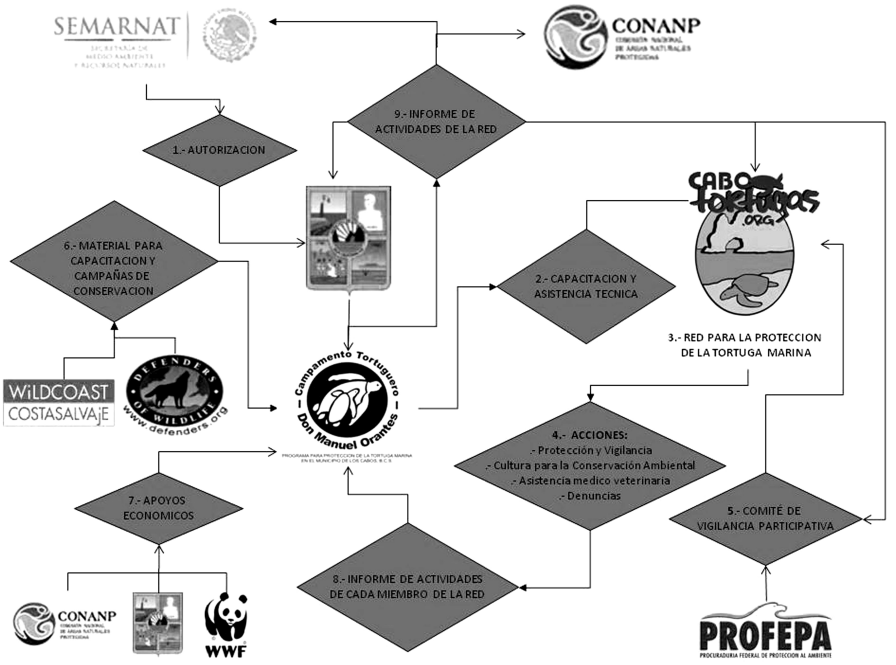

Source: Tiburcio et al. 2004b and Tiburcio et al. 2006**.**

Figure 3. Diagram of the structure of the "Network for the protection of sea turtles" in Los Cabos municipality.

The members that work on the field need to be trained for the different activities and data collection for the conservation of these species, but a basic operational structure is always in place and it works as follows: (Figure 3).

The Mexican legislation indicates that people interested on working for the management and conservation of sea turtles must have permits that follow up regulations.

1. The Mexican agency responsible to issue research permits is the Environment and Natural Resources Administration (Secretaria de Medio Ambiente y Recursos Naturales, SEMARNAT) supported by the Wild Life General Management (Dirección General de Vida Silvestre). This permits follow the *Management Plan for Sea Turtles Conservation for Los Cabos municipality*; consequently the local government has to work on six main research areas and activities for conservation as follows:

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- Patrolling and surveillance of nesting females and nests ("Don Manuel Orantes" sea turtle nesting camp)
- Culture and Science divulgation for the environmental sustainability
- Community Involvement (Sea Turtle Protection Network)
- Research
- Birds protection
- Tourism as a conservation strategy

In this way the Sea Turtle Protection Program run by the local government is responsible for the work conducted at the Network through the Don Manuel Orantes turtle camp

2. Technical Assistance and Training. Considering the importance of scientific information to ensure a proper management and implementation of sea turtle conservation actions, the Network for sea turtle conservation has implemented on regular basis a series of workshops on sea turtle conservation and management for the participants on the network. Workshops are the responsibility of the Don Manuel Orantes camp. Participants are trained on data collection to make sure all information is collected under a similar protocol. Instructors will keep constant contact with the participants and will provide technical support when needed.

3. In 2006, the Federal Agency for the Protection of the Environment (PROFEPA, acronym in Spanish) recognized the legal identity of the network, it was recognized as a SURVEILLANCE COMMITTEE (COMITÉ DE VIGILANCIA PARTICIPATIVA RED PARA LA PROTECCIÓN DE TORTUGAS MARINAS)", giving its members an official identification to perform some surveillance activities that were previously restricted to just government officials. PROFEPA trains the participants before they get certified, gives support on surveillance and follows up on reports by the network.

4. The members of the Network for sea turtle conservation have different activities, some of the most important are:

- Protection of sea turtles, their nest and the nesting areas
- Development of an Environmental Conservation Culture (Education and Broadcasting)
- Medical assistance from qualified veterinarians for sea turtles and marine mammals
- Inspection and Denounces

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5. The Sea Turtle Protection Network is created since 2010 as a Municipal Committee and is integrated by different community sectors represented by a board. It is important to highlight that the Chair to the board, the representative from the Hotel's Association and the Representative for the International Community positions are elected by direct vote by all the members of the Network. There is a set of rules for the internal operation that includes at least two meetings a year (Figure 4).

Figure 4. Formal meeting (Sesion Ordinaria) of the committee for the Network for the conservation of sea turtles in Los Cabos municipality. Credit: Programa para Protección de la Tortuga Marina del Municipio de Los Cabos, BCS.

The incorporation of new members to the sea turtle's conservation network, need to be approved by the board, that will be evaluated case by case, since members should not have any legal active environmental procedures, especially those related to sea turtles. After the incorporation of a new member, the company will name a representative that will participate at the meetings and serve as liaison and contact person for any information related to the network.

The Network operates in Los Cabos Municipality under a management plan presented and authorized by SEMARNAT and that follows the

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specifications of the Mexican Official Regulations (Norma Oficial Mexicana) NOM-162-SEMARNAT-2013, which was instituted for the protection, recuperation and management of the sea turtle's populations at their nesting grounds. The Network has regional coordinators to fulfill its conservation goals that are responsible for all the required activities.

6. Los Cabos Municipality throughout the Program for the Protection of the Sea Turtles fund raises resources with private associations and government agencies to conduct communication campaigns and to produce scientific outreach materials that can be used for training.

7. The Protection Program for Sea Turtles run by the municipality gets economic funds from the local government in Los Cabos and other foundations to conduct training workshops on selected topics by experts, for the production of outreach materials and fieldwork materials. Nevertheless, network members cover most of the operational cost.

8. Every network member presents a partial report in November and a final report in January.

9. The Program for the protection of sea turtles compiles the information and presents a partial report at the end of November and a final in May for SEMARNAT and the different authorities from the federal and local governments.

TRAINING: ESSENTIAL GROUND TO DEVELOP CONSERVATION ACTIONS

Conducting conservation actions require more than just love for nature. If actions were conducted without scientific advice and not following legislation it could can result on problems with authorities and fines, and even worst, on actions that may affect even further on the species or ecosystem that we are trying to help.

The Network has implemented a series of workshops for employees at the different companies to address the problem described above. Personnel at the Don Manuel Orantes camp conduct regular workshops on conservation and management to train participants at national and international standards not only for sea turtles but also other species. In addition, PROFEPA and experts from other institutions also conduct workshops on specialized topics.

Interdisciplinary knowledge exchange take place, specially that related to environmental legislation, biological information and strategies for the

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conservation of sea turtles and their habitat, taking in consideration their priority status and how emblematic they are of the biological diversity in our country; at the responsible handling practices and the conservation of the beaches with touristic development.

Workshops are run following this format:

- The success of a training program is mainly a result of the level of interest by participants. Goals can be achieved if participants can be *motivated/stimulated* and captivated by the topic to increase their participation towards the final objectives. (Figure 5). Their interests need to be identified, and it is priority to use "shock" activities so their "to-do" desires can be awakened. Some of the activities that are implemented during the workshops are:

  a) Integration activities to motivate teamwork spirit between participants.
  b) Activities to inform and stimulate stakeholders in relation to environmental problems.
  c) Learn to recognize the actions that their classmates are conducting.

Figure 5. Integrational and stimulation activities about environmental problems that affect sea turtles. Credit: Programa para Protección de la Tortuga Marina del Municipio de Los Cabos, BCS.

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- After participants demonstrate their concern in relation to the environmental problems, an activity to *reinforce their knowledge* and acquire facilitation techniques is conducted. Videos are observed, fieldwork is conducted, and classes are taught, in addition to chats and games that facilitate learning. At the end of workshops, participants get materials with references in relation to classes, guides, books and posters for future consultation to prepare cultural activities related to environmental conservation, such as education and outreach (Figure 6 and 7). In the other hand, there are other activities conducted throughout the year to acquire new knowledge and reinforce the learned information such as:

  a) Conferences on specific topics by experts
  b) Workshops to reinforce the knowledge on specific topics.

Later is worked on *criticism and reflexion*; that takes participants to value the reasoning behind the acquired knowledge, provoke the questioning of what they just learned, thus promoting value acquisition in participants or, at least, to have a critical thinking towards reality.

Figure 6. People implementing the learned techniques on the field. Credit: Programa para Protección de la Tortuga Marina del Municipio de Los Cabos, BCS.

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Figure 7. Use of sea turtle id guides to identify the different species. Credit: Programa para Protección de la Tortuga Marina del Municipio de Los Cabos, BCS.

We have schedule periods of time for participants to work individually or collectively on reflexing, debate, decision-making, and also thinking about their opinion in relation to current environmental affairs and their own future behavior (Figure 8).

- *Action* to mitigate problems and *communicate* learned lessons to other people. A training program will miss its goals if there is no change on the environment or community. Therefore, and to conclude, the final critic and reflexion results are recorded as proposed *conservation actions* from the participants to the rest of the classmates, facilitating the *communication* of its own ideas between the participants in relation to specific topics.

The mentioned actions aim to:

- Create awareness and promote the conservation of the natural heritage in our region
- Develop new habits and behaviors towards the environment
- Increase local participation for the solution of current and future environmental problems, by understanding their origin, magnitude, consequences and the needed actions to mitigate them with the aim to reach environmental, economical and social sustainability in the region.

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Figure 8. Collective work by participants to express current problems and their future actions. Credit: Programa para Protección de la Tortuga Marina del Municipio de Los Cabos, BCS.

These actions will incorporate a new generation that works actively within the community for the conservation of sea turtles.

AN INDICATOR OF TOURISM AND ENVIERONMENTAL SUSTAINABILITY AT LOS CABOS, B.C.S. DESTINATION

After 10 years of the creation of the network (2003-2013) that patrolled and protected on 32 km of coast at the beginning, by 2013 the total protected coastline increased to 76.36 km that were divided in 8 regions.

Hotels and private companies protect and patrol approximately 42.42% of the 180 km of coastline that belong to Los Cabos municipality (Table 1).This level of protection is reached thanks to the participation of the companies that participate on conservation of sea turtles.

It started with only 18 hotels in 2003, but by 2013 there was also 50 community representatives, which reflects the increased interest and participation.

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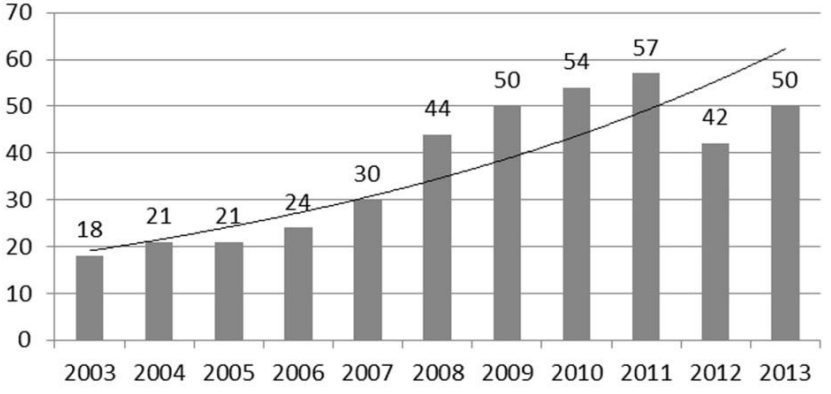
Table 1. Regions in which the network is divided and the areas covered by regions

Region	Responsible	Covered area (km)
Pacific	Hotel Pueblo Bonito Sunset Beach	5.56
Finisterra	Hotel Playa Grande and Finisterra	2
Cabo del Sol	Hotel Sheraton	2
Bahía de Cabo San Lucas	Hotel Casa Dorada	6
Corredor Turístico	Hotel Hilton	25
San José del Cabo	Baja Properties	6
La Ribera	Marina Cabo Ribiera	24.3
Migriño	Rancho Las Margaritas	5.5
TOTAL		76.36

Source: Tiburcio et al. 2012 and H. XI Ayuntamiento de Los Cabos, BCS, 2014.

There was a slight decrease in 2012 as a consequence of the changes on regulation, nevertheless for the following year the positive tendency returned once the new rules were included for the implementation of activities. (Figure 9 and Table 2).



Source: Tiburcio et al. 2013 and Tiburcio 2014.

Figure 9. Participation in the Sea Turtle Protection Network over the past 10 years.

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Table 2. List of committee members for the Sea Turtle Protection Network that participated in 2013

1	Bomberos Cabo San Lucas	23	Hotel Holiday
2	Cabo Dolphin	24	Hotel Pueblo Bonito Blanco
3	Cabo Hacienda	25	Hotel Pueblo Bonito Pacifica
4	Cabo Riviera	26	Hotel Pueblo Bonito Rose
5	Cabo Villas Beach Resort	27	Hotel Pueblo Bonito Sunset
6	Campo de Golf el Dorado	28	Hotel Royal Solaris
7	Casa del Mar	29	Hotel Sheraton
8	Casa del mar Condominios	30	Hotel Solmar
9	Condominios La Jolla	31	Tortuga Bay Luxury Condominiums
10	Diamante Cabo San Lucas	32	Hotel Villas del Palmar
11	Hotel Cabo Azul	33	Ventanas al Paraiso
12	Hotel Cabo Hacienda	34	Los Cabos Animal Center
13	Hotel Cabo Villas	35	One and Only Palmilla
14	Hotel Casa Dorada	36	Programa Municipal de Prot. de la Tortuga marina
15	Hotel Coral Baja	37	Protección Civil Cabo San Lucas
16	Hotel Dreams	38	Pueblo Bonito Cotur
17	Hotel Finisterra	39	Puerto Los Cabos
18	Hotel Hilton	40	Villas del Arco
19	Las Mañanitas Condominiums	41	Hyatt Ziva
20	Hotel Secrets Marquis Los Cabos	42	Del Mar Development
21	Hotel Melia	43	Hotel Grand Solmar
22	Hotel Playa Grande		

Source: Tiburcio, 2014.

After 10 years of nonstop work, a total of 71 workshops on the management and conservation of sea turtles have been conducted, resulting in 1,879 trained people (Table 3 and Figure 10).

Additionally to the workshops on management and conservation, there is an average of two workshops by year on selected topics. The most important ones over the last 10 years have been:

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Table 3. Number of people that participated on training workshops in the past 10 years

Year	Number of workshops	Number of participants
2003	6	129
2004	7	209
2005	5	124
2006	5	124
2007	7	207
2008	7	210
2009|	8	169
2010	6	130
2011	7	240
2012	6	97
2013	7	240
TOTAL	**71**	**1,879**

Source: Tiburcio, 2014.

Figure 10. Trained personnel on the management and conservation of sea turtles. Credit: Programa para Protección de la Tortuga Marina del Municipio de Los Cabos, BCS.

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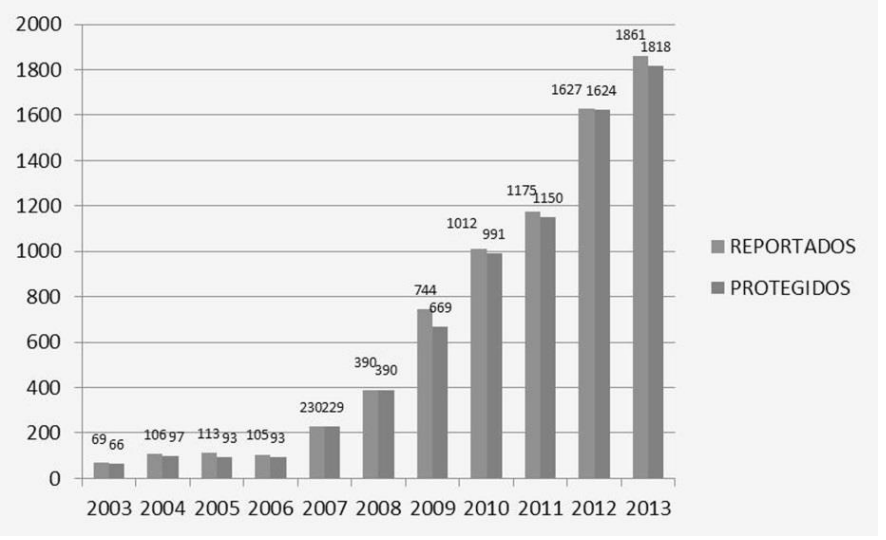
- Environmental Legislation focused on wildlife.
- Best Practices for management and conservation of sea turtles arriving at beaches with touristic development.
- Rescue, Diagnosis and Rehabilitation of sea turtles.
- The legislation included in the NOM-162-SEMARNAT-2012
- Light regulation at sea turtles' nesting areas.

Training and participation of personnel during the past 10 years has resulted on the recording of 7,432 olive ridley's nest, from these 7,220 (97.14%) were successfully protected at beaches monitored by network members (Figure 11 and Figure 12).

Actions to protect nests have resulted on the hatching and release to the sea of 554,265 newborns of Olive Ridley's sea turtles (Figure 13)

The number increase of protected nests is an indicator of the success of workshops. It also highlights the importance of community participation for the protection and conservation of natural resources.



Source: Tiburcio, et al. 2013 and Tiburcio, 2014.

Figure 11. Report and sea turtle's nest protection for a period of 10 years.

A higher participation of properly trained community members results both on an increased number of protected nests and length of the patrolled coastal line (do not confuse the increased number of nests, due to a larger coverage as a result of conservation efforts, with an increase of the sea turtle

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population). It is important to highlight that even tough the number of participants decreased in 2012; the number of protected nest was the same thanks to the effort of the 42 people that participated on that nesting season (Figure 14, 15 and 16).

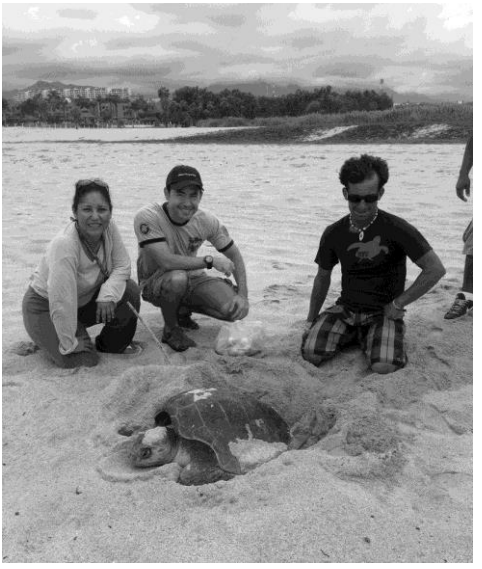
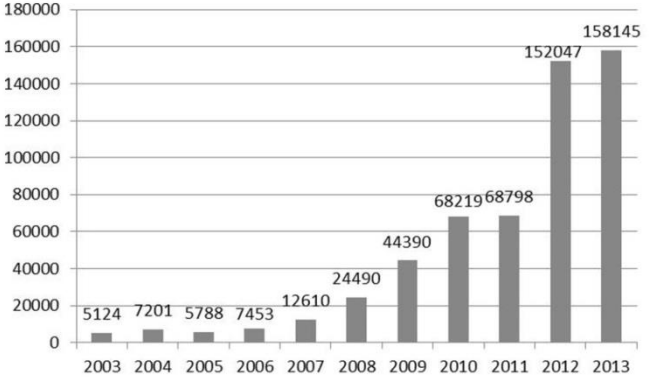


Figure 12. Sea turtle protected by personnel of the Network in collaboration with municipality agents responsible for sea turtle protection. Credit: Programa para Protección de la Tortuga Marina del Municipio de Los Cabos, BCS.



Source: Tiburcio et al. 2013 and Tiburcio 2014.

Figure 13. A total of 554,265 newborn sea turtles have been released after 10 years of work.

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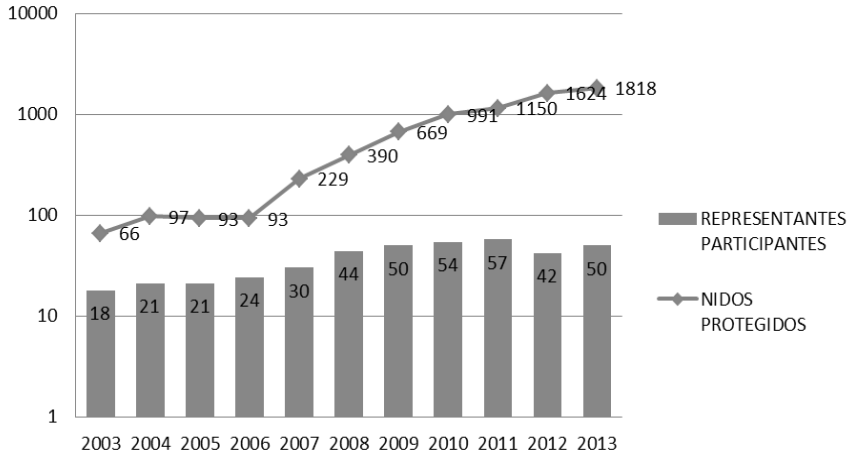

Source: Tiburcio et al. 2013 and Tiburcio 2014.

Figure 14. Relation on the increase of network's participants and a positive increase in the number of nests reported over the past 10 years.

Figure 15. Nest protected at the beach in front of Hotel Playa Grande. Credit: Red para Protección de la Tortuga Marina del Municipio de Los Cabos, BCS.

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Figure 16. Protection of a nest by hotel's security members. Credit: Programa para Protección de la Tortuga Marina del Municipio de Los Cabos, BCS.

As a result of the surveillance efforts implemented in the region, four turtle egg poachers and four people in possession of sea turtles have been put in jail. We have been able to recover two death sea turtles and four organisms that were still alive and were set free in the ocean.

There are also activities to promote awareness within the hotel guests, these activities include hatchlings release (Figure 17 and 18), environmental education campaign aimed for the collaborators and their relatives; another strategy includes the treatment of injured turtles and marine animals by veterinarians and Turtle Network participants, it is important to mention that

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the hotels lend their infrastructure for the recovery of some of these organisms (Figure 19).

In the other hand, some hotels are sponsoring scientific research by donating satellite tags for sea turtles like a Hilton and Esperanza Hotels, providing funds for outreach materials and the production of videos, guides, posters, t-shirts, etc. All these activities are organized by the Municipality Program's Coordination for the Protection of Sea Turtle and with the participation of NGOs such as Consultura Cultural Estrella Azul, Wildcoast, Defenders of Wildlife and WWF.

Figure 17. Environmental talks to create awareness on sea turtle conservation by security elements of Las Mañanitas' Condos. Credit: Red para Protección de la Tortuga Marina del Municipio de Los Cabos, BCS/Condominios Las Mañanitas.

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Figure 18. Hatchlings sea turtles being released by tourists from La Laguna condos. Credit: Programa para Protección de la Tortuga Marina del Municipio de Los Cabos, BCS.

Figure 19. Rescue and care to an injured sea turtle provided by security elements from the Hotel Westin Regina. Credit: Red para Protección de la Tortuga Marina del Municipio de Los Cabos, BCS/Hotel Westin Regina.

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Tourist operators from the hotels have voluntarily proposed and adopted the following management strategies towards a responsible use of sea turtles as a touristic attraction:

- *In situ* nest protection.
- Reduction of excessive artificial light.
- Communicate environmental activities and education to guest and workers as a strategy to reinforce sea turtle protection.
- Promote appropriated behavioral codes on the areas to protect the reproductive cycle of the nesting species.
- Protection of nesting areas with significant nesting activity.
- Removal of sunbeds and umbrellas from areas with nesting activity.
- Avoid vehicles on the beach.
- Maintain to the minimal hatchling manipulation by avoiding their retention, all hatchlings are released right away. Release with the participation of tourist is only the responsibility of a trained staff from the hotel.
- Outreach campaigns to increase public awareness on environmental conservation focused to hotel's staff, as an alternative to reinforce sea turtle conservation by reducing consumption (Figure 20).
- Creation of a manual that includes some of the points previously mentioned.
- Create a georeferenced map of the nesting beaches under the supervision of hotels. The map will be shared at national and international level.
- The establishment of sea turtles as natural heritage to promote tourism.

Hotels present a high personnel turnover but managers have identified the need of maintaining a training program for new personnel at all times. This has been promoted by new personnel that has already been trained, which also results in the incorporation of new hotels to the Network but also a continue interest by current members.

Some unexpected benefits from these activities are:

- Room occupation is linked to some degree to those days when hatching is expected or during turtle nesting, consolidating sea turtle observation as an attraction, this has also resulted in the production of

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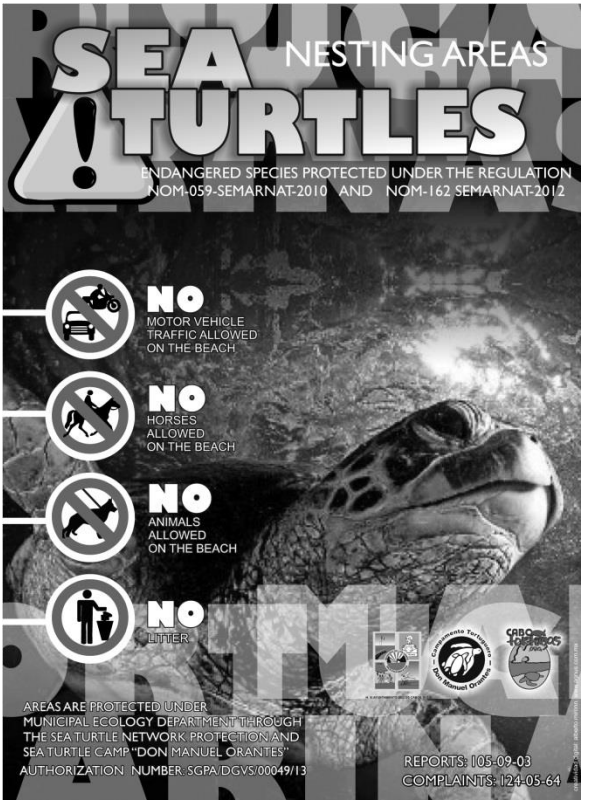
various items with turtle images such as t-shirts, glasses, key rings, etc. Some hotels have also adopted turtle designs on their logos, uniforms, art and complex design (Figure 21).

- Fulfillment of regulation on "Manifestaciones de Impacto Ambiental" (Environmental Impact Assessments) that required sea turtle protection but was not put into practice.
- Compliance of requirements to obtain green and environmentally friendly certificates.
- Added value to hotel attractions by including sea turtle as Los Cabos' natural heritage.
- Higher satisfaction for tourist during their visit.
- Recurrent visits by guests that want to experience sea turtle interactions in subsequent years.



Source: Tiburcio, 2014.

Figure 20. Campaigns for the Protection of Sea Turtles promoted by hotel operators.

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Figure 21. Towel sculptures of sea turtles exhibited by the swimming pools at the Hotel Holliday Inn. Credit: Red para Protección de la Tortuga Marina del Municipio de Los Cabos, BCS/Hotel Holliday Inn.

The same model implemented by the Network was implemented for the protection of the "Gallito Marino" / Least Tern (*Sterna antillarum*), a bird under special protection that nest on the coast of Los Cabos, just in front of several hotels. Since 2012, the Program for the Protection of Sea Turtles included on their training program topics for the management, protection and knowledge of the "gallito marino", this has resulted in the protection of nesting colonies that are detected in the area (Figure 22).

The nesting camp Don Manuel Orantes covers 75 km (approximately 41.66% of beaches at Los Cabos) has been complemented by the efforts of the Sea Turtle Protection Network that increased the total protected beach on 76.36 km (42.42%) with hotel operators and private companies' participation.

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Source: Tiburcio, 2014.

Figure 22. Campaign for the protection of the "Gallito Marino" promoted by the hotel operators.

These joint efforts have resulted on the protection of 151.36 km, 84.08 % of the total beaches at Los Cabos region.

These actions have contributed to the increase of olive ridley's populations (*Lepidochelys olivacea)* that shows a positive response to the implemented recovery actions. The black sea turtle (*Chelonia agassizii* or *Chelonia mydas agassizii*) also show some positive population trends. On the other hand the leatherback *(Dermochelys coriacea)* continues with a negative trend for the Western Pacific. Another strategy is the use of the charismatic personality of sea turtles that in addition to the conservation actions has transformed Los Cabos in one of the top touristic destinations in Mexico. Sea turtles are one of the main attractions for naturalist, a niche that has not been completely exploited but that has the interest for the development of the sector (Tiburcio, 2012 and 2014).

Los Cabos has an unusual involvement of the different community sectors as a result of the different conservation actions, and the *Sea Turtle Protection Network* is a major result. This network, besides the protection of nests and nesting females, is also conducting research by satellite tracking of sea turtles (Figure 23) (Red, 2009 and Sanders et al. 2011).

Some other adopted strategies for the protection of the nesting grounds is the decrease of artificial light emissions, protection of the most important nesting areas, dunes, "gallito marino", outreach to tourist and collaborators by the implementation of environmental education to reinforce knowledge and

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contribute to sea turtle protection. Appropriate conduct codes are also promoted for the benefit of sea turtles and their life cycle.

The major result is the creation of a group of local tourist operators that are trained to national and international standards on the management and conservation of sea turtles and their nesting habitat.

The sea turtle conservation efforts implemented by the network have been recognized by different institutions during the many years of its operation, the most significant one was the "Recognition to Nature Conservation (*Reconocimiento a la Conservación de la Naturaleza*) by the CONANP (Comisión Nacional de Áreas Naturales Protegidas) in 2008, a the most valued recognition by the Mexican federal government.

Figure 23. Tagging and release of "Marisol" to be followed by satellite technology. Tag was sponsored by the Hilton Hotel. Credit: Programa para Protección de la Tortuga Marina del Municipio de Los Cabos, BCS.

CONCLUSION

Sea turtle conservation efforts increased in the last decades as has been demonstrated along the present chapter, the increased awareness and

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understanding of the importance and relation of the human population of Los Cabos with sea turtle permitted the implementation of conservation and management plans that are both realistic and efficient.

There is still a big gap of knowledge about sea turtles in the region, especially within the local community and even authorities, and it is essential to establish permanent training programs to improve local knowledge. It is also important to inform the local community so they can contribute and participate on decision making by pressing on their representatives into taking appropriated measures.

Tourists are currently increasing the problems of environmental degradation and it is evident that educational programs for visitors and locals are a priority (Eckert et al. 1992). Conservation of sea turtles will only be achieved if tourist operators, visitors and the local communities are trained and educated in relation to the management and biology of the different species, this includes nesting and hatching patterns of sea turtles.

Nesting habitats and feeding grounds are essential for the survival of sea turtles. Their conservation in Mexico needs to be approached with a holistic vision that includes social, historic, economic, environmental, educational, scientific and legal components. A key aspect is the participation of those groups that interact and depend on natural resources, including individuals, social groups, government, research and teaching institutions that have information on the origin and possible solutions to threats that sea turtle species are facing. Therefore, conservation plans need to consider the participation of the different stakeholders as a key strategy to be developed.

Those conservation programs that include all the different sectors of the communities as a key component on the strategies are more likely to be successful, but the activities need to be properly organized and justified.

Coastal development for tourism can seriously modify the environmental conditions that sea turtles need for nesting. The habitats that sea turtles need for nesting are critical for their reproduction and the survival of the various species. Changes that result from human activities at nesting beaches are generally severe and need to be a priority for conservation plans and actions. A serious contradiction to this behavior is that sea turtles represent a major touristic attraction for visitors from different areas, including local and international places.

Since sea turtles are reptiles of slow grow rate and late sexual maturity (more than eight years) an inadequate exploitation plan is reflected after those same years depending on the species. Therefore their exploitation needs to be carefully planned, without putting the species at risk and linked to research,

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recovery and environmental protection programs. This will prevent episodes such as the one between 1969 and 1972, when various populations were commercially extinct with effects that can be observed up to date. Sea turtle species still have a high acceptance and commercial value resulting on illegal fisheries, poaching and commerce of meat and skin. A negative impact of the ban on sea turtle commerce has been the increase in the price of turtle products, moving locals away from economic activates that require more effort and represent less income, such as small-scale fisheries. Therefore is recommended to implement strong educational campaigns and the development of economic alternatives for the local users. One of these alternatives is the use of sea turtle observation for touristic alternatives, that has high demand in countries such as Costa Rica, Brazil and Australia, and that is incipient in Mexico.

The Sea Turtle Protection Network is an Indicator of Touristic and Environmental Sustainability of a Touristic Destination, and represents a model of work that includes the different sectors of society such as government, private sector and communities, where the last two show the highest voluntary commitment. Companies that compete are working together for the conservation of sea turtles and the protection of their natural resources; this work has been organized, collaborative and for no economical benefits. The work by the Network at Los Cabos brings us to the following reflexion: "There is no ranks in a network, it is a commitment between equals. The forces that keep it together are not an obligation, material benefits or social status, but personal values that provide the knowledge that working together is the only way to achieve these tasks. A major commitment of the network is to remain all members that they are not alone" (Briseño, 2004).

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Chapter 6

HEALTH ISSUES IN SEA TURTLES: BARNACLES, SNAILS AND LEECHES

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ABSTRACT

Bahía Magdalena in Baja California Sur, Mexico is an important nursery and feeding ground for several species of sea turtles. It provides abundant marine algae, seagrass and invertebrates that turtles consume for growing until reaching maturity. The most common species in this region is *Chelonia mydas*, locally known as black turtle or east pacific green turtle. All species of sea turtles are carriers for a variety of epibionts that attach to their shells. Here we examined the epibionts found in the most abundant species of sea turtle found inside Magdalena Bay. Turtles were caught on different monitoring trips and epibiont samples were collected from shells and appendages of each turtle. The species

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found attached to *C. mydas* were the seaweeds *Cladophora* sp., *Polysiphonia* sp. and *Enteromorpha* sp., the arthropods *Chelonibia testudinaria*, *Gammarus* sp., *Lepas* sp. and *Caprella* sp. and the bryozoan *Antropora tincta*. The marine leech *Ozobranchus branchiatus* was also found on sea turtles at this location. The relationship between the size and number of the barnacles and the size of the turtle was investigated and analyzed. A correlation was found between turtle size and number of epibiont species present, but more turtles must be caught and analyzed to confirm the trend. The results of this study can be used in: A) the future to monitoring of sea turtle behavior and distribution, B) to analyze the effects of epibionts on turtles, and C) to assess the overall ecological health of Bahia Magdalena and the region of the Pacific coast of the Peninsula of Baja.

SEA TURTLES AND THEIR EPIBIONTS

Sea turtles live in different habitats throughout their life cycle. Bahia Magdalena in Baja California Sur, Mexico has an average depth of less than 15 m (Alvarez-Borrego et al. 1975) and is recognized as an important place for several species of sea turtles by providing abundant marine algae, seagrass and invertebrates as sources of food (Nichols 2003, Koch 2006). There are five species of sea turtles that occur in this region: *Chelonia mydas agassizii* (Black turtle), *Dermochelys coriacea* (Leatherback), *Lepidochelys olivacea* (Olive Ridley), *Caretta caretta* (Loggerhead) and *Eretmochelys imbricata* (Hawksbill) (Nichols 2003, Lutz et al. 2003). The *Chelonia mydas agassizii* and the *Caretta caretta* come for feeding and development; meanwhile *Lepidochelys olivacea* and *Dermochelys coriacea* arrive to the region for nesting. The species of sea turtle face different challenges for their survival, but all of them are related to human activities or human induced changes on the habitats that sea turtles use along their life cycles. All of the 5 species are endangered and the main reason for this is that during the 1960's and 1970's the turtles were the target of fishers and the result was a drastic decline in the populations (Nichols 2003). But their conservation status has been changed and currently *E. imbricata* is listed as critically endangered by the International Union for Conservation of Nature (IUCN), while the other four species are considered as endangered (Bjorndal 2003).

The *Chelonia mydas* habitat distribution is different for the adults and the juveniles. The adults come from southern Mexico to feed in Bahía Magdalena and the juveniles tend to stay in mangrove channels because the changing

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water depth and tidal cycles can physically restrict the turtle's movement to defined corridors (Seminoff and Nichols 1999). The most common species in this region is the *Chelonia mydas agassizii* locally called the black turtle or East Pacific green turtle (Nichols 2003). Since so many species use this region for different purposes, it is crucial to learn more about why they come and what they do here so they can be protected. This is the area where they spend most of their juvenile and adult lives. Once green sea turtles have reached maturity both male and female green turtles begin to make regular breeding migrations back to the beach where they were born (Bjorndal 2003).

Sea turtles are carriers for a variety of epibionts that attach to their shells and skin using them as a mobile substrate. These epibionts attach themselves to the sea turtles as they make their journeys to and from feeding and nesting grounds. Epibionts that reside on sea turtles include organisms such as barnacles, leeches, amphipods, and algae, but also suckerfish and crabs (Perrine 2003). Most epibionts are harmless and reside on the turtle's shell as a surface for feeding (Pfaller et al. 2006). However, the role of epibionts on the turtles is still under debate, since some epibionts may drain on the energy of the sea turtles by increasing drag and may create gateways or access points for fungal and bacterial infections (Lutz and Musick 1997). Leeches are considered ectoparasites and attach to the sea turtles skin having a negative effect on the sea turtle (Schneider 2005). The actual details of this effect on sea turtle's health are still unknown. For example, barnacles can cause drag, which increases the amount of energy needed to swim; nevertheless these organisms may also be beneficial to the turtles in some aspects, including providing camouflage and possibly some protection from large predators (Bjorndal 2003). Investigating epibiont populations attached to sea turtles may give us some clues to where the individuals have been living and their relative health.

Of the five sea turtles found in Bahía Magdalena, previous studies in other regions shown that loggerhead turtles (*Caretta caretta*) and hawksbill turtles *(Eretmochelys imbricata)* are likely to be more infested with epibionts than black turtles (Manual of Sea Turtle Research and Conservation Techniques, 1983). Nevertheless, not many studies have been done on the epibionts of black turtles, one of the few studies was conducted in Ceara, Brazil, that identified only two phyla inhabiting the carapace and flippers of captured juvenile turtles: an annelid and two types of arthropods (Pereira et al. 2006). The most common epibiont attached to sea turtles is the barnacle *Chelonibia testudinara*, found living on more than 70% of marine turtles in some regions (Brusca 1980, Nichols 2003). But it is also common to have the presence of

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another barnacle species called *Platylepas hexastylos* that settles on the turtle's skin, mouth and esophagus (Nichols 2003).

The species associated to green sea turtles in Bahía Magdalena were investigated for turtles caught using nylon nets 120 x 8 m that were deployed for 24 hrs., check every 1.5 hrs. for any entangled turtle to prevent drowning, at different estuaries within the bay. All of the captured turtles were measured by standard monitoring methodologies, and samples of algae, epibionts and parasites were taken and place into a solution of 70% alcohol – 30% fresh water.

The epibiont species that we found present on sea turtles captured for research purposes in Bahía Magdalena between 1998 and 2010 were: the green seaweeds *Cladophora* sp. and *Enteromorpha* sp., and the red seaweed *Polysiphonia* sp. We report the presence of the arthropods: *Chelonibia testudinaria* (turtle's barnacle), *Gammarus* sp. (amphipod), *Lepas* sp. (goose barnacle), and *Caprella* sp. (skeleton shrimp), the bryozoan *Antropora tincta*, and only in one occasion the hydrozoan *Aglaophenia* sp. Many of these species have been previously reported as epibionts of sea turtles, for example *Polysiphonia* sp. was also found on a Loggerhead sea turtle in Spain (Baez et al. 2002).

Compared to other turtle species such as the loggerhead turtle, the black turtles in Bahia Magdalena do not host a large variety or number of epibionts. Much of the information about turtle epibionts comes from organisms associated with loggerheads, so it is believed that loggerheads support a more diverse population of epibionts (more than 125 species worldwide) than any other marine turtle species (Frick et al. 2003). A study of algae on loggerhead turtles in the Balearic Islands found a 64% incidence of algae in 1999 and a 69.1% incidence in 2000. These turtles have nesting grounds in the Gulf of Mexico (Baez et al. 2002). Epibionts are generally harmless to a host (Schneider, 2005) and according to the Manual of Sea Turtle Research and Conservation Techniques, older turtles are more likely to be infested with epibionts, even though turtles captured in Bahía Magdalena did not show this pattern because most of them were juveniles.

Parasites were also present on many of the sea turtles that were captured in Bahía Magdalena. These parasites recorded were marine leeches of the species *Ozobranchus branchiatus* (Figure 1). Some of the negative effects of these associated species include dislodgement of skin, increase in drag forces, shell destruction, higher energy requirements, reduced mobility and lower fecundity and morality in extreme cases (Thieltges and Buschbaum 2006).

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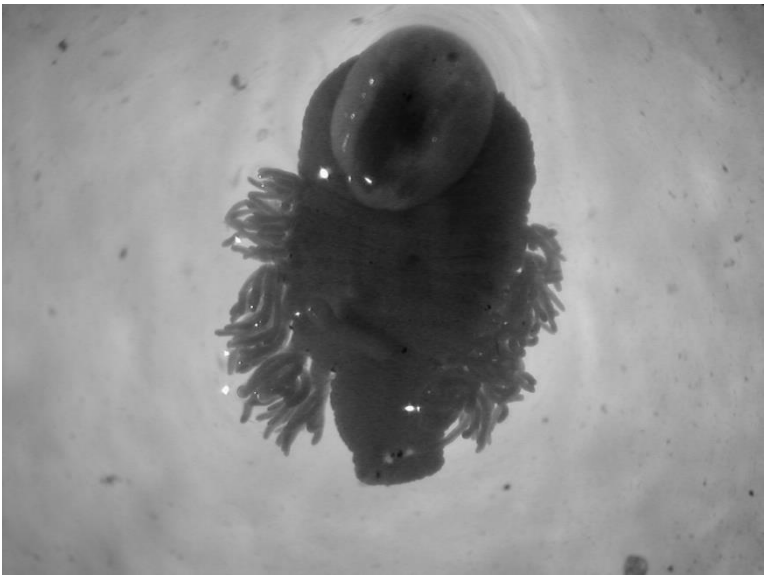

Figure 1. *Ozobranchus branchiatus* leech found on *Chelonia mydas* sea turtles in Bahía Magdalena. Leeches were relatively common on this sea turtle species, with abundances ranging from 1 to 10 leeches per turtle when present on an individual.

Bahía Magdalena is a very productive area due to the high availability of nutrients; this characteristic allows for a diverse number of species to reproduce and grow (Alvarez-Borrego et al. 1975), consequently there are many types of species of invertebrate larvae that need a substratum for settling. The shell of sea turtles is a good place to settle because the surface area is large and the turtles usually stay in the channels of the bay. Each type of algae found in the spring usually is found in the intertidal zone or the channels where the current is less rough.

Some explanations to the presence of barnacles on sea turtles include the feeding behavior of the latest. As *C. mydas* feed predominantly on sea grass, they are known to disturb the sediments as they pull the grass from the sand or as they swim to the bottom to find the sea grass. This action allows nutrients to escape into the water column. Filter feeders, such as barnacles, can benefit greatly from this behavior, as it allows them to filter the freshly disturbed sediments for nutrients. As a turtle increases its consumption, it also increases the amount of sediments it disturbs, and therefore the amount of food that barnacles receive. Thus, a newly settled barnacle on a turtle that is feeding often in order to maintain its weight has a higher rate of survival, due to an increased availability of food.

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Sampling of sea turtles and their barnacles since 1998 in Bahía Magdalena, showed a general trend to increase the number of barnacles as a result of increases on turtle size and weight. This could be due to the availability of a greater surface area, which represents a greater potential area for barnacle larvae to settle and potentially thrive. Turtles captured with barnacles ranged in size from 41 cm to 96 cm, with a mean of 59.45 cm in 2006. However there were two turtles with over a hundred barnacles on them, there was one with 157 and another with 111 individuals. We found that the average number of barnacles found on the carapace of the *C. mydas* turtles captured is higher than the average number of barnacles found on the plastron of the turtles, it appears that the carapace is a more favorable environment for a barnacle. The chances of a barnacle's larvae settling on the top of a turtle are much more likely than the chances of a larvae landing on the bottom of a turtle. While a turtle is lying in the sand, only its carapace is exposed to the water column, which may contain settling larvae. Even when the turtle is swimming, the chances that at larvae will fall through the water column and land on the carapace is much more likely than the chance that a larva will swim up, or be forced up by currents onto the plastron of the turtle.

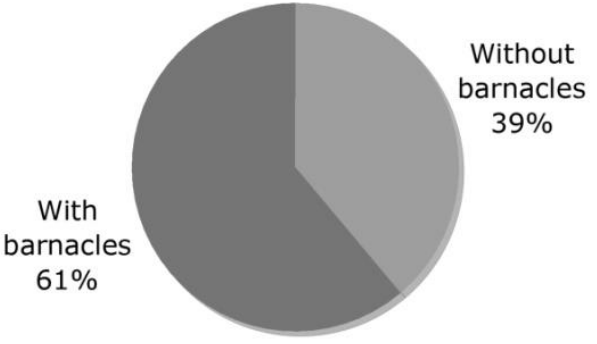

Figure 2. The percentage of turtles that presented barnacles *Chelonibia testudinaria* attached to either their plastron or carapace. The total number of green sea turtles captured in Bahía Magdalena since 1998 was 824. Only barnacles measuring at least 1 cm were counted.

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Also, barnacles settled on the carapace of a turtle are likely to have less contact with rough substrates, such as rocky or sandy ocean bottoms.

The relationship between the turtle size and number of barnacles was not statistically significant, since there are different processes that prevent the covering of the carapace with this and other epibionts; for example, as the turtle shell grows it shreds and the attached organisms peel off. This process prevents the excessive accumulation of organisms over time. Also, barnacles settled on the plastron of the turtles may scrape against any number of different types of ocean bottoms in their feeding, or daily activities.

We explored the relation of barnacle's size to the turtle section they were attached. We observed that bigger *C. testudinaria* were present at the upper and lower front sections of the sea turtles (Figure 3). On the top of the shell the boundary layer gradient (density of flow) is greatest at the front. Along the bottom the boundary layer gradient (density of flow) is greatest to the middle - back third (Hart, 1960). What this means for turtles is that the greatest amount of water will be hitting the upper front of the shell and the lower back half of the turtles shell.

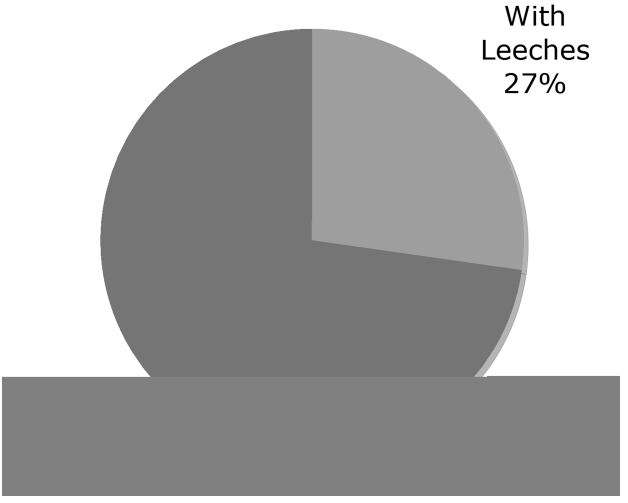

Figure 3. The percentage of turtles that presented leeches, *Ozobranchus branchiatus*, attached to soft tissue, most common around neck and rear flippers. A total number of 66 turtles captured between February 2007 and April 2008 were used for this calculation.

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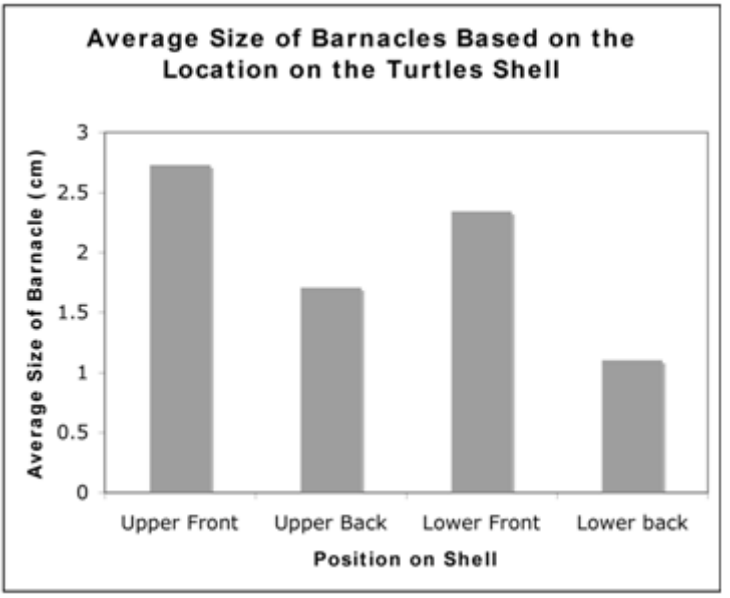

Figure 4. This graph shows the average size of the barnacle found at different locations on the turtles shell.

This pattern on water flow provides more food to the barnacle as well as a longer life span allowing the barnacle to get bigger and healthier. If this is correct, then most barnacles should be located on the upper front and lower back. The barnacles are most likely to be located here because as they are filter feeders they will catch the most food where there is the most opportunity to catch the most food, and the place with the greatest opportunity to catch food is where there is the greatest water flow. However, due to scratching to the sea bottom, barnacles on the lower back will be more likely removed resulting on the pattern observed with bigger barnacles at the lower front (Figure 4).

EXPLORING THE EFFECTS OF EPIBIONTS AND PARASITES ON GREEN SEA TURTLES

Chelonia mydas has long been documented as participating in a symbiotic relationship with many epibionts, most significantly, barnacles from the species *Chelonibia testudinaria* (Pereira et al. 2006) that were observed on regular bases on the majority of the turtles captured in Bahía Magdalena. The

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relationship between these two aquatic organisms has been declared to be commensal, as barnacles derive habitat from the turtle, while the turtle suffers no detrimental effect in most of the cases, since turtles are used solely as a substrate (Pfaller et al. 2006). It was observed in this study that some barnacles fall off of turtles with very little applied pressure, thus implying that barnacles that come into contact with any surface, and may be dragged along that surface, have a good chance of becoming dislodged.

However, previous studies on turtle-barnacle associations have noted several possibly detrimental effects of barnacle infestation. For instance, it has been suggested that barnacles can interfere with mating practices, as when the male climbs onto the back of the female, high abundances of barnacles could create a physical separation between the mating pair, preventing the male's cloaca from reaching the female (Seigel 1983). Another factor affecting the relationship is the struggle that females may face when crawling across beaches to build their nests. The females may experience reduced mobility, and thus be exposed to predation, and lack the ability to properly dig a nest (Seigel 1983). While neither of these factors was observed for the population of green sea turtles in Bahía Magdalena, it is important to consider the effects that barnacles may be having on the turtle throughout its life stages.

Barnacles may cause other effects, such as increased hydrodynamic drag. It is important to consider the relationship between increased drag leading to increased energy expenditure and decreased turtle size. Turtles have adapted so that their shells have minimum drag forces acting on it however with barnacles the drag is increased and energy is expended during long migrations (Lutz and Musick 1997). Watson and Granger (1998) focused on the hydrodynamic effects of a satellite transmitter on a juvenile green sea turtle. In this study the transmitter increased the drag forces on the turtle by 27-30%. The swimming speed of the turtle was decreased by 11%, increases the energy demand of the turtle by 9% and there were more trips to the surface for air. While a transmitter is bigger its effect on a green turtle relates to the kind of effect the barnacle *Chelonibia testudinaria* could be having on *C. mydas*. In a study of blue crabs that explored their relation with barnacles, *Chelonibia patula,* detrimental costs to the crab included increased drag and hampered movement of appendages from the increase in weight the barnacles caused (Key et al. 1997). A study conducted with regard to swimming sea turtles, found using models that a heavy barnacle load may increase drag up to tenfold, and energetic requirements more than threefold (Gascoigne and Mansfield 2002, as cited in Lutz 2003 p 175, Pfaller et al. 2006). This is especially true for when barnacles are attached to the turtle's flippers because

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turtles use their front flippers to propel themselves through the water so if there is an extra appendage and weight on the flipper the turtle will have more drag as it is bringing its front flippers back and pulling them forward during its power stroke (Watson and Granger 1998).

In terms of parasitism, we observed that a minority of sea turtles (27%) in a subsample of 66 individuals captured in Bahía Magdalena presented attached leeches to the soft tissue (Figure 5). This is comparable to the 34% found for black sea turtles captured in Brazil (Pereira et al. 2006).

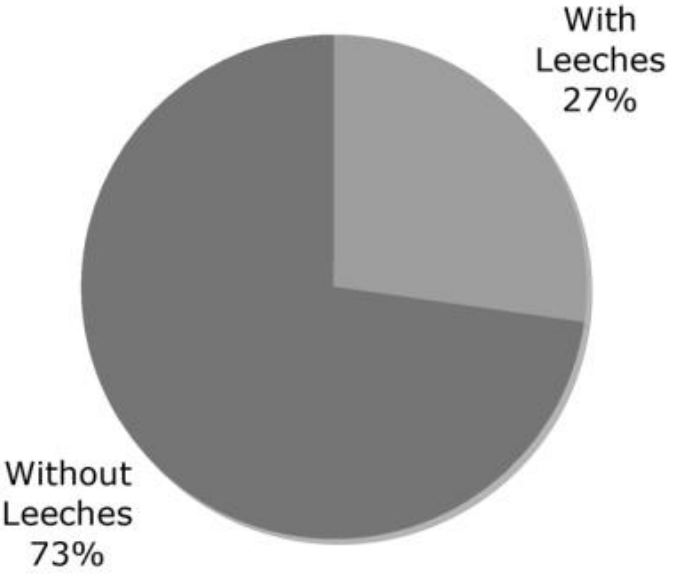

Figure 5. The average number of leeches present on sea turtles was 8.3 individuals per turtle. The highest number of leeches recorded for a single sea turtle was 77.

Leeches are in the class Hirudinea characterized as highly specialized annelids with an anterior and a larger posterior sucker for attachment; they feed on blood from their host and are found in various marine environments (Smith and Carlton 1975). A potential negative effect of the presence of *O. branchiatus* is the possibility of infection of sea turtles by the virus that produces fibropapilloma tumors on other populations of sea turtles around the world.

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It has been reported that leeches carry a high viral DNA load which means that it could be a vector for fibropapilloma-associated turtle herpesvirus (Greenblat et al. 2004). The development of tumors in the green sea turtle population in Bahía Magdalena has not been a regular occurrence and has been observed only for three individuals from 2000 to 2010 (G. Hinojosa, pers. observations). There has not been record of massive development of tumors observed on more than 800 sea turtles captured during that period of time (Figures 6 and 7).

Figure 6. *Chelonia mydas agassizii* with small tumors, recapture in San Buto BCS, Mexico. December 2007.

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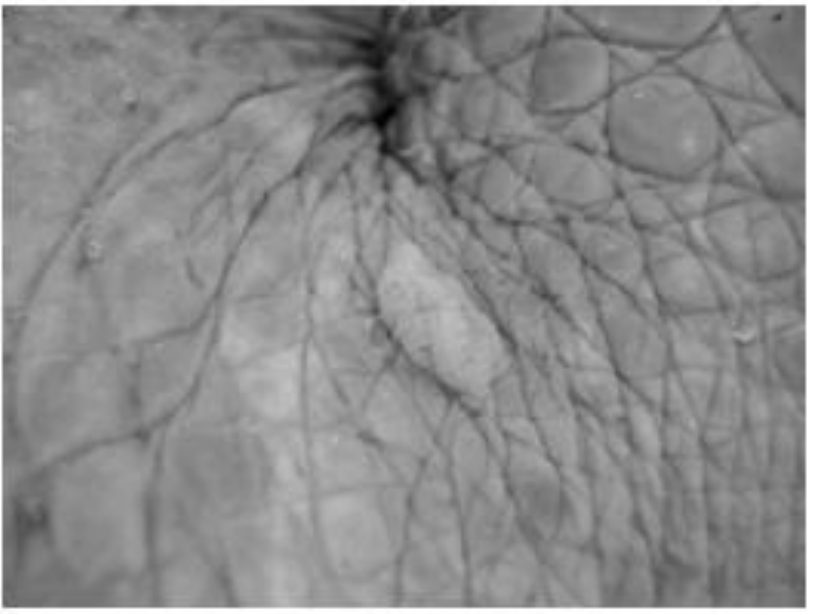

Figure 7. *Chelonia mydas agassizii* with small tumors, captured in San Buto, BCS, México December 2007.

THE USE OF EPIBIONTS TO EXPLORE THE DISTRIBUTION AND HABITAT USE BY SEA TURTLES

The epibionts can be studied using biogeography, which is analyzing the distribution of an organism and the factors that affect habitat selection and turtle movements (Caine, 1985). The biogeography of the epibionts helps in understanding the habitat distribution of the sea turtle. It is important to mention that all epibionts found on sea turtles from Bahía Magdalena were native to the bay and they are less diverse that epibionts associated with other turtle species that inhabit the waters of the Pacific Coast of Mexico. Therefore it is important to know the habitat of the epibionts. There have been other studies done on analyzing the epibionts to know more about where the turtles are distributed. One study was done on the Loggerheads and the *Polysiphonia* sp. algae found on them. The scientists used the algae as a biological marker to distinguish the Loggerheads that come from the Atlantic Ocean and the ones that come from the Mediterranean ocean (Moya et al. 2002). In Brazil a study was done on the black turtle and the epibionts found were barnacles and the

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leech *Ozobranchus brachiatus* (Pereira et al. 2006). There has also been a study done using biogeography of the epibionts to find out the migration of the Loggerhead (Frick et al. 2000).

Certain epibiont species only being found on turtles captured in specific estuaries may indicate that sea turtles remain in one estuary for the duration of their time in Bahía Magdalena, for example *Caprella* sp. Previous research indicated that juvenile green sea turtles come to estuaries in his area as juveniles and are believed to remain in their respective estuaries year round to feed and develop to maturity (Brooks 2005). The barnacle *Chelonibia testudinaria* and the green seaweed *Cladophora* sp. have been also used as markers to better understand the habitat distribution of the green sea turtle.

CONCLUSION

The need for efficiency when swimming brings the importance of understanding barnacle abundance and location on *C. mydas* into context. This study has shown that turtles of larger SCL and greater weight have significantly more barnacles attached to their shell than those of smaller SCL and weight. Therefore, it does not appear that barnacles are detrimental to the growth of sea turtles, at least at the abundances observed for juvenile organisms in Bahía Magdalena.

While there was no significant trend in the location of barnacles among the four sections of the shell, there was a noticeable difference in the size of barnacles located anteriorly versus posteriorly on the turtles' shells. Barnacles located anteriorly have a larger average size than barnacles located posteriorly. Again, this may indicate more about the preferred habitat of the barnacles than the detrimental effects of barnacles to sea turtles.

In conclusion, it was determined that the majority of sea turtles that reside in Bahía Magdalena have barnacles but do not have leeches.

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Chapter 7

PAST, PRESENT AND FUTURE OF CONSERVATION OF SEA TURTLES IN MEXICO

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ABSTRACT

Mexico is one of the most biologically diverse countries in the world, not only in relation to the number of species, but also in terms of genetic and ecosystem diversity. It is estimated that Mexico harbors between 10 and 12% of the total species known to science. Even though, our country represents only 1.35% of the total land surface of the world. Mexico is one of the most important countries in terms of plant, amphibian and reptile diversity.

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Mexico is considered a very important place for sea turtles. The high diversity within coastal environments and the richness associated offers perfect conditions for foraging, resting and reproduction of various sea turtle species. Six out of the seven species of sea turtles in the world nest on Mexican shores, which catalyzed the development of a sea turtle conservation culture at the different nesting grounds. One of the first steps towards sea turtle conservation was the implementation of a ban on sea turtle egg commercialization in 1927 to prevent the destruction of nests. However, this action did not prevent the commercialization of various species, especially physically attractive species, such as the hawksbill (*Eretmochelys imbricata)*. In 1929, the hunting ban for most sea turtle species included the concept of a minimum catch size which reinforced the prohibition on egg exploitation, yet did not have much effect overall. It wasn't until 1964 when the Mexican government established the National Sea Turtle Program that has worked towards sea turtle conservation for more than 50 years within Mexican territory. Sea turtle species use federally protected areas to feed, nest, grow and rest, but habitat modification and negative interactions with human populations have highlighted the importance of our country for the conservation, protection, research and management of chelonians.

INTRODUCTION

Different management strategies have been implemented over the past six decades by the Mexican government for the conservation, protection and research of sea turtles. The main goals are to understand the biology, migratory movements, and population densities on nesting grounds, to characterize the genetic diversity of populations, and to define units that can be more easily managed for restoring populations.

Sea turtles arrive to Mexican shores in the thousands every year. A process called "arribada", where olive Ridley species (*Lepidochelys olivacea*) all arrive simultaneously can be observed at only a few beaches around the world. Nesting occurs with extraordinary punctuality every year which currently provokes great challenges. The history of sea turtle species started to be modified during the last century when fishing and egg poaching activities increased. Both are common activities around the world and a major challenge for conservation (Table 1) since poaching of nest and females have put sea turtle species on different levels of risk, mostly to the break of extinction, as reflected by the International Union for Conservation of Nature (IUCN).

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It is high priority to protect sea turtles as the natural treasure that they represent for our country. Federal authorities, NGOs and local communities have implemented collaborative efforts for the conservation of sea turtle species for many decades. These activities aim for the sustainable development of the communities by preserving natural environments and their ecological services (food supply, costal protection, tourism, etc.).

Table 1. List of the different actions implemented for the protection of sea turtles on the second half of the 20th century

1966 - Establishment of the Sea Turtle Research Program by the National Institute of Biological and Fisheries Research (Instituto Nacional de Investigaciones Biológico Pesqueras)
1968 - Establishment of the regulation for the capture, use and commercialization of loggerhead, black and hawksbill sea turtles.
1972 - Partial bans for the sea turtle catch
1973 - Total ban on sea turtle fishery and capture
1986 - Nesting grounds used by sea turtles declared as Reserves or Refuges for the protection, conservation, repopulation and management of the various sea turtle species
1990 - Declaration of a total and permanent ban on the use, fishery or catch of any of the species and subspecies of sea turtles, including eggs, skin or any other products on water bodies under National jurisdiction
1990 - The National Program for the Protection and Conservation of sea turtles was implemented by the Secretary for Urban Development and Ecology (SEDUE in accord to the Spanish acronym)
1991 - Mexico implements the National Program for the Evaluation of Incidental Catch of Sea Turtles and the Economic and Technical Impact of the Implementation or Turtle Excluding Devices (TEDs) for Sea Turtles (National Institute of Fisheries)
1992 - Mexico signs the Convention on International trade in endangered species of wild fauna and flora agreement (CITES)
1993 - The Commission between Secretaries for the Protection and Conservation of Sea Turtles was created by the Mexican government
1993 - The National Committee for the Protection and Conservation of Sea Turtles was established with the participation of the private sector, academics and government officials

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Table 1. (Continued)

1993 - The official Mexican Norms 002-PESC-1993 and 008-PESC-1993, that established the mandatory use of TEDs for the Gulf of Mexico and the Caribbean fishing fleets
1993 - The Mexican Official Norm, NOM-002-PESC-1993, was published for the sustainable harvest of shrimp on Federal Mexican Waters, that included the compulsory use of TEDs
1994 - The NOM-059-ECOL-1994 sets the conservation status of the seven sea turtle species present in the country as endangered
1995 - Establishment of the agreement for the classification of export and import products under regulation but the Secretary of the Environment and Natural Resources (Spanish acronym: SEMARNAT)
1996 - Publication of the emergency NOM-EM-001-PESC-1996, for the compulsory implementation of TEDs on shrimp trawl nets in the Pacific Ocean, including the Gulf of California
1996 - Inclusion of Environmental Crimes to the penal code in the Federal District and to the rest of the country as a federal crime for take of sea turtles
1997 - The Program for the Conservation of Wildlife and Diversification of Rural Production was implemented (1997-2000). This document defined a strategy for the conservation and restoration of priority species, including sea turtles
1997 - Modification to the NOM-002-PESC-1993, to reinforce the mandatory use of TEDs in all shrimp trawl nets and allows for the use of rigid excluders
2000 - The General Law for Wildlife was created (Ley General de Vida Silvestre)
2000 - The National Program for the Protection, Conservation, Research and Management of Sea Turtles was updated
2001 - Environmental crimes will be punished by a maximum prison time of 12 years
2005 - The Program for the Conservation of Species at Risk (PROCER, Spanish acronym) included loggerhead turtles as a priority species
2007 – Mexico declared the Year of the Sea Turtle. The first National Meeting for the conservation of sea turtles was conducted in November and included talks, workshops and posters about sea turtle research in Mexico
2013 - The NOM-162-SEMARNAT-2012 is published to protect, restore and manage sea turtle's populations at their nesting grounds

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The National Program for the Protection, Conservation, Research and Management of Sea Turtles was updated in 2000 and included the use of four management tools for the restoration of sea turtle populations: a) implementation of current laws, 2) decentralization of management agencies, 3) improvement of operational strategies and 4) assignment of funds for sea turtle conservation. Some of the specific strategies that were developed include: protection for females, eggs and hatchlings at nesting beaches; research on the biology and ecology of the different sea turtle species and populations; regulation, inspection, and surveillance activities at nesting grounds, the design and use of a National Information System, and finally, but most important, the promotion of community participation on sea turtle conservation activities.

The program above described included the coordination and cooperation of multiple government agencies at the federal level, such as the General Secretary for Wildlife (SGVS), the Federal Police for Protection to the Environment (PROFEPA), the National Institute of Fisheries (INP), the Sub secretary for Protection to the Environment and Natural Resources and the General Secretary for Ecological Planning (all acronyms are in Spanish), that need also the work in coordination with state and local governments, research institutes, universities, NGOs and the private sector.

Despite the coordinated efforts of different national and international agencies and governments, sea turtles in Mexico are considered within two main risk categories in accord by the IUCN; endangered or critically endangered. The Secretary of the Environment and Natural Resrouces (SEMARNAT, acronym in Spanish, *Secretaria de Medio Ambiente y Recursos Naturales*) classified all species of sea turtles as endangered (*en peligro de extinction*) by NOM-059 ECOL 2001. This federal regulation formally prohibits the capture or fishing of adults and juveniles, and the consumption of sea turtle eggs (Briseño-Dueñas 1991, Semarnat, 2001). All species are also listed in the appendixes (I and II) of the Convention for the Conservation of Wildlife Migratory Species (CMS) or Convention Bonn; and on the appendix I of the CITES (Instituto Nacional de Ecología, 1999).

Many coastal states in Mexico have implemented different measurements for the protection and conservation of sea turtles. One of the most important is the creation of sea turtle protection camps, locally known as “campos tortugueros”, to protect nests, eggs, hatchlings and nesting females. In some camps, eggs are incubated and the hatchlings are released from secure areas. From 1996 to 1999, these camps were coordinated by the National Institute for

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Biological and Fisheries Research, currently named National Institute for Fisheries) (SEMARNAT 2002).

One of the biggest steps towards sea turtle protection was the publication of the total and permanent ban on sea turtle fisheries, catch and their products on May 20, 1990. The Mexican government complemented this action by the creation of the Mexican Environmental Program (Programa Ambiental de Mexico) under the National Institute of Ecology (INE) and with funds from the World Bank. This program installed permanent nesting camps at 12 beaches from 10 states in the country (SEMARNAT 2005). Camps started formal operations in 1992, conducting beach patrolling, nest relocation to protective hatcheries, and secure release of hatchlings. These actions have resulted in the protection of thousands of individuals from the seven species of sea turtles that inhabit Mexican waters (Table 2).

Table 2. Common and scientific names of the seven species present in Mexico are listed below

Leatherback (*Dermochelys coriacea*)
Loggerhead (*Caretta caretta*)
Hawksbill (*Eretmochelys imbricata*)
Green sea turtle (*Chelonia mydas*)
Black sea turtle (*Chelonia agassizii*)[1]
Olive's ridley (*Lepidochelys olivacea*)
Kemp's ridley (*Lepidochelys kempii*)

[1] Controversy exists whether the black sea turtle should be considered as a separate taxonomic species from the green sea turtle.

A total of 2004 temporary or permanent camps for sea turtle protection were operating in 2007, but only 144 had official permits from SEMARNAT (Figure 1) currently known as Centers for the Protection and Conservation of Sea Turtles (Centros para la Protección y Conservación de Tortugas Marinas or CPCTM) (SEMARNAT 2002, 2005).

Nesting grounds in Mexico are distributed on beaches in the states of Oaxaca, Tamaulipas, Nayarit, Jalisco, Michoacan, Guerrero, Veracruz, Chiapas, Quintana Roo, Campeche, Sinaloa and Baja California Sur. Information regarding Mexican conservation efforts demonstrates that sea turtle protection is a top priority. It is evident that hatching production has increased at specific nesting beaches over time, and similar patterns can be observed for some feeding areas. In contrast, there are some locations where

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turtle populations are still decreasing and more research needs to be conducted to understand the reasons of these negative patterns (Márquez, 2000).

Figure 1. Temporary or permanent camps for the protection of sea turtles were operating in 2007, but only 144 had official permits from SEMARNAT. (Creation by staff Cristina Mota Rodríguez data of: Carreras et al., 2013; Barragán, 2012, Cuevas et al., 2010; CONANP, 2010; Abreu y Guzmán, 2009; Guzmán et al., 2008; Raygados, 2008; CONANP, 2008; Sarti et al., 2007; SEMARNAT, 2002; Márquez, 1996) Imágenes de especies: Fernando Zeledón, tomadas de: <http://darnis.inbio.ac.cr/ubis/FMPro?-DB=ubipub.fp3&-lay=WebAll&-error=norec.html&-Format=detail.html&-Op=eq&id=4134&-Find>.)

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A specific case of conservation from the Yucatan Peninsula is considered as a Geopolitical Conservation Unit (GCU) for the recovery of hawksbill turtles. In this region, nesting reached an average of 30 nest/km of beach (Guzmán-Hernández 2003) resulting in the second most important reproductive population in the world. The number of nests and nesting females had steady increased until 2000 (Garduño et al. 1999; 2000, Guzmán-Hérnandez, 2001). The most important nesting beaches in this region include: Celestún, Sisal, Dzilam de Bravo, El Palmar, Telchac Puerto, Río Lagartos, Coloradas, El Cuyo and Isla Holbox (Quintana Roo) (Cuevas et al., 2000, 2006). However, a dramatic decrease was observed during the following years until 2004 when only 40% of previous nesting and hatching was reported in comparison with the highest numbers of 1999 (Cuevas, et al., 2000).

The Yucatan GCU is comprised of three states, Campeche, Yucatan and Quintana Roo. The GCU, located in a tropical zone characterized by estuaries, lagoons and coastal ecosystems, is highly preferred by sea turtles of different species. This GCU is important for nesting hawksbill (*E. imbricata*), green sea turtle (*C. mydas*), loggerhead turtles *(C. caretta)*, and for the feeding of leatherbacks (*D. coriacea*). The Yucatán peninsula is considered a very important nesting region for green, loggerhead and hawksbill species (Guzmán-Hernández, 2001; 2005) with the exception of the state of Quintana Roo which has few nesting reports of the two first species, respectively. For example, Xcacel and Xcacelito beaches are considered the most important nesting grounds in Mexico for green sea turtles and loggerheads (Abreu et al., 2000). Each beach in this region has specific characteristics of sand grain size, length and width, dune morphodynamism, vegetation composition, and tidal cycle.

The state of Campeche contains 52% of the total hawksbill nests registered for the Yucatan Peninsula. In 1981, this state reported a record high number of green sea turtle nests protected in the region. Campache is also the southernmost area for Kemp's ridley *(L. kempii*) nests on record (Guzmán-Hernández, 1996). In 2013, Campeche registered a total of 773 nests of hawksbill sea turtles, which represents a 55.25% increase when compared to the records of 2012. Records for green sea turtle increased a 36.6%, for a total of 816 nests in 2013.

Conservation efforts for sea turtles in Quintana Roo started more than 25 years ago at the Center for Research of Quintana Roo. However, the center was abandoned in 1996. At that time, the Program for the Protection of Sea Turtles in Quintana Roo Shores was implemented by the National Park of Xcaret. Eventually the program incorporated into the programs of the

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Campamentos Tortugueros de Flora, Fauna y Cultura de Mexico A.C in an effort to coordinate all the institutions working in favor of sea turtle conservation (Flora & Fauna 2010).

Another program that was implemented to study and protect sea turtles was the Sea Turtle Conservation Program of the Rivera Maya which complements the efforts throughout the Peninsula. This program constitutes a linear distance of 34 km compromising 13 nesting beaches between Punta Venado beach (south of Xcaret) and the Sian Ka'an Marine Reserve making it the biggest program in the country. The nesting camps operating in this region include: Aventuras-DIF, Xcacel, Xel-há, Tankah, Kanzul and Lirios Balandrín (Flora & Fauna 2010). Meanwhile, seven camps operate along the coast of Yucatán and Alacrane reef, Celestún, El Cuyo, Parque Marino Alacranes, Reserva Estatal de El Palmar, Dzilam de Bravo, Telchac Puerto and Las Coloradas. Combined, these camps have released 189,520 hatchlings of different sea turtle species between 2010 and 2011 (Cuevas, 2002)

In comparison, after 25 years of conservation efforts for olive and Kemp's ridley species present extraordinary signs of recovery and raise hope for the other species, especially those critical endangered such as loggerhead and hawksbill. Kemp's ridley is considered worldwide as a conservation success because the number of nests at the Santuario Playa Rancho Nuevo, in Tamaulipas, averages 21,000 from the most recent nesting seasons. This beach is considered as the most important nesting site for this species and it was the first camp established by the Mexican government for the protection of sea turtles in 1966.

Information collected from the Kemp's ridley nesting beach at Rancho Nuevo dates back to 1947. There are reports of approximately 40,000 females nesting on the same day, a historical "arribada". However, overfishing reduced the nesting population to only 800 individuals per year in a very short time. By 2012, employees and volunteers at the camp were able to protect over 21,000 nests with a hatchling production of 1,120,000 individuals. Despite clear indications of recovery, more work is still required to reach the nesting levels of the 40's (CONANP, 2009).

In the southern Pacific coast of Mexico, the Mexican Center for Sea Turtles (Centro Mexicano de la Tortuga, CST) is also a remarkable success, located in Mazunte in the state of Oaxaca. As at most camps, the CST aims to generate knowledge on the biology of sea turtles for the development and implementation of management strategies that catalyze the recovery of sea turtle population. La Escobilla, Barra de la Cruz and Morro Ayuta are three beaches where CST installed nesting camps in 1970. A common strategy to

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estimate the total number of nest during "arribadas" is the model proposed by Marquez and Van Dissel in 1982 that suggests the monitoring a minimum of 10% of the total number of nest. This method has been used for the past 25 years at La Escobilla and shows the effects of different management strategies. For example, the total ban implemented in 1990 resulted in an increase of the number of nesting females in subsequent years. One of the most remarkable observations occurred the following year when this species exhibited an extended nesting season lasting almost 11 months starting in May continuing until February or March of the following year. This resulted in an exponential increase of sea turtle nests according to Martha Harfush (personal Communication) (Figures 2 and 3).

Figure 2. Logo of The Centro Mexicano de la Tortuga established in 1994 in Mazunte, Oaxaca to help national efforts for sea turtle conservation. http://www.centromexicanodelatortuga.org/wp-content/uploads/2011/03/eco-c1.jpg

Figure 3. Sea turtle arriving to a nesting ground during a massive nesting event regionally known as "arribada" in Mazunte, Oaxaca.

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Leatherbacks are of special interest due to their critically endangered status. Since 1995, monitoring has been conducted at all known nesting sites along the Pacific coast of Mexico. Nesting beaches are classified into two categories: (1) Priority beach and (2) Secondary beach. Priority beaches record significant numbers of nests. Examples include: Mexiquillo, Michoacan, Tierra Colorada, Guerrero, and Cahuitán and Barra de la Cruz in Oaxaca. Secondary beaches are nesting grounds beaches where nesting occurs in low densities. Examples include: Agua Blanca and Los Cabos in Baja California Sur, and La Tuza, San Juan Chacahua, Bahia de Chacahua and Cerro Hermoso in Oaxaca (SEMARNAT, 2009 Sarti et al. 2007). Cumulatively, these beaches protect 70-75% of the total nests in the Mexican Pacific, a coastline approximately 245 km in length. Nevertheless, priority beaches contain 45% of all nests reported for this area. Although no changes have been reported on the historical distribution of leatherback nesting, the density has changed along those nesting sites (Figure 4) (Sarti et al. 2007).

Michoacan is an important nesting site for leatherbacks, black and olive ridley sea turtles. This state is also recognized as an important foraging area for hawksbill sea turtles. Colola and Maruata are two named beaches which have been designated as reserves for the protection of sea turtles, yet there is a total of 17 nesting beaches recorded in the state.

Carlos Delgado Trejo, a researcher at the Universidad Michoacana of San Nicolas de Hidalgo, has studied sea turtles for various decades. He explains that in the 60's, nesting females used to be as many as 150,000, but nowadays there has been a decrease of 90% for most beaches. In the critical cases, poaching has occurred for 100% of nests in some years, such as in Paso de Noria, Chocola, Montin del Oro, Arena Blanca and Cachan de Echeverria. Nesting is still occurring at only 10 beaches, representing a 42% reduction on the nesting range for black sea turtles. The density of nests per kilometer has also declined. The only exception to this negative trend is Colola. Volunteers at this beach recorded 12,600 nests laid by an estimated 3,500 and 4,000 females out of the 30,000 black sea turtle adult male and females from the Mexican Pacific (personal communications Delgado Trejo).

A major concern for conservation efforts around the world is the loss of nesting beaches as a consequence of climate change and sea level rise in the near future. The ability of sea turtle individuals to find new nesting areas is going to be critical for the survival of sea turtles, especially when human-induced changes to beaches is also another critical factor in the conservation equation.

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Figure 4. Leatherback turtle spotted during nesting. The site selection for egg deposition is critical for the success of the nesting season and species preservation. (http://www.centromexicanodelatortuga.org/wp-content/uploads/2011/03/eco-c3.jpg)

Sea turtle conservation efforts extend throughout the Mexican coastline. For example, in the northwest, various institutions work in sea turtle conservation. Camps located in Sinaloa, Playa Ceuta, Barras de Piaxtla, El Pozole, Acuario Mazatlán, Isla de La Piedra, Estrella de Mar and Caimanero (La Guasima) are considered some of the most important conservation areas in the region. In particular, Verde Camacho, a high priority conservation nesting site is located 25 km north of Mazatlan. Volunteers from these communities work in collaboration with the Federal Comission for Protected Natural Areas (Commission National de las Areas Naturales Protegidas, CONANP) to generate scientific information of the most common species in the area, the olive ridley and two of the most endangered species; leatherback and hawksbill. Work at these camps is not easy. Volunteers patrol long extensions of beaches from dusk until late at night or even until dawn. They constantly risk encounters with poachers who steal recently laid nests to sell eggs on the black market. To combat poaching challenges, some conservation programs offer jobs to local poachers which in turn promotes taking pride in conservation efforts. In turn camps benefit from the second-hand knowledge of sea turtle species from the poachers which invariably contributes to conservation actions (Van der Heiden, 1988, Briseño, 2003).

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Research institutes play a major role in sea turtle conservation. For example, researchers from the National Polytechnic Institute in Sinaloa (CIIDIR-IPN (Centro Interdiscuplinario de Investigacion para el Desarrollo Integral Regional) conduct tracking experiments on sea turtles released at Playa Las Glorias, Guasave, to analyze individual migration routes and habitat use in the Gulf of California via GPS transmitters (ARGOS). A total of six individuals, three black sea turtles and three loggerheads, have been tracked thus far. The transmitter tags are placed on the carapace of an adult and attached with epoxy glue. Individuals are followed for one year and the route is displayed at www.seaturtle.org. "Hits" are tracked via satellite when the sea turtle surfaces to breathe.

An exceptional case on the history of sea turtle conservation in Mexico is the effort conducted in Baja California Sur (BCS). This state includes habitat for five of the seven sea turtle species: black turtle, loggerhead, olive ridley, hawksbill, and leatherback. These species use beaches and coastal areas of the state as nesting areas and feeding areas for all species. The Southern Baja California Association for the protection of the environment and sea turtles Asociación Sudcaliforniana de Protección al Medio Ambiente y la Tortuga Marina A.C. (ASUPMATOMA as its acronym in Spanish) is one of the most important protection camps in the northwest region. This non-governmental organization (NGO) began monitoring nesting beaches in the Los Cabos municipality and now is recognized as the first NGO devoted to the protection of sea turtles in BCS. ASUPMATOMA is supported by local researchers and students that conduct scientific studies on the nesting females and hatchlings at two named beaches; Rancho San Cristobal (6 km long) and Cabo Falso (15 km long) as shown in Figure 5. Environmental education provided to local schools is a vital component of the work at these camps which incorporates the participation of Marine Biologists from the University of Baja California Sur (Universidad Autonoma de Baja California Sur, UABCS).

Local governments also serve as an important factor for the sea turtle conservation movement throughout the Baja Peninsula. For example, the sea turtle camp "Don Manuel Orantes" was created in 2000 to protect 35 km of coastline and is operated by the Los Cabos municipal government. This camp received the prestigious "Carolina Anderson" award in recognition of projects containing a strong environmental education component. The General Secretary for Ecology and Environment granted an award at the XI Annual Meeting of Grupo Tortugero as testament to the 13 years of work at the Camp "Don Manuel Orantes".

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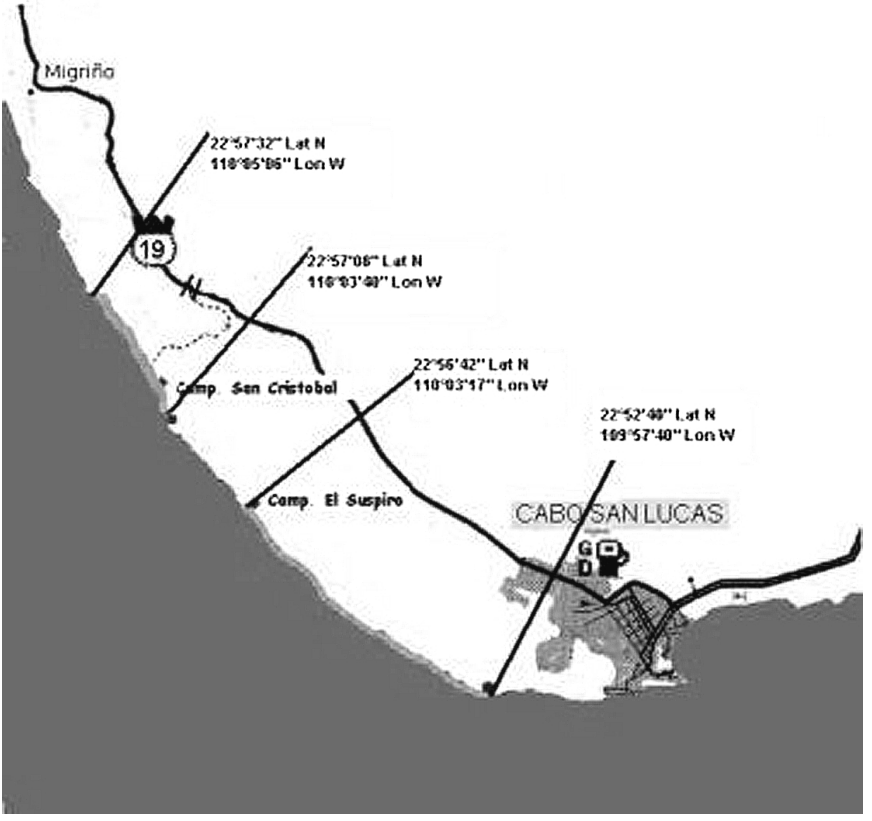

Figure 5. Location of the nesting beaches used by leatherback and olive ridley sea turtles in the region of Los Cabos, BCS.

Biologist Graciela Tiburcio, who coordinates the nesting camp, reports three species arriving to Los Cabos beaches, olive ridley, black, and leatherback. The importance of sea turtles has created the need within the local government to implement a specific plan for the protection of sea turtles in the region. It has achieved the participation of more than 20 hotels and resorts in the tourist corridor which extends from the towns of San Jose to Cabo San Lucas. This sector has trained some of their staff on rescue and protection of wildlife to conduct related activities on the beaches in front of the hotels and involve the local community. It is estimated that more than 1,000 people from different social strata have participated as volunteers in beach patrolling, nest protection and release of sea turtle hatchlings.

A major result of this initiative by the local government is the creation of an Alert Network. Hotel personnel, firefighters, marines, schools, NGOs and

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government officials share responsibilities for sea turtle protection. Female sea turtles are monitored during nesting and then eggs are protected by fences in-situ or they are relocated to nurseries and safely released. People as old as 70 years of age participate as volunteers. As a result, poaching has decreased on average from 55 nests per year to only one (personal communications by Graciela Tiburcio). The total number of nests protected in 2012 was 1,815 which resulted in 144,597 released hatchlings.

Figure 6. Some of the institutions working towards sea turtle recovery in Mexico are Red Tortuguera A.C. (RETO), El Naranjo (Guayabitos, Nayarit), Boca de Chila (Zacualpan, Nayarit), Mayto (Cabo Corrientes, Jalisco), Puerto Vallarta (Jalisco). Cam Careyeros (Punta de Mita, Nayarit), Punta Raza (Monteon, Nayarit) and Caminando con Tortugas (Jalisco) a RETO. (http://redtortuguera.org/images/logos-footer.jpg).

The creation of collaborative networks for the protection of species is an effective strategy to promote community participation. In 2011, the Red Tortuguera A.C. was created between camps in Jalisco and Nayarit, with the

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later incorporation of nesting camps at El Naranjo and Boca de Chila from Nayarit, and Sociedad Ecologica de Occidente located in Puerto Vallarta, Jalisco. There are a total of 12 conservation programs currently participating within this network (Figure 6).

Grupo Tortuguero de las Californias, started in 1992 by two Ph.D. students from the United States, J.A. Seminoff and W.J. Nichols, completed the current network of sea turtle conservation groups. Their efforts focus on foraging and nesting areas along the coast of Baja California with the participation of local fishermen, students and research institutions. Research techniques include tagging, genetic analyses, GPS tracking systems, and general biometrics. By 2007, Grupo Tortuguero was officially recognized as an NGO in Mexico and works towards sea turtle conservation not only in the Peninsula of Baja but also in other regions of the country. Nowadays, Grupo Tortuguero works with more than 50 communities along the Pacific coast of Mexico and has collaboration agreements with similar networks in Central America, Cuba and even Japan.

CONCLUSION

The National Program for Sea Turtle conservation provides an excellent response to the problems these species face as a consequence of commercial overexploitation. The history of sea turtle conservation in Mexico dates back more than 40 years and has evolved from simple measures conducted by the government to the active participation of research institutions, NGOs and local community involvement. There are clear examples that sea turtle recovery is possible when strategies such as nest, beach, and female protection at nesting areas are applied, however more effort is needed to protect other fractions of sea turtle populations such as juveniles and adults that congregate at foraging sites.

Mexico issued different laws to protect sea turtles (e. g. NOM-162-SEMARNAT-2012 for management and protection of sea turtle habitats and NMX-AA-120-SCFI-2006 to catalyze sea turtle's conservation) which reinforce the work of many agencies and stakeholders on the Pacific, the Atlantic and Caribbean coasts of Mexico. However, there is still work to be done for sea turtle recovery. Historical threats from fisheries and poaching still exist, yet new risks are emerging, such as underwater mining, pollution, sea level rise, coastal development, all of which need to be considered when planning integral conservation strategies.

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We would like to finish this chapter by including some reflections and ideals from the groups and people participating on sea turtle conservation in Mexico:

> "The fact that you can observe many sea turtles within a specific site does not mean that the full population has recovered" (Grupo Tortuguero de Las Californias)
>
> "The problems are not over, there is a lot to be done. We are on the right track and advancing very fast" Ing. José Antonio Agundez (Governor in BCS) and Graciela Tiburcio (Coordinator of Manuel Orantes's turtle camp).
>
> "There is not one, not ten… there are thousands…it is an arribada…" (Centro Mexicano de la Tortuga)

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Chapter 8

SEA TURTLES AND CONSERVATION CHALLENGES IN THE PENINSULA OF BAJA CALIFORNIA

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ABSTRACT

Magdalena Bay in Baja California Sur, Mexico is an important feeding and resting ground for marine turtles, since five species of sea turtles come on regular bases to this region: *Chelonia mydas* (Black Turtle), *Dermochelys coriacea* (Leatherback), *Lepidochelys olivacea* (Olive Ridley), *Caretta caretta* (loggerhead) and *Eretmochelys imbricata* (hawksbill). *C. mydas* and *C. caretta* come for food and nesting, while *D. coriacea, E. imbricata* and *L. olivacea* come mainly to feed on the

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abundant marine algae and invertebrates that the bay offers. The most common species of sea turtle in this region is *C. mydas* locally called black turtle or Eastern Pacific green turtle that was considered for some time to be a sub species *C. mydas agassizii*. Given that many species use the Peninsula of Baja for different purposes, it is crucial to learn more about why they come here and what they do once they arrive so they can be protected and preserved. Madgalena bay is very important for turtles and plays a major role on their life cycle, therefore it is of high importance for their conservation. Study results may help to better understand where populations live so these areas can be properly protected.

GENERALITIES OF SEA TURTLE

Sea turtles are considered as a very successful group of vertebrates that adapted to a life in the ocean; they are exothermic and need to come to the surface of the waters to breath. These animals have improved senses, being vision and the sense of smell two of the most important, playing a major role to find food and used for orientation both in water and land especially when females come to nest on the shores. Their bodies have adopted shapes that allow for improved movement and displacement in the water. All four of their extremities have been modified to flippers that provide propulsion and direction. Most of the body is covered by a hard structure called carapace, formed by fused sections, also known as scutes or scales (Bjorndal 1995). A hard shell called plastron also protects the chest area. Sea turtles head cannot be retracted into the shell due to the structuring of the neck that prevents them from retracting it into the shell, this represents one of the main differences between land and marine turtles. A total of seven species of sea turtles have been described and recognized worldwide: logger head (*Caretta caretta*), green sea turtle (*Chelonia mydas*), flatback sea turtle (*Natator depressus*), kemp's ridley (*Lepidochelys kempii*), olive ridley (*Lepidochelys olivacea*), leatherback (*Dermochelys coriacea*), and hawksbill (*Eretmochelys imbricata*) (Bolten 2003).

An important anatomical modification that allowed for sea turtles to live in the oceans is their ability to deal with salinity by the presence of special glands located at the rear of their eyes. This process feeds believes that females "cry" when they are laying their eggs on beaches around the world, which is a romanticized perspective about sea turtles reproduction.

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These glands, together with an excellent immune system has allowed sea turtles to be present on the oceans for thousands of years with little, if any, modifications to their body structure. Another well-extended myth about these organisms is that once that newborns touch the water, only females will return to land to laid their eggs, nevertheless it has been observed that males and juveniles come to shore on some Pacific islands to rest (NOAA 2011).

The Life Cycle of Sea Turtles

Sea turtles have complex life cycles that involve coming back to shore to lay their eggs, a process that is a reminder of their previous terrestrial existence. One of the main differences between species are the areas used for reproduction, that in some cases involve travelling thousands of miles to reach nesting areas, e.g. loggerhead turtles that cross the entire Pacific ocean from Mexico to reach beaches in Japan (Gardner and Nichols 2001).

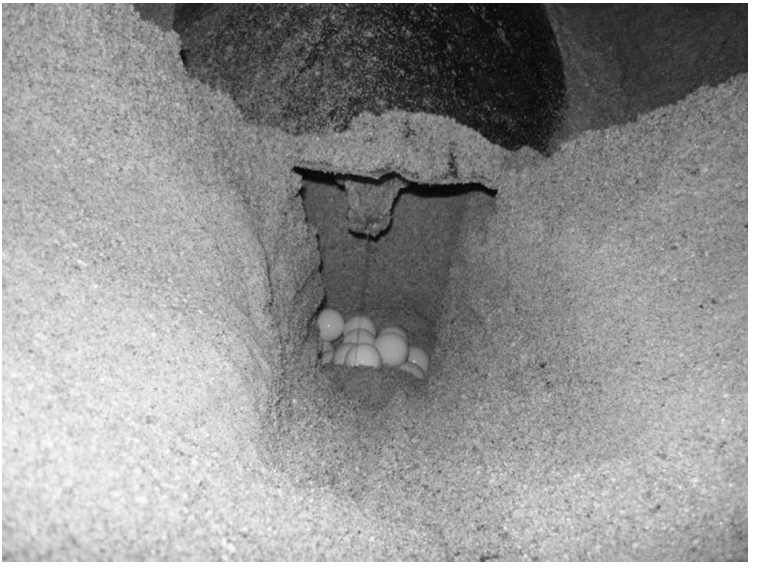

Figure 1. A female turtle creates a nest to lay her eggs at their natal nesting beaches. This is a very dangerous moment for females because they are exposed to terrestrial predators but most importantly to poachers.

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Reproduction is one of the key stages in the life cycle of sea turtles, but also one of the most vulnerable for adult females. They gather in shallow waters in the front of the nesting beaches where males also congregate for mating. Females usually get back to their natal beaches, but it is also considered that a small portion of them explore new areas (Bjorndal 1995).

After fertilization, females come to shore looking for the optimal conditions above de high tide line to lay their eggs, some of the most important characteristics that beaches must possess are a) temperature that determines turtles sex, and b) humidity to prevent egg desiccation, both factors are essential for the development of babe turtles and the success of the nesting season. Once the perfect spot is located, females use their body to create a pit by moving sand with her flippers; next she digs a cavity to deposit the eggs that will be left to be incubated by the heat of the sun (Carr 1952).

Nest has an average depth of 60-70 centimeters and females usually lay about 120 eggs per nest; this differs between the seven sea turtle species. The process of nesting is repeated between 1 and 4 times every nesting season every 10 to 14 days. These numbers are dependent on different factors that include: female age, health, and time within the nesting season. After placing the eggs within the cavity, sea turtles cover the eggs with sand, flattens the pit and uses her flippers to disguise the nest. Eggs are incubated by sun heat in approximately 40 days; this period changes from year to year depending on the environmental temperature (Bjorndal 1995). This physical factor determines sea turtle gender, temperatures above 28.3^{o} C will produce mostly females, if temperatures are below this temperature most of the eggs will develop into males. After development, babe turtles crack the egg at nighttime with the help of an egg's tooth that is present on their nose to reduce the chances of predation. After hatching, newborns follow the light of stars and the moon reflecting off the ocean surface and ride the currents into the open sea. They will drift with seaweed and marine debris for up to 10 years; then they will swim to coastal areas to feeding and growing areas (Bolten 2003).

Females are rarely selective in relation to the males that they mate, in some cases they will mate with more than one male, phenomenon that results on nest that are fathered by different individuals. Males use their tail to introduce sperm into the cloaca of females and achieve egg fertilization. Copulation can last up to 10 hours to prevent mating of a

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female with another male before reaching the nesting beach. Sperm can be stored by females for some time and used to fertilize eggs at a lately time (Carr 1952).

After nesting, females will travel back to their feeding grounds where they will spend one or two years to initiate another nesting cycle. It is believe that sea turtles use earth's magnetic field to navigate, in addition to smells and their vision to some degree (Bolten 1967).

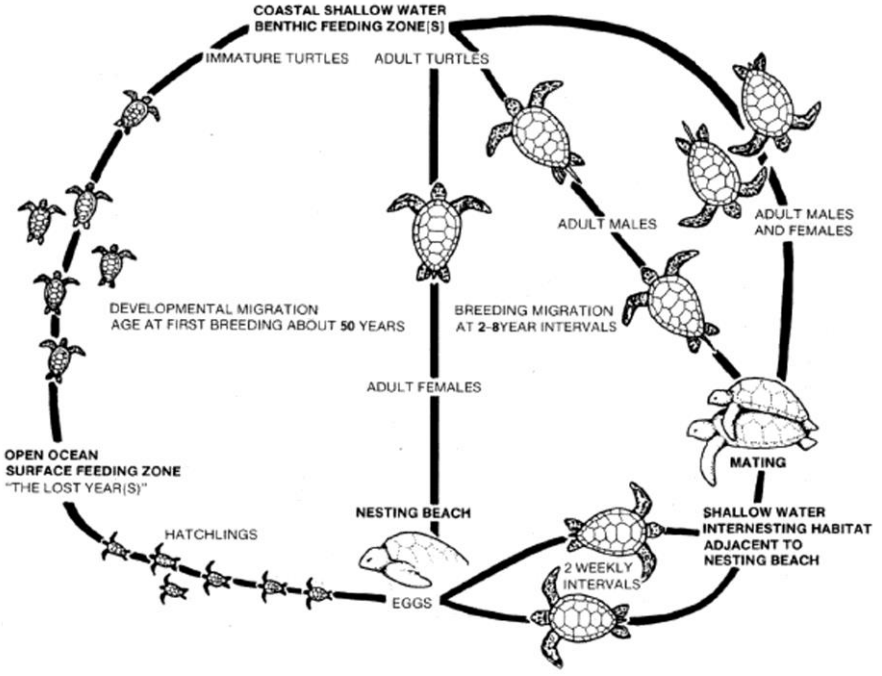

Figure 2. Generalized life cycle of sea turtles; the main differences between species are the areas where each phase takes place. In some cases all phases can happen close by and in another times they can take place at the other side of entire oceans. Green Sea Turtle Life Cycle http://www.gulfturtles.com/interesting-turtle-facts.

Sea turtles take an average of 25 to 30 years to reach sexual maturity depending on the species. This time is expended at their foraging areas that are usually located on coastal lagoons or very close to shore. It has been observed that there is a change between diets along the life of sea turtles. They can be omnivores, carnivores or herbivores at different stages (Riosmena-Rodríguez et al. 2011).

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Sea Turtles around the Peninsula of Baja

It has been well established that food resources are plentiful around the peninsula of Baja that has resulted in a high biodiversity for the region (Zaytsec et al. 2003). Sea turtles are also beneficiaries of food supplies and areas of refuge. There are five species of sea turtles that inhabit the region: *Caretta caretta* (loggerhead), *Chelonia mydas* (green turtle), *Dermochelys coriacea* (leatherback), *Eretmochelys imbricata* (hawksbill), and *Lepidochelys olivacea* (olive ridley).

Photo Monica Lara Uc.

Figure 3. Loggerhead turtle from Bahía Magdalena, a coastal lagoon in Baja California Sur, México.

Even though there are five species present in the area, three of them use the region most commonly for feeding and during interbreeding periods: loggerhead, olive ridley and green sea turtle. In the other hand, olive ridley and leatherback turtles are the most common nesting species in the south of Baja; the second one nest on very low densities. Occasional reports of nesting by other species are also known, but confirmation of major nesting populations is still needed.

Sea turtles are great travelers and live in most oceans of the world. One of the most impressive migrations is the one conducted by loggerhead sea turtles. They use the coastal waters in the Pacific side of the peninsula, known as Golfo de Ulloa, as foraging grounds. In these waters, they feed mainly on red crabs (*Pleuroncodes planipes*) that also congregate in the

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area to reproduce. Once they reach sexual maturity they travel thousands of miles to Japan to nesting grounds, a trip that can take different lengths of time. A special case was "Adelita", a loggerhead turtle that took over a year to cross the entire Pacific Ocean (Nichols et al. 1997).

Figure 4. Green sea turtle being released after sampling in Bahía Magdalena.

Olive ridley turtles are also abundant in the area and nest in considerable numbers in the south of the peninsula. They are known residents of the waters of the Gulf of California and use coastal areas both in the peninsula and mainland for nesting. There has been long-term efforts for their protection and recovery for the past 15 years; different NGOs and government agencies have established programs to protect nesting areas, females and their nest, supported by other activities to promote also juvenile protection.

THREATS IN BAJA CALIFORNIA

Beside natural mortality of sea turtles, human interactions represent a major threat to species survival (Peckham and Nichols 2006). At nesting

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grounds, birds, raccoons, snakes, crabs, and some feral animals, e.g. dogs and pigs, are responsible for a large mortality of newborns and the loss of eggs. Once babe turtles reach seawater, there are plenty of predators that reduce their survival until reaching adulthood. Sharks and large fishes are common predators of sea turtles at different life stages.

Photo Jorge A. Vega Bravo.

Figure 5. Olive Ridley turtle coming ashore for nesting.

Sea turtles have a long history of human use in the Peninsula and the threats related to human activities are extensive. Ethnic groups in the region used turtle meet as a source of protein, oil and used in the treatment of some diseases, same use that is still attached to traditions in the region, even though current legislation has established a permanent ban on sea turtle consumption and extraction in all Mexico (Dawson 1945, Caldwell 1963, Delgado and Nichols 2005). Sea turtles were commercially exploited for many decades in the southern state of Baja, catches were sent to international markets live or canned. The extraction of sea turtle species reach a maximum around the 50's and population experienced a drastic decline that pushed the Mexican government to create quotas in the 70's and then a permanent ban in 1990 (Mancini and Koch 2009). One of the most threatened species is the hawksbill that possesses a magnificent

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carapace, used in jewelry and as a coin even more valuable than gold in Asia some centuries ago.

The region of Baja California is considered as a paradise due to the beauty of the landscape, the beaches and the diversity of species that can be appreciated. This has propelled the development of tourism as one of the main economic activities for the peninsula, but mostly for the southern state. This has resulted on the loss of many nesting beaches that have been modified by hotel and restaurant constructions or preventing free access to beaches by nesting sea turtles. Also the use of off-road vehicles and human traffic on the shore are another threat since nest can be destroyed or the sand on top of them compacted, making it harder for babe turtles to get to the surface of the beach and reach the ocean.

Some organization have actively participate in the establishment of conservation programs to prevent these problems in collaboration with the local government and tourist operators, such is the case of Los Cabos Municipality that created a multidisciplinary program for sea turtle conservation that includes tourist operators, local NGOs, government agencies and local communities.

Another important factor that has affected sea turtle populations in the Gulf of California and the Pacific coast of the peninsula is fisheries. Since this activity is probably the most important for the economy, and also the most traditional, for the region, the number of fishermen and the gear that is used to catch the many resources that are exploited have led to high mortalities of sea turtles and a major challenge to harmonize development, sustainability and conservation (Gardner and Nichols 2001). Reports of by-catch have been made on regular bases, as reported by organizations such as the School for Field Studies (SFS) in Puerto San Carlos (research in Bahía Magdalena) and the Grupo Tortuguero de Las Californias (research and work on the entire Peninsula) for more than 10 years. The problems in the region were species specific, loggerheads showed some evidence of interactions with fishing nets but were drop into the water and washed up dead on the sore sometime after (Peckham et al. 2007). In the case of green sea turtles, fishermen target individuals to be consumed; even though the restrictions by federal legislation do not allow any type of extraction or use. Turtles are considered a delicacy in the region and consumed on regular bases.

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Figure 6. Sea turtle remains of a harvested individual from the Bahía Magdalena region that are commonly found at dumps and around coastal towns.

Mancini and collaborators reported in 2009 the existence of a very lucrative black market that extended along the peninsula. After many years of environmental education and constant efforts by SFS, Grupo tortuguero, Vigilantes de Bahía Magdalena and others, there was some evidence that consumption was reduced, or maybe fishermen were working harder to hide the evidence of consumed turtles, but the continuity and expansion of sea turtle festivals in the region ought to have an effect at different scales on the reduction of sea turtle fishing (Delgado and Nichols, 2005).

Even though the above-mentioned signs of reductions on turtle consumption, recovery of sea turtles is a complex matter and cannot be achieved without community participation. The challenges for conservation of these emblematic organisms are species specific, knowledge about species distribution and the sites used by them call for the implementation of various strategies.

For example, species with the longest distributions such as the case of loggerheads, depend not only on the work that is conducted in Mexico, but also on the collaboration of other countries such as Japan, USA and other users of international waters.

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Figure 7. A black turtle caught in our nets to be measured, weighted and tagged to understand the current status of the population in Bahía Magdalena. This species has been constantly targeted by fishermen since it is considered a delicacy in the region.

In Baja, the creation of a ground base organization called Grupo Tortuguero facilitated the participation of fishermen and other community members in the conservation efforts for sea turtles in the region.

Community members that were worried about decreases on turtle populations accepted to participate on the monitoring of the various species at nesting grounds and feeding areas. The information that is generated is used to follow up on turtle abundance and for the development of management strategies in collaboration of government agencies.

In 1990, the Mexican government issued the law for a complete ban on sea turtle consumption to prevent poaching, extraction and the use of any products of sea turtle, e.g. skin, shells and eggs (DOF 1990).

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Figure 8. Data collection is critical to understand the status of the various species of sea turtles. Work for conservation needs to be inclusive, multi-specific, and cover all the stages of their life cycle.

This law has been effective to some extent but isolation and the extent of the Baja region have prevented it from being a complete success. Sea turtle consumption is still attached to tradition and capture for food or to be sold on the black market are still common practices. These activities together with by-catch and natural mortality, result on sea turtles facing an uncertain future that has push some species such as leatherback and hawksbill turtles close to extinction.

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Figure 9.Taking information from sea turtles by staff and students from the School for Field Studies.

In addition to current conservation efforts, there is some support actions that can be implemented in Baja to reduce turtle mortality and increase the impact of already existing regulations. First of all, we consider that environmental education needs to be a priority in the communities and taught at local schools. Education creates awareness and younger generations are more likely to assimilate conservation as a source of economic benefit for them now and in the future. Sea turtle species can be used as flagship or umbrella species that promote conservation of other resources in the region.

It is clear that fishermen fear for their future, as declines of many fisheries have been observed worldwide but also in the region of the Gulf of California and Pacific coast of Baja. Some organization are already working on strategies to restore fishing stocks of various species in the area, some go even further to implement ecosystem conservation to increase resilience of the fisheries and the consequently of the coastal communities, but further work is needed (Micheli et al. 2012). It is not correct to consider sea turtle conservation as a new trend in the Peninsula, a history of more than 20 years of work by different groups talks about concerns for this species after the commercial

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collapse of sea turtle's fishery and further depletion of turtle populations in the region (Peckham and Nichols 2006). Narratives from fishermen show the close relation that they keep with sea turtles, older fishermen recall the large amounts of turtles of "enormous sizes" used to be a common component of the bay's fauna. Middle age generations express how large carapaces were used to slide down sand dunes for fun (Personal comments by A. Romero). This kind of comments make it evident that we need to work to prevent the permanent disappearance of these species from the regional folklore. There is interest by fishermen for their children and grandchildren to be able to witness and interact with these extraordinary marine animals.

Nevertheless, interactions between fisheries and sea turtles is still one of the main and most complicated issued threatened their conservation. The agendas between socio-economic development and conservation have not been able to reach sustainability. Fishing gear used in the region still results on a high by-catch of turtle species but no current alternative seems to be close to replace such gear. Coastal communities depend highly on extraction of marine products for their living and fishing tradition is still a reality for the Baja peninsula, therefore creative alternatives to harmonize human activities and sustainability is a priority for the success of conservation measures.

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