BIOLOGY AND CONSERVATION OF SEA TURTLES IN BAJA CALIFORNIA, MEXICO

by

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STATEMENT BY AUTHOR

ACKNOWLEDGEMENTS

In my first meeting as a graduate student I sat on one side of a large rectangular table in Room 1 in the basement of the Biological Sciences East Building at the University of Arizona. Facing me were an ichthyologist (Dr. Donald Thomson), a wildlife ecologist (Dr. Cecil Schwalbe), and an emeritus sea turtle biologist (Dr. John Hendrickson). After presenting my proposal to study the biology and conservation of sea turtles in Baja California for my doctoral research I was surprised by their response.

"There really aren't enough turtles left to accomplish your goals in a reasonable amount of time," I was told.

With that we set out on what has become nearly a decade of sea turtle research, conservation and education that has reached south to Central America and west to the waters off Japan.

Since that day my advisors have provided enthusiastic research advice, constructive criticism and professional guidance as my efforts have been seemingly guided by the wind. I first thank all of them and especially Jeff Seminoff for their encouragement and friendships.

In the field, especially during the first months of research, the help of many experienced fishermen probably saved my life. Left to my own devices it is likely that I'd be tangled in a mass of turtle net adrift on the sea, somewhere between Mexico and Japan. I cannot adequately explain the patience of the men who assisted this project. *Mil gracias* to all of the fishermen who have taught me, and who have opened their boats, homes, kitchens, and minds to me.

Antonio and Bety Resendiz have been wonderful colleagues to work with, but also role models and friends. Their commitment to the conservation of marine resources in Bahía de los Angeles sets a standard few can meet but all aspire to.

A large, diverse group of people, friends, family, organizations and foundations has contributed in many ways this work. To all of them I owe my confidence in and commitment to the belief that in learning and education lie the restoration and conservation of much of the world's biological diversity, wilderness, and natural resources. As there are literally thousands of names to mention, and at the risk of leaving one out I'll simply say, thank you.

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ABSTRACT

I studied the in-water anthropogenic impacts on sea turtles, origins of sea turtles on foraging and developmental areas, their migration routes, and described regionally appropriate conservation needs. Sea turtles inhabiting Baja California waters originate on distant beaches in Japan, Hawaii, and southern Mexico. Results from genetic analyses, flipper tagging and satellite telemetry indicate loggerhead turtles (*Caretta caretta*) feeding along Baja California's coast are born in Japan and make a transpacific developmental migration of more than 20,000 km, encompassing the entire North Pacific Ocean and that East Pacific green turtles (*Chelonia mydas*) originate on and return to rookeries in Michoacan, and the Islas Revillagigedo, Mexico. Hawksbill turtles (*Eretmochelys imbricata*), once the target of a lucrative fishery for their shell, are now extremely scarce and only juveniles were encountered. The region's importance to the biology of sea turtles, regionally and Pacific-wide, warrants urgent conservation action.

While protected legally, sea turtles are subject to furtive hunting and incidental catch. Coastal development, pollution, and boat collision are secondary threats. Annual consumption of sea turtles in the region is estimated at between 7,800 and 30,00 animals. Sea turtles are eaten regularly in most coastal communities and turtles are considered an irreplaceable traditional food. The decline of sea turtles in these waters has cost us both ecologically and culturally.

Sea turtle recovery in Baja California, as all conservation activities, will be a matter of cultural and social evolution. For recovery to occur, strong, community-based incentives and educational programs are needed. In the near term, increased enforcement

efforts, monitoring of mortality, and establishment of sea turtle sanctuaries are among the solutions. Without expansion to include community-specific initiatives such efforts may be futile.

A long-term, multi-faceted sea turtle “conservation mosaic” program has been launched, consisting of community-based research on life history and population biology, an international education and public outreach campaign, regional sea turtle conservation areas, a monitoring and stranding network, and several policy initiatives that will permanently protect sea turtles and their habitat.

GENERAL INTRODUCTION

Published information regarding the life history, conservation, and management of sea turtle populations occurring along the Baja California peninsula, México, is insufficient relative to the ecological and cultural importance of this endangered group. Despite a long history of sea turtle exploitation in northwestern México (Townsend 1916, Caldwell and Caldwell 1962, Caldwell 1963, O'Donnell 1974, Felger et al. 1976), the precipitous decline in population sizes (Cliffton et al. 1982, Fritts et al. 1982, Alvarado and Figueroa 1990), and the vulnerable status of each of the five species occurring in the region (Nichols 1999b) scant information is available on their biology, and conservation efforts in the region have been minimal. The vast majority of research and conservation programs conducted along the Pacific coast of Latin America have focussed on sea turtle nesting beaches (Pritchard and Cliffton 1981, Cliffton et al. 1982, Cornelius 1982, Green 1984, Alvarado 1989, Briseño-Dueñas and Abreu-Grobois 1994). Very few studies have considered the anthropogenic impacts on sea turtles in the water, nesting beach origins of turtles on foraging grounds, the pelagic developmental stages, migratory routes or the location and demographics of populations on neritic feeding and developmental grounds—all critical components of a regional species recovery plan (Bjorndal 1999, Limpus et al. 1999).

My overall goal is to produce new information on the biology, life history—particularly those aforementioned aspects—and management of Baja California’s sea turtles, and to consolidate available information from published and unpublished sources. Second, I hope that this project will help initiate an integrated approach to and ongoing dialog concerning recovery, conservation and investigation of these endangered populations of sea turtles. Finally, I hope to present my findings and ideas in clear, easily understandable prose so that they will be easily accessible to the fishermen, conservationists, students and resource managers who take it upon themselves to work towards sea turtle recovery in the Baja California region.

Organization of the Project

This project has been carried out in three parts: 1) identification and description of the problem and initial conditions, 2) formulation of approach, field logistics, data collection and analyses, and 3) dissemination, evaluation and implementation of results and recommendations. The first part, comprised of review of sea turtle literature and reconnaissance surveys of conservation projects along the Mexican coast, led to identification of the indisputable need for research, education, and conservation efforts on critical sea turtle feeding and developmental grounds in Baja California, México (steps I-II). The second part focussed on practical elements of project development and investigation including defining my research hypotheses, permit and funding acquisitions, field logistics, data collection and data analysis (steps III-V). In the final part (steps VI-VII) I shared findings with the scientific community, resource managers, and the general public and initiated the formation of regional conservation network and species recovery teams, focussing on identified problems and utilizing the new biological information.

PART I: Reconnaissance and literature review**.**

Step 1 (1993-4)**:** Survey of relevant sea turtle nesting beaches and conservation camps in México; inventory of literature on sea turtle (published and unpublished). I visited more than 50 sea turtle conservation projects in México to learn about the biology of sea turtles, to meet those working in the field and to assess the needs for further research and conservation efforts. Based on those visits and interviews as well as the paucity of published information, I determined that there was a strong need for research and protection of sea turtles during their pelagic and neritic, developmental, and foraging stages.

Step 2 (1994)**:** Survey of sea turtle feeding areas in northwest México, the coasts of Sonora, Baja California and Baja California Sur. Jeffrey Seminoff and I visited the principle sea turtle foraging areas in northwestern México. I also began a series of interviews with fishermen and resource managers in order to determine the feasibility of a large-scale study and the social and cultural climate towards such a project.

PART II: Field operations, data collection and logistics.

Step 3 (1994-8)**:** Funding and permits for in-water investigation of sea turtles on Baja California feeding grounds (Appendix B). Funding largely consisted of small grants and assistance from organizations such as the Wallace Research Foundation and the National Geographic Society, educational collaborations with schools like Rivers School (Wellesley, MA), E.H. Green School, and Sycamore Junior High School (Cincinnati, Ohio) as well as eco-tourism partnerships with universities and non-profit organizations such as Earthwatch Institute, Coastal Conservation Foundation, and School for Field Studies (Boston University). Acquisition of funding was approached as a conservation education project in itself and a diversity of funding sources were sought and long-term relationships developed with each source. Research permits were applied for via the U.S. Embassy (Mexico City) Science Office and issued by Mexico's Secretariat of

Environment (SEMARNAP) [, National Institute of Ecology (INE), and CITES (Appendix B).

Step 4 (1995-1999)**:** Investigation. I conducted surveys for pelagic turtles, capture and release of sea turtles, satellite telemetry deployments, collection of tissue samples and laboratory genetic analyses, collection of morphological data, collection of stomach contents, and collection of data on stranding and incidental catch. I continued interviews with fishermen and members of fishing communities (Appendix C).

Step 5 (1998-1999)**:** I performed analyses of data on sea turtle demographics, molecular genetics, biotelemetry, morphometrics, mark-recapture, and documented strandings/incidental catch, by region and by year.

PART III: Outreach, publication and management planning.

Step 6 (1998-2000): Dissemination of results in a variety of forms including writing of this dissertation, scientific publications and reports, educational lectures and workshops, popular press articles, internet webpages, e-mail listserves, television and video programs, Sea Turtle Conservation Network of the Californias meetings, and International Sea Turtle Symposia. Through the course of this project, inadequate knowledge of sea turtle life history was deemed a major impediment to recovery efforts. During this step I focused a portion of my time and energy on the dissemination of results via a variety of educational and media outlets, meetings, and informal gatherings (Appendix D).

Step 7 **(**1998-2000**)**: I initiated recovery planning, management, and conservation efforts, beginning with short informational lectures/discussions in fishing communities, followed by the formation of the community-based Sea Turtle Conservation Network of the Californias (Grupo Tortuguero de las Californias) and participation in the international Black Turtle Working Group meetings (Nichols and Arcas 1999). I initiated a recovery plan for sea turtles in waters of the Californias. Through the newly formed conservation team, WiLDCOAST, the formation of international and regional alliances, focusing on marine conservation and the recovery of endangered species, is a continuing priority.

Organization of the Dissertation

The dissertation has nine chapters. The first chapter is an overview of our current knowledge of sea turtle biology in Baja California. The majority of this information is based on original research and interviews in Baja California but is supplemented by information from various reports, unpublished theses, and scientific publications. I present a simple key and guide for the identification of the five species of sea turtle, descriptions of turtle taxonomy, a list of common English and Spanish names, and a discussion of aspects of their biology relevant to conservation and recovery.

The second chapter describes the subsistence and commercial use of sea turtles in Baja California. I researched unpublished historical fisheries data, collected direct observations, and conducted more than 200 interviews and surveys. Capture numbers, locations, methods and traditional beliefs associated with sea turtles are described.

In the third chapter I describe sea turtle mortality patterns for the region based on stranding rates, consumption rates and known mortality of tagged turtles.

In the fourth chapter I present the results of the first use of satellite telemetry to track the transpacific movement of a captive-raised loggerhead turtle.

Chapter five presents the results of satellite telemetry studies of adult East Pacific green turtles tracked from Baja California foraging grounds. Movement of turtles was monitored between Baja California and nesting beaches in Michoacan, the first documentation of homing migration by East Pacific green turtles.

In chapter six I describe the stock composition of East Pacific green turtle aggregations on Baja California's Pacific coast and Gulf of California feeding grounds, utilizing molecular genetic techniques (mtDNA).

Chapter seven is a taxonomic and morphological description of the East Pacific green, or "black", turtle and a contribution to resolution of its highly debated taxonomic status. I also elaborate on several important factors relevant to green turtle conservation.

Chapter eight is a description of the "conservation mosaic" approach I have taken while developing sea turtle conservation programs in Baja California. I present the successes and benefits of a community-based conservation approach to sea turtle recovery, as well as the positive results obtained through multi-media educational and outreach campaigns.

The final chapter presents conclusions and recommendations for management strategies, a list of critical areas and habitats, and a summary of important research findings.

Description of the Region

The waters of Baja California provide some of the richest fishing grounds in México (Casas Valdez 1996) as well as a high level of endemism (Thomson et al. 1979). For the same reasons the fishing is so productive, sea turtles once occurred in large numbers, feeding on abundant algae, sea grasses, and invertebrates (Seminoff 1998). The coastline is impressively varied but can be generally characterized as a mosaic of shallow lagoons or *esteros* and rocky headlands interspersing long, wide sandy beaches on the Pacific coast and a rocky coastline interspersed with short narrow beaches and small bays on the Gulf of California coast. The cape region of Baja California has wide sandy beaches suitable for sea turtle nesting. Along both coasts of the peninsula, Pacific and Gulf of California, there are large numbers of near and offshore islands and *islotes*, some of volcanic origin and most characterized by steep, rocky cliffs and surrounded by rocky reefs (Thomson 1979). The region holds a diversity of temperate and tropical habitats, including mangrove swamps, estuaries, seagrass beds, rocky reefs, mud flats, salt marshes, sandy beaches and numerous coves, bays, and lagoons. This diversity of environments, combined with the wide range of physical factors (temperatures range from 10º C to 32º C), and nutrient rich waters, have allowed all five Pacific sea turtle species to flourish along this coast.

Physical description

The Baja California peninsula extends southeastward from the southern border of the state of California, USA (Figure 1). The separation of the peninsula from the mainland and its movement along the San Andreas Fault resulted in the formation of the Gulf of California (*Golfo de California*), also known as the Sea of Cortez, to its east. The Gulf of California extends from the Colorado River delta in the north to roughly the line drawn from Cabo San Lucas, Baja California Sur, to Mazatlán, Sinaloa. To the west is the Pacific Ocean. The peninsula itself is about 1,600 km in length with 3,500 km of coastline and more than 200 nearshore islands and *islotes*. The coast consists of variably rocky shorelines, long sandy beaches, coastal lagoons, and estuaries. The Gulf of California coast is predominantly rocky whereas the Pacific coast is largely sand or mud with occasional rocky headlands (Figure 2). Numerous shallow bays and coves (Figures 4 and 5) punctuate both coasts and the Pacific coast has several extensive lagoon systems (Figure 6) containing mangrove and sea grass beds. The diversity of topographic and bathymetric features of the Baja California coast provides a wide variety of environments for marine life (Thomson et al. 1979).

Waters along the peninsula are strongly influenced by the California Current System (Miller et al. 1999) (Figure 3) and tidal flow in the Gulf of California. During the winter and spring months, the combination of upwelling and currents from the north produce lower sea surface temperatures and high productivity. The Davidson Counter-current from the south generally displaces the California Current in summer and fall months, resulting in higher surface water temperatures over the shelf (Wyrtki 1965).

Annual sea surface temperatures in the northern Gulf of California range from below 10˚C during winter to 32˚C in summer. In the central and southern Gulf of California, temperatures do not fluctuate as widely. On the western coast of Baja

California the temperature range is moderated by the Pacific Ocean and does not reach such high temperatures in summer. However, there is a clear north-south temperature gradient and El Niño cycles can influence temperature patterns. Seasonal nutrient-rich upwelling occurs along both coasts (Briggs 1974).

Demographics

The Baja California peninsula, composed of two Mexican states—Baja California (BC) and Baja California Sur (BCS)—has always been relatively sparsely populated, especially prior to the construction of the transpeninsular highway in the mid 1970's. Major urban centers occur in the extreme north (Tijuana, Mexicali, and Ensenda, Baja California) and south (La Paz and Cabo San Lucas, Baja California Sur), and hold more than 80% of the region's population. Throughout the peninsula are scattered more than 3,000 small towns, fishing communities and seasonal encampments, wish more than 200 permanent coastal settlements. Fishing, agriculture and tourism are the main industries with the exception of growing industrial operations along the US border. During the past 30 years the population has consistently grown at rate greater than the national rate (de la Torre, 1998).

Fisheries

The waters around the Baja California peninsula, including the Gulf of California (henceforth referred to as "Baja California waters"), are considered some of the most important fishing zones in México and yield more than half of the annual volume of fisheries production. The principal species captured are sardine (*Sardinops sagax caerulea*, *Opisthonema* spp.), anchovy (*Engraulis mordax*), shrimp (*Penaeus* spp.), and tuna (*Thunnus albacares*), but of the approximately 100 commercially exploited species along México's Pacific coast, 75% are present in Baja California waters (Arizpe 1998). The total fishing fleet is estimated at 4,200 vessels in addition to the artisinal fleet, which consists of more than 16,000 small skiffs with outboard motors, called *pangas* (INE 1996).

According to Garcia et al. (1996) the shrimp fishery is the most important in terms of income and employment in northwest Mexico and represents the vast majority of the large-scale commercial fishing fleet (INEGI 1995). According to 1998 SEMARNAP fisheries data estimates, shrimping effort has expanded in Pacific Baja California waters in recent years, including an influx of shrimpers from Mazatlán, Sinaloa and Guaymas, Sonora. The regional shrimp fishery represents 75% of the Pacific coast production and more than 50% of the national production (Table 1). The Mexican shark fishery is considered the largest in the Americas and Baja California waters have been the site of much of this exploitation in recent years.

Despite this rich diversity and abundance of valuable marine resources, the regions fisheries can best be characterized by a pattern of overexploitation and under-management. This has led to commercial extinction of several once important species, such as marine turtles and mammals, grouper, and pearl oysters, and the vulnerable status of others, such as several species of shark, mollusk, and crustacean species. The importance and magnitude of the commercial shrimp industry in the region has grave consequences for artisanal fisheries as well as sea turtle recovery.

Tourism

Baja California and the Gulf of California draw large numbers of tourists each year. The main tourist centers in the region include Cabo San Lucas, Loreto, and La Paz, Baja California Sur; Mazatlan, Sinaloa; and San Carlos, Sonora. In addition, tourists drive from Arizona and California to many of the region's smaller coastal communities. Tourism activities include sport fishing, SCUBA diving, kayaking, sailing, beach combing, whale watching, camping, and archaeological sightseeing. However, many tourists simply come for the sun and the beach.

There are four major marine protected areas in the region comprising almost 1,300,000 ha (Table 2). These areas indirectly protect critical sea turtle foraging habitat as well as a wide variety of marine species and resources. Marine protected areas also provide adventure travelers and sports enthusiasts with an unparalleled natural outdoor experience.

Recent increases in the tourism industry, particularly in Baja California Sur and the Cape region, have been a mixed blessing (Young 1999). While providing the local population with a wider array of economic possibilities, tourism has also brought pollution and development on sea turtle nesting beaches (R. Pinal, pers. comm.). Unchecked development continues in many coastal communities and lighting, traffic, and pollution on beaches will result in diminished numbers of nesting sea turtles. In addition, the growing population needed to service the expanding tourism industry includes immigrants from southern states where turtle egg poaching and consumption is common. As the human population increases, the demand for sea turtle products will continue to grow.

In summary, the Baja California waters hold extensive, highly diverse, and productive marine ecosystems as well as a high degree of endemism. The region is primarily populated in concentrated urbanized areas. However, population and development have increased exponentially over the past 30 years. Well-developed commercial and artisanal fisheries encompass virtually all of the coastal areas. Fishers utilize primarily trawls, gill nets, and hook and line gear. The region is considered Mexico’s most productive in terms of annual fisheries yields. As such, sea turtle population recovery and conservation efforts face issues related to commercial fisheries expansion and industrial development, and the pressures of a growing, increasingly urban, population. Existing and proposed marine protected areas may provide a refuge for some vulnerable species. An increased knowledge of the sea turtles in these areas and their life histories will aid recovery efforts. An understanding of the historical and cultural significance of sea turtles in the region must inform recovery and conservation efforts.

Description of main study areas

Bahia de los Angeles, Baja California. Approximately 12 km wide, Bahía de los Angeles (28º 58' N, 113º 33' W) is protected from the open gulf by 17 rocky islands/*islotes* and the offshore Isla Angel de la Guarda. The bay is a NNE-oriented shallow sandy inlet bordered by several rocky bluffs. Mean monthly sea surface temperatures range from 14º C to 30º C (Robinson 1973). Marine algae are abundant in the bay, predominantly *Sargassum johnstonii* and *Gracilariopsis lemaneiformis* (Pacheco-Ruíz and Zertche-González 1996a, Pacheco-Ruíz and Zertche-González 1996b, Pacheco-Ruíz and Zertche-González 1996c).

Laguna Guerrero Negro, Baja California Sur. This lagoon is located near the border between Baja California and Baja California Sur (from 27 57' 00" to 28 06' 00" N and 114 04' 00" to 114 11' 00" W) and has a surface area of approx. 2100 ha. It is part of the Ojo de Liebre lagunal complex and opens into Bahía Sebastian Vizcaíno on the Pacific coast of the Baja California peninsula. Seagrass beds (*Zostera marina* and *Ruppia maritima*) are important habitat for migratory birds such as the Brandt's goose (*Branta bernicla*) and sea turtles. The gray whale (*Eschrichtius robustus*) arrives here to calve and mate during winter and spring. Important fisheries resources such as crabs, clams, scallops, and fish occur in the lagoon. The lagoon has suffered considerable contamination due to the proximity to the town of Guerrero Negro.

Laguna Ojo de Liebre, Baja California Sur. Part of the same lagoon complex as Laguna Guerrero Negro, this body of water is located between 27 35' 00" and 27 55' 00" N and 113 58' 00" and 114 10 00" W. This region has a dry climate and cold air temperatures in winter (18º C). The lagoon is larger than Guerrero Negro and reaches a depth of 16m in the channels. The company Exportadora de Sal, S.A. (ESSA) uses surrounding salt flats to produce commercial salt. *Zostera marina* is abundant in the extensive network of canals. *Spartina* sp. and *Salicornia* sp. dominate the muddy intertidal shores of this lagoon.

Laguna San Ignacio, Baja California Sur. Located 700 km south of the U.S.-Mexico border between 26º 43' and 26º 58' N and 113º 08' and 113º 16' W, Laguna San Ignacio forms part of the 2.5 million ha El Vizcaíno Biosphere Reserve. The lagoon has a surface area of approximately 17,500 ha and a depth that permits boat entry. The lagoon has extensive seagrass beds and mangrove swamps lie just south of the mouth. The lagoon is also an important reproductive area for the gray whale as well as several species of migratory seabirds and sea turtles.

Punta Abreojos, Baja California Sur. Estero la Bocana and Estero Coyote lie to the north and south, respectively, of Punta Abreojos, a fishing community focused mainly on lobster and abalone. These small, shallow *esteros* are relatively pristine and contain seagrass and algae beds. Offshore the rocky coasts of Punta Abreojos are several seamounts, important fishing areas for the local community as well as areas of frequent loggerhead sightings.

Bahía Magdalena, Baja California Sur. This lagunar system (Santo Domingo-Magdalena-Almejas) extends 175 km (from 25º 43' N to 24º 20' N) along the Pacific coast of Baja California Sur, communicating with the Pacific Ocean through five mouths or channels. This lagoon system is the largest and most diverse in the region. Vegetation includes vast seagrass beds (*Zostera marina* and *Phyllospadix* sp.), algae beds and mangrove swamps. A wide variety of commercially exploited species are known in these bays as well as many migratory seabirds, marine mammals and fishes. Of note are the dense aggregations of pelagic red crabs (*Pleuroncodes planipes*), found in spring just outside the bay's mouths, that provide abundant food to squid, fish, birds, sea turtles and marine mammals.

Bahía de Loreto, Baja California Sur. The 206,000 ha area around Loreto is protected as a National Marine Park. Four major islands and several *islotes* lie within park boundaries. The relatively warm waters of this region support a diversity of tropical species. Abundant algal beds and invertebrate populations make this an important sea turtle foraging area.

Historically, each of these study areas supported commercial sea turtle fishing activities. Green turtles (*Chelonia mydas*) were the primary target species. However, along the Pacific coast loggerhead turtles (*Caretta caretta*) and olive ridley turtles (*Lepidochelys olivacea*) were commonly hunted, and along the southern Gulf of California coast a hawksbill (*Eretmochelys imbricata*) fishery was active in Loreto and La Paz, Baja California Sur. An active fishery for leatherback turtles (*Dermochelys coriacea*) is not reported for the region; however, subsistence egg collecting on southern nesting beaches was common.

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Table 1. Shrimp production for northwestern México relative to total national production for 1997/1998 (SEMARNAP fisheries data).

Region/State	Production (mt)	
	1998*	1997
BAJA CALIFORNIA	315	107
BAJA CALIFORNIA SUR	347	97
SONORA	3,957	4,595
SINALOA	11,538	6,630
NAYARIT	1,797	1,440
JALISCO	0	0
COLIMA	243	222
MICHOACAN	0	0
GUERRERO	62	55
OAXACA	1,299	899
CHIAPAS	1,846	1,778
Baja California/ Gulf of California waters	~16,157	~11,429
Pacific Coast	21,406	15,823
Gulf of México / Caribbean	8,603	8,762
TOTAL (all of México)	30,009	24,585

* estimated 1998 harvest

Table 2. Marine protected areas of the Baja California peninsula and Gulf of California region. NMP=National Marine Park. Source: Unidad Coordinadora de Áreas Naturales Protegidas, SEMARNAP.

Name	State	Type / Date decreed	Area (ha)	**Ecosystem**
Upper Gulf and Colorado River Delta	Son., BC	Biosphere Reserve 1993	934,756	Marine and coastal lagoons
Gulf Islands	Son, Sin., BC, BCS	Special Biosphere Reserve 1978	150,000	Terrestrial, islands, desert
Vizcaíno	BCS	Biosphere Reserve 1988	2,546,790	Pacific lagoons, mangroves, islands, Gulf coast, terrestrial
Cabo Pulmo	BCS	NMP 1995	7111	Coral reef
Bahía de Loreto	BCS	NMP 1996	206,581	Marine and islands
Total			3,845,238	

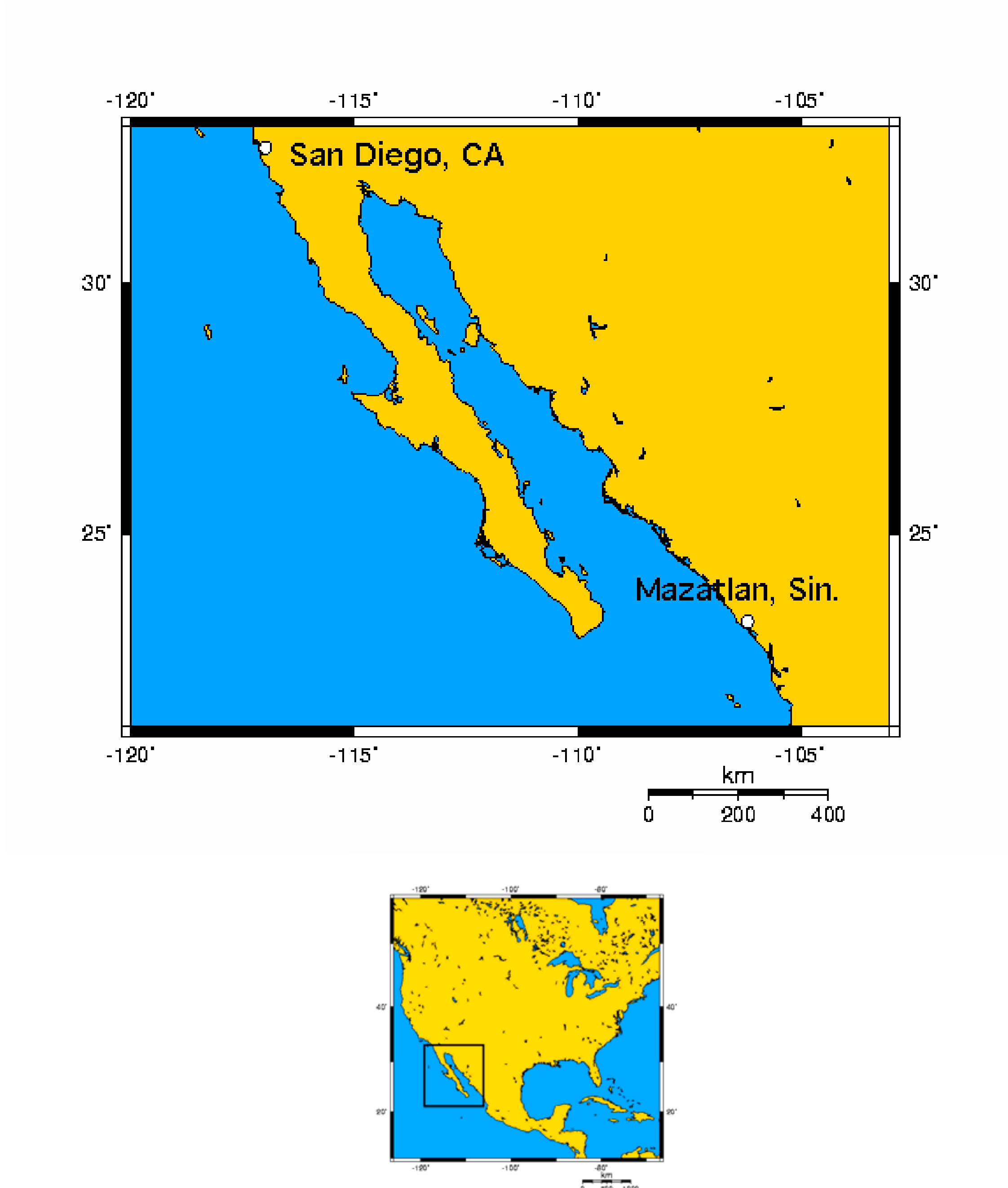

Figure 1. Location of the Baja California peninsula, México (within box) relative to the North American continent.

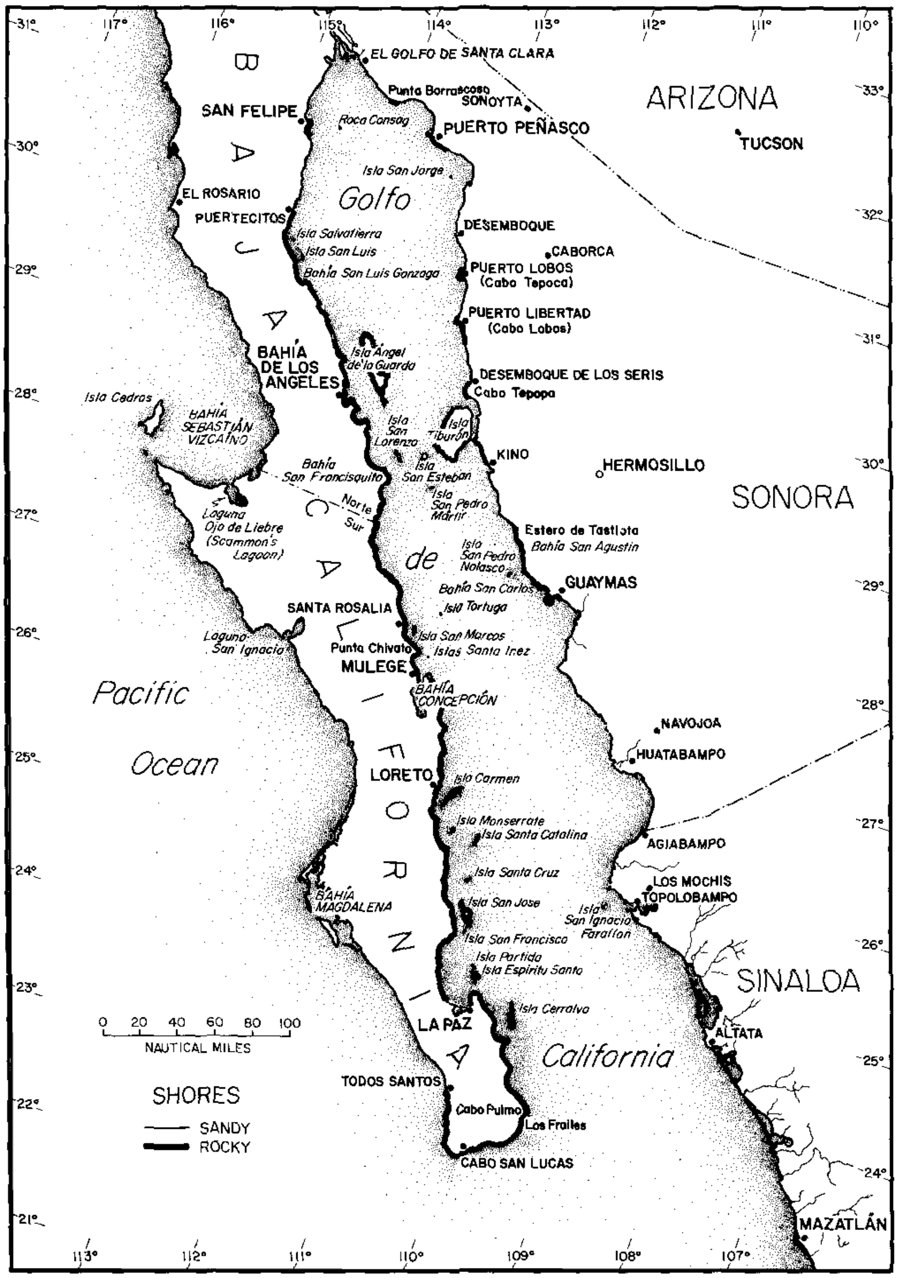

Figure 2. Map of the Baja California peninsula indicating the extent of rocky and sandy coastlines in the Gulf of California and primary study areas (from Thomson et al. 1979).

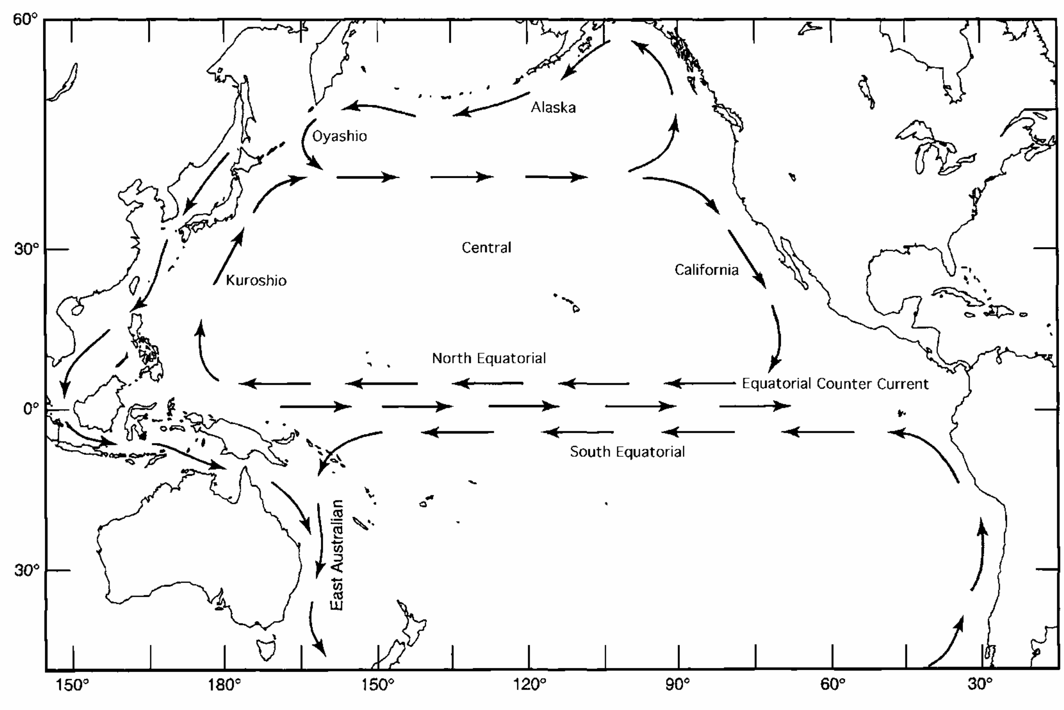

Figure 3. Major surface currents of the North Pacific Ocean (adapted from Wyrtki 1965).

Figure 4. Gulf of California rocky island environments in Bahía de los Angeles, Baja California, México.

Figure 5. Barrier island beach, typical of Baja California's Pacific coast. Isla Magdalena, Baja California Sur, México.

Figure 6. Pacific coast lagoon: sea grass and mangrove ecosystem. Estero Banderitas, community sea turtle conservation area in Bahía Magdalena, Baja California Sur, México.

CHAPTER 1

Aspects of Sea Turtle Life History in Baja California, Mexico

ABSTRACT

Five species of sea turtle occur in waters of the Baja California peninsula. The most common species, the green turtle (*Chelonia mydas*) and the loggerhead turtle (*Caretta caretta*), use the region primarily as developmental and foraging habitat. They originate on nesting beaches as far away as southern Mexico and Japan, respectively. The two species known to nest in Baja California are the olive ridley turtle (*Lepidochelys olivacea*) and the leatherback turtle (*Dermochelys coriacea*). The Baja California coast represents the northern extreme of the nesting range for both species. The hawksbill turtle has become exceedingly rare in waters along the peninsula due to the fishery for its shell. The region provides critical feeding and developmental grounds for all five sea turtle species as they feed on the abundant marine algae, seagrass, and invertebrates. Understanding of the life history of sea turtles in Baja California is critical to their recovery, yet there remain large gaps in our knowledge.

INTRODUCTION

Due to its favorable location, encompassing both temperate and tropical latitudes, a richness of marine biota, and a varied coastline, the Baja California peninsula hosts all five species of sea turtle known from Pacific waters. On feeding grounds and developmental habitats ranging from the border with California, U.S.A in the north, to southern nesting beaches in the cape region, the peninsula has offered sea turtles from all around the Pacific Ocean a safe haven to reproduce, develop, and forage for millions of years. Only over the past century have populations declined sharply due to bycatch and overhunting, requiring immediate action to avoid regional extirpation.

Basic biological information pertaining to sea turtles occurring along the coast of the Baja California peninsula, particularly concerning their foraging and developmental grounds, has been lacking. The National Marine Fisheries Service (1998) considers the notable deficiency of information a main threat to the survival of eastern Pacific sea turtle stocks.

Apart from early reports by explorers, whalers, and missionaries (Chapter 2), a few studies by Caldwell (1962a, 1962b, 1963) in the 1960’s—primarily at Bahía de los Angeles, Baja California—and scouting trips by Carr (1961) represent the first systematic studies from the region. O’Donnell (1974) described an active green turtle fishery near the end of its production peak. A few published, but incomplete, reports of the green turtle fishery in Baja California provide a glimpse of the levels of extraction (Parsons 1962, Caldwell 1962a, 1963, Márquez 1965, Montoya 1966, Martinez 1967).

Considering that Baja California was the most productive turtle fishing area at the time, the studies are ruefully brief. Several university theses, focussing primarily on green and to a lesser extent loggerhead turtles, have been produced during the past decade (Montano-Rodriguez 1978, Stinson 1984, Olguin 1990, Villanueva 1991). However, virtually none of these data have entered the peer-reviewed literature and most studies ignored the other three, less commercially important, species. Recently, researchers from the University of Arizona, together with biologists at the Centro Regional de Investigaciónes Pesqueras-Estación de Conservacion e Investigación de Tortugas Marinas, Bahía de los Angeles, Baja California (CRIP-ECITM) and the Centro para Estudios Costeros (CEC), Puerto San Carlos, Baja California Sur, have begun to publish baseline information on the biology and status of Baja California's sea turtles (Resendiz and Resendiz 1992, Nichols et al. 1998, Resendiz et al. 1998, Garcia-Martinez 2000, Seminoff 2000b, this thesis).

This chapter provides an overview of the biology of the five species of sea turtle inhabiting Baja California waters. The information presented here was compiled from field research—including work presented elsewhere in this dissertation, unpublished data, unpublished university theses, government reports and fisheries statistics, interviews with Baja Californian fishermen, and the general sea turtle literature.

IDENTIFICATION OF THE FIVE SPECIES OF SEA TURTLE INHABITING BAJA CALIFORNIA WATERS

The accurate identification of sea turtles to species is the first step in understanding their biology. Each species has distinct life history characteristics, stock viability concerns, and only two of the five species occurring in Baja California waters are currently known to nest on the peninsula in significant numbers (*Lepidochelys olivacea* and *Dermochelys coriacea*). Furthermore, stocks may exhibit localized morphological or behavioral variation. As such, correctly attributing observed behavior with one of the five species is critical.

Information on the distribution and abundance of sea turtles sighted at sea, on nesting beaches, and stranded on shore is extremely important to biologists and managers working towards their recovery. Misidentification of species is compounded by ambiguous or misused common names in both English and Spanish (Table 1). As a case in point, Frazier (1985) described the hazards of misidentification of marine turtles in the Pacific and resolved discrepancies in the early records for loggerhead turtles along the Pacific coast of the Americas. They were correctly identified as olive ridleys (*Lepidochelys olivacea*), precipitating our understanding of the transoceanic migrations of Pacific loggerhead turtles.

The simple key to Baja California's sea turtles (Table 2) will work without fail if the specimen is available for examination. However, sightings of turtles at sea, while diving, or attempts to classify an animal using a verbal description require extra knowledge of the animal's habits and a trained, experienced observer. Familiarity with the aspects of each species' biology, relative abundance, and distribution will aid in identifying species and determining which observations are most important to record and report.

A simple visual guide to the sea turtles of the eastern Pacific has been produced and should aid and encourage reporting of strandings and sightings of both adults and hatchlings (Figure 1). The free guide is available at <www.wildcoast.net>. Photographs, diagrams, and detailed notes should be collected to aid the proper identification of the specimen, if it is not possible to make collections. Several authors provide more detailed anatomical descriptions of each species than space allows here (Witzell 1983, Dodd 1988, Márquez 1990, Pritchard 1996, Pritchard and Mortimer 1999).

The leatherback turtle is perhaps the easiest to identify due to its distinct morphology, large size (up to 1000 kg) and leathery carapace (Figures 3 and 4). Furthermore, leatherbacks are known to nest on Baja Californian beaches. Known locally as *tortuga laud* or *tortuga siete filos*—referring to the seven prominent dorsal ridges running the length of the carapace—the leatherback stands out clearly in the memory of anyone who has encountered one. Its most distinguishing characteristics are its black color and its smooth leathery shell lacking scutes. Reports of leatherbacks in the region are common from nesting beaches in the southern cape region (Fritts et al. 1982) and in upwelling areas such as the Canal de Ballenas, near Isla Angel de la Guarda or north of Isla Tiburón. Leatherbacks are rarely sighted nearshore or by divers. Antonio

Resendiz (CRIP-ECITM) reports that the leatherback turtle is the least common turtle sighted in the Bahía de los Angeles, Baja California, area.

The other four species are thecate—have hard carapaces—and due to their smaller size may prove more problematic to distinguish for the novice turtle watcher or when seen at a distance.

Olive ridley (Figures 5 and 6) and loggerhead turtles (Figures 7 and 8) are often confused at sea as they bask at the surface, their carapaces drying in the sun. The olive ridley turtle is known most commonly as *tortuga golfina*. Its carapace is steep-sided, is nearly round in shape—straight carapace width nearly equals carapace length—and is slate gray to dark olive in color with a light cream colored plastron. The carapace may have 5 or more (up to 9) lateral scutes, often asymmetrically numbered. Both immature (from 25 cm) and mature turtles (up to 75 cm) are known in the region. Immature olive ridley turtles may have vertebral projections and a lighter, almost white, plastron than mature turtles. The flippers of the ridley each have two claws, though claws may be lost in some animals. The olive ridley is the species most likely to be encountered on Baja California nesting beaches, predominantly in the cape region, but occasionally elsewhere (Fritts et al. 1982).

The loggerhead turtle is also often seen basking at the surface. However, its shell is less round in shape than the olive ridley turtle—narrowing at the posterior end—and more orange/brown in color (Figures 7 and 8) than the olive ridley turtle. The plastron of the loggerhead turtle is yellowish orange and the head is relatively wide. Small immature

(<40 cm) loggerhead turtles may have serrated marginal scutes. The front flippers are relatively short and have two claws on each flipper. Mature loggerhead turtles (> 85 cm) are rarely encountered in Baja California waters. It is known locally as *javelina*, *tortuga amarilla*, or simply *caguama*. Elsewhere in the region it is known as *tortuga perica* or *cabezona*.

East Pacific green turtles (*Chelonia mydas*)—also known as black turtles—(Figures 9 and 10) are typically encountered in nearshore, rocky, or seagrass environments as are the small hawksbill turtles. Unlike the loggerhead and olive ridley turtles, when encountered at the surface, the green turtle will quickly dive and swim away—green turtles are rarely seen basking. Green turtles can be extremely variable in shape and coloration (Chapter 7). Carapaces are typically heart-shaped, often with pronounced posterior tapering over the rear flippers in large immature and mature turtles. Coloration varies from radiating streaks of brown, black, and tan in immature turtles to nearly completely black in some mature animals. Most adult turtles are predominantly dark brown, gray, and black with spots or streaks of color. Plastron color varies from pale cream to nearly completely dark gray, but is typically a mixture of gray and pale yellow/cream. Green turtle flippers have one claw. Head and flipper color varies from completely dark gray/black to light gray/buff with light borders. Green turtles found in Baja California waters are typically between 40 and 100 cm in length, although smaller turtles may be found offshore associated with pelagic kelp mats (Nichols, pers. obs.). The darker, more tapered, East Pacific green turtle form is considered by some to be a distinct taxonomic entity (*Chelonia agassizii*) (Pritchard 1999). See Chapter 7 for a discussion of the taxonomic debate and the conservation status of the East Pacific green turtle.

Hawksbill turtles have distinctive, overlapping scutes and a serrated posterior margin (Figure 11). The carapace is variably dark and light brown, with radiating bold patterns. The plastron is light yellow with black markings (Figure 12). The head is relatively narrow and the beak bird-like. Two claws are present on each flipper. Hawksbills are most frequently encountered in coastal areas feeding near rocky reefs, although are occasionally seen at the surface, lingering longer than the green turtle and permitting capture in scoop nets. All of our recent hawksbill records have been juveniles between 25 cm and 60 cm.

SPECIES-SPECIFIC LIFE HISTORY CHARACTERISTICS

General sea turtle life history has been described in great detail elsewhere for many regions and stocks. However, species-specific details for Baja California are lacking. For example, movement patterns of Baja California turtles are unique, as are current population status and some aspects of foraging ecology. Here I summarize the current knowledge specific to Baja California waters.

Green turtle, *Chelonia mydas*.

The green turtle is currently the most common species of sea turtle in Baja California waters, despite the dire state of the East Pacific stock (Table 3). Many people consider the green turtle historically the most important animal native to the region, and Baja California was once the most important region for the Mexican sea turtle fishery (O'Donnell 1974, Groombridge and Luxmoore 1989). The green turtle plays an ecologically, culturally, and economically central role in Baja California—unlike any other marine or terrestrial animal.

Distribution and Population Size

Data on the former abundance of green turtles in Baja California are sporadic and records of hunting are incomplete (Chapter 2). One of the earliest quantitative accounts of sea turtle abundance in Baja California is by Townsend (1916), on the expeditions to the Gulf of California by the ‘Albatross’ in 1911. Here, during a stop in San Bartolome (now known as Bahía Tortugas) on Baja California’s Pacific coast Townsend wrote:

> "In a single haul of a seine 600 feet long we brought to shore 162 green turtles, many of them of large size. Probably half as many more escaped from the seine before it could be beached; there being a continual loss of turtles crawling over the cork lines during the entire time we were hauling it."

Areas of reported green turtle former abundance along the Pacific coast of Baja California include Bahía Bartolome (Bahía Tortugas), Bahía Magdalena, Laguna San Ignacio, Laguna Ojo de Liebre, and Estero Coyote. Areas of former green turtle abundance in the Gulf of California include the Canal de Infiernillo (Isla Tiburón), San Felipe, Bahía Gonzaga, Bahía de Loreto, Bahía Willard, and Bahía de La Paz. Fishermen from Bahía de los Angeles report flotillas, or *cardumenes*, of hundreds of green turtles along the east coast of Isla Angel de la Guarda. Green turtles, quite simply, were one of the most common large marine vertebrates along the entire coast of the peninsula, from the Cabo San Lucas region to the border of California, USA, and the mouth of the Colorado River (Townsend 1916):

> “We found deserted turtle camps and an abundance of turtle shells at Tiburón and other islands in the Gulf. Turtles are said to abound near the mouth of the Rio Colorado where their eggs are deposited in the sands. The inhabitants of the Peninsula seem to have no difficulty in obtaining a supply of them…turtles are plentiful in the Gulf of California, and the “Albatross’ obtained specimens in the vicinity of Willard Bay, on the Peninsula near the head of the Gulf in 1889.”

Fisheries data indicate that turtles were abundant and the target of a lucrative industry well into the 1960s. However, by the 1970s, sharp population declines were obvious and by the mid-1980s most reports from fishermen indicate that the green turtle reached an all-time low (Chapter 2).

Now, our catch per unit effort (# of turtles caught in100m of net set for 12 hours) consistently averages less than 0.5, and ranges from 0.2 to 4.0, a decrease of at least an order of magnitude from decades past. A similar decline has been observed on the nesting beaches in Michoacan, where it is estimated that in the late 1960s, up to 1,000 turtles nested nightly (Cliffton et al. 1982).

Green turtles are known to be present in Baja California waters year round (Table 4). Aerial surveys conducted monthly in the Midriff Island region of the Gulf of California in 1994-1995 resulted in the sighting of only five turtles. All of the sighted turtles were *C. mydas* and were recorded within 50 meters of island coastlines. All of the turtles appeared to be large juvenile or adult-sized turtles and were sighted only during summer (June) and fall (October) months (Seminoff and Nichols 1995). The locations of these five sightings are presented in Table 5.

Generally, the smaller size classes of green turtle are more frequently encountered on the Pacific coast (35-45 cm), than in the Gulf of California, resulting in a lower mean size for Pacific coast green turtles. However, mature turtles up to 105 cm are found along both coasts. Preliminary data suggest that on the Pacific coast, the smallest turtles are found in the shallow, upper reaches of esteros. While the mature turtles range throughout the deeper channels and along the rocky headlands. Turtles ranging in size from approximately 45 to 100 cm are most common in the Gulf of California.

The green turtle ranges from Alaska to Chile, in the eastern Pacific. Stinson (1984) described the green turtle as the most commonly observed thecate turtle along the Pacific coast of the U.S., based on historical sighting records. While sighting ranged from Baja California to Alaska, the majority were from northern Baja California and southern California, USA. A small population of approximately 60 green turtles resides in San Diego Bay, concentrating around the effluent from a power plant during winter months (Stinson 1984, McDonald et al. 1995). Green turtles are frequently encountered along the coast of northern California, Oregon, and Washington, though they are often incidentally captured in nets or cold-stunned and require rehabilitation (Eckert 1993). The majority of green turtles encountered along the Pacific coast of North America are likely from the eastern Pacific stocks.

East Pacific green turtles have been found in Japan (n = 3), but are uncommon (Kamezaki, pers. com.). Recently, a green turtle feeding in Hawaii was determined to be of Mexican origin (Balazs, pers. comm.). However, this is also likely a rare occurrence. A small percentage of green turtles foraging in Baja California waters were determined to be of the Hawaiian stock (Chapter 6).

Migration and Movement

Our current knowledge of green turtle movement in Baja California waters can be described in three general categories: reproductive migrations of mature turtles, foraging movements of mature turtles, and foraging movements of immature turtles.

Mark and recapture studies, satellite telemetry (Chapter 5), and genetic analyses (Chapter 6), indicate that the majority of mature green turtles foraging along the Baja California coast are from the Mexican stocks (Michoacan and Islas Revillagigedo). Flipper tag recoveries indicate that post-nesting green turtles move from Michoacan nesting beaches to Baja California feeding grounds.

Vargas-Molinar (1970) recovered six flipper tags from green turtles marked in the south of the peninsula, three had moved toward the northwest of the Gulf of California (tagged in February 1966) and three others to the Sinaloan coast. While the data are not clearly presented, it is apparent that green turtles move north and south between Gulf of California feeding grounds and, likely, southern nesting beaches on the mainland coast. It is possible that the foraging movements of mature turtles encompass large areas.

Satellite telemetry studies of mature green turtles on foraging grounds indicate that foraging movements may encompass as much as 30 km of coastline (Chapter 5). Recaptures of mature green turtles in consecutive years on the same feeding grounds suggest that they may have some degree of site fidelity, much like their affinity for natal nesting beaches.

Homing turtles depart Baja California feeding grounds for nesting beaches in late summer and early fall, following a direct, coastal trajectory. The mean swimming speed of three homing green turtle tracked with satellite telemetry in 1997-1999 was 45 km/d (Chapter 5). The details of migration from nesting beaches back to feeding grounds has not yet been documented with satellite telemetry, but can be implied through analysis of genetic markers and flipper tags.

Seminoff et al. (in press) studied the station keeping movements of 14 (11 immature and 3 mature) green turtles during summer in Bahía de los Angeles, Baja California. The mean home range (Kernal estimate) size was 3,367 ha. Twenty-four hour tracking sessions of 8 green turtles in Bahía de los Angeles indicate that the mean daily distance traveled was approximately 9.5 km. Turtles exhibited “shuttling” behavior between activity areas—typically divergent coastal and island foraging sites.

Preliminary data from studies of immature green turtle movements on Pacific coast foraging grounds suggest similar patterns (Brooks et al., in prep). Pacific coast green turtles may have similar home range sizes, 24-h movement patterns, demonstrate a high level of site fidelity, and shuttle between patches of vegetation (multiple activity centers) within lagoons and estero—in synchrony with the semi-diurnal rise and fall of the tides—as those on Gulf foraging grounds (Nichols, unpublished data). Pacific coast habitat is different from that in the Gulf of California, and these differences may be reflected in subtle variations in turtle movement patterns. For example, extensive feeding grounds in Bahía Magdalena occur in narrow, relatively shallow (< 6m) mangrove esteros with long principle channels where tidal fluctuations produce strong currents. Thus, changing water depths and tidal cycles physically restrict turtle movements to defined corridors. Turtles were active during both day and night on all feeding grounds studied.

On one occasion an immature green turtle, recaptured on two occasions in Estero los Cuervos in Bahía Magdalena (24.865N, 112.174), exhibited strong site fidelity traveling 12 km and 10 km from the release point back to the recapture location. The predictable, synchronous movements of green turtles with the tidal cycles in the channels of Pacific esteros make them particularly vulnerable to poaching. On several occasions poachers, using several large 100 m-long entanglement nets, eradicated turtles from study areas between field seasons.

We have encountered immature green turtles associated with floating mats of kelp (*Macrocystis* sp.) up to 20 km offshore of Bahía Magdalena, Baja California Sur. Olguin-Mena (1990) also reported immature green turtles approximately 25 km offshore of San Juanico, Baja California Sur, and hypothesized that they may have been feeding on pelagic red crabs (*Pleuroncodes planipes*). These may be pelagic stage, carnivorous, green turtles, arriving to coastal feeding grounds.

The green turtle may hibernate during the winter months, coming to the surface occasionally to breath, and feeding very little (Felger et al. 1976). Fishermen from Pacific lagoons (San Ignacio and Guerero Negro) report this behavior. Hibernation is known from other sea turtle species and populations (Ogren and McVea 1982)

The Seri Indians of Sonora, Mexico sing a song that eloquently and concisely depicts the green turtle’s life history. The song refers to summer foraging movements, overwintering behavior, and describes green turtle foraging movements (Coolidge 1971):

The Turtle Song
The turtle swims on top
Where there is no wind.
When the wind blows he goes down
On the bottom for a long time.
When the wind stops he travels far
Looking for food,
And he eats the seaweed.

No data are available on the dispersal of hachlings from nesting beaches. Based on the small sizes of turtles encountered on feeding grounds along the Pacific coast and the few sightings of pelagic turtles associated with kelp mats, it is assumed that some green turtles are carried passively to the region by ocean currents.

Diet and Foraging Ecology

Until recently, the diet of the East Pacific green turtle was sparsely known. Carr (1961) reported two kinds of algae in stomach contents of turtles at Bahía Kino, Sonora and that turtles also grazed on algae at La Paz, Baja California Sur. Along the Pacific coast of Baja California green turtles had been observed feeding on eelgrass (*Zostera marina*) and surf grass (*Phyllospadix scouleri*) at Bahía Magdalena (Takasaki 1962).

Data from the Gulf of California indicate that green turtle diet may vary between gulf foraging habitats. Green turtles in the Infiernillo Channel region near Isla Tiburón consume large quantities of eelgrass (Felger et al. 1980). Turtles captured from nearby Bahía de los Angeles, have diets composed primarily of red algae species and, to a lesser extent, invertebrates such as sponge, soft corrals, Sabellid worms, and sea pens (Seminoff et al. 1998). Regardless of differences between regions, green turtles feeding along the shores of the Baja California peninsula exhibit a strong tendency toward herbivory.

After dispersing from pelagic environments to coastal waters along the Pacific coast of the Baja California peninsula, immature green turtles enter a different habitat composed primarily of sandy and rocky coastlines interspersed with bays and estuaries. These bays are typically have mud bottoms and host seagrass communities dominated by surf grass (*Phyllospadix scouleri*) and eelgrass, *Zostera marina* (Dawson 1951). Green turtles have been documented as historically abundant in these areas (Townsend 1916, Nelson 1921, Hodge 1979). Stinson (1984) described eelgrass consumption by green turtles in the coastal lagoons of the eastern Pacific Ocean.

Seminoff et al. (1998) described green turtle foraging on several species of red algae, predominantly *Gracilariopsis laeminoformis* and *Gracilaria robusta,* in BLA. However, remnants of several invertebrate species were also noted. These included Sabellid worms, sea hares (*Aplysia vaccaria*), and the fleshy sea pen (*Ptilosarcus undulatus*). Considering their patchy distribution and solitary, uncommon occurrence, respectively, it is possible that foraging turtles actively seek these organisms.

In Bahía Magdalena a total of eleven stomachs were collected during1999. *Gracilariopsis* sp., *Ulva lactuca*, *Rhodymenia* sp., *Phyllospadix* sp., *Zostera marina*, and unidentified invertebrates (sponges and tunicates) were the predominant stomach contents. The red algae, *Gracilariopsis* sp., made up 56.9% of the total stomach content weight in the summer turtles and 63.9% of those obtained in the fall. In the summer of

1998 a small number of stomachs containing predominantly *Phyllospadix* sp. were observed from turtles incidentally captured along the Pacific coast of Isla Magdalena.

Elsewhere along the Pacific coast, green turtles have been observed foraging in sea grass beds (San Ignacio Lagoon, Estero Coyote, and Roca Ballena near Punta Abreojos).

In summary, during spring, summer, and fall, green turtles routinely graze the *Zostera marina, Phyllospadix* sp., and *Gracillariopsis* sp. pastures of shallow peninsular coastal environments, and their foraging movements are dictated by bathymetry, abundance of forage, temperature, and tides. As algal and sea grass abundance changes from site to site, so does the green turtle diet. At northern latitudes green turtles may cease foraging during winter, or move south to warmer waters. While the green turtle diet is largely herbivorous, turtles along the Gulf of California and Pacific coasts are commonly known to consume a number of invertebrate species.

Growth

Growth data for East Pacific green turtles are sporadic. The majority of data are from BLA in the Gulf of California and for captive turtles at the CRIP-ECITM station. Seminoff and Nichols (unpublished data) recorded 16 growth intervals of greater than 6 months. Mean growth rates were approximately 2.0 cm/y (0.0 to 5.1 cm/y). Mean growth rates for 16 captive green turtles with straight carapace lengths between 43.9 and

73.9 cm ranged from 0.1 to 6.7 cm/y. The overall average growth rate for captive turtles was 3.0 cm/y (Resendiz, unpublished data).

Very few recaptures providing growth data are available from other regions. One 52.3 cm turtle recaptured in Bahía Magdalena grew 0.4 cm (1.1 cm/y) between 24 January and 2 June 1998. Another immature green turtle from Bahía Magdalena (48.8 cm) grew 3.2 cm (8 cm/y) between 6 July and 21 November 2000. This suggests seasonal variation in growth rates—higher growth rates during summer are noted—but more data are clearly needed. In the Bahía de Loreto National Marine Park a 73.4-cm turtle captured and recaptured during the summer of 1997 grew 0.3 cm (3.6 cm/y) in approximately one month. Additional growth data are available from post-consumed carapaces of tagged turtles. However, due to the possible change of shape of the turtle carapace after butchering and heating, those data are not included.

Reproduction

The primary nesting rookeries for green turtles in the eastern North Pacific are in the Mexican state of Michoacan, approximately 1,000 km from the southern tip of the Baja California peninsula. Other known rookeries are in the Islas Revillagigedo, an archipelago off the coast of Colima, Mexico, approximately 500 km from the Baja California peninsula. Additional green turtle rookeries represented on Baja California feeding grounds include those in the Hawaiian archipelago (French Frigate Shoals), and possibly those in Central America (Chapter 6). Sporadic nesting is also known along virtually the entire Pacific coast of Mexico, at Playa "El Quelite" in Sinaloa, for example (Vargas-Molinar 1970).

I have never documented green turtle nesting in Baja California, leading me to the conclusion that nesting of this species is rare or absent from the peninsula at this time. This lack of activity is supported by several other authors (O'Donnell 1974, Fritts et al. 1982). McGee (1898), who studied the fishing activity of the Seri Indians, thought that the beaches of the Infiernillo Channel, between Isla Tiburón and the Sonoran mainland, would be optimum nesting habitat. During the course of his studies he only documented turtle capture at sea. However, numerous unsubstantiated claims of green turtle nesting exist in the literature (Caldwell 1962), especially in years past (Townsend 1916). Among older fishermen, who during interviews have reported sporadic green turtle nesting along the peninsula and nearshore islands, suggesting that green turtle nesting in Baja California may have occurred in the past. It is unclear whether olive ridleys were mistaken for green turtles while nesting, or if there were once numbers of *Chelonia* reproducing along Baja California's coast and islands. Fishermen interviewed from Puerto San Carlos, Baja California Sur, on Bahía Magdalena, distinguish between green and olive ridley turtles and claim that the former nest on Pacific beaches of Isla Margarita.

Early accounts from the major nesting beaches provide more detail of abundance levels.

Cliffton et al. (1982) quoting Peters (1956):

> "The evidences of their activity were everywhere...In a half mile stretch between two stringers I counted 472 such tracks (nesting turtles), which would indicate 250 individual turtles...many turtles returned to the ocean via the track they made so I'm sure my estimate is not high."

Cliffton et al. (1982) refer to informants from Colola, Michoacan, who describe 500 to 1,000 turtles nesting each night. For comparison, this year (1999-2000) there were a *total* of approximately 1,000 green turtle nests at Colola. This represents a decline of at least an order of magnitude over the past several decades. In 1991-1992 reproductive season the number of breeding females in the Colola and Maruata, Michoacan, population was estimated to be 726 (Figueroa et al. 1992). The recovery goal of the Black Turtle Working Group for the Mexican green turtle stock is 5,000 reproductive females.

Epibionts

The most common epibionts found on green turtles in Baja California are barnacles. More than 70% of all turtles encountered on feeding grounds had *Chelonibia testudinaria* on their carapace and often on the plastron, head and flippers. The number of barnacles ranged from one to several hundred. *C. testudinaria* were not typically found on skin, except at very small sizes (< 5 mm). The barnacle *Platylepas hexastylos* was found in the fleshy areas of larger turtles. *P. hexastylos* typically embedded in the skin along the leading edge of the front flippers. Growth of *Enteromorpha* sp. and coraline algae was noted on several green turtle carapaces. Lethargic turtles were typically more infested with epibionts.

In Bahía Magdalena it was common to encounter small (45 cm SCL) green turtles without a single barnacle, presumably new recruits to feeding grounds. However, *C. testudinaria* were recorded for green turtles associated with floating kelp mats, sighted 20 km offshore of Bahía Magdalena.

Barnacles were recorded from green turtles during all seasons.

One observation of growth of *C. testudinaria* on the head of an immature green turtle in Bahía de los Angeles indicates that barnacles can grow from settlement to over 6 cm in size in less than one year (minimum average growth rate of 6 mm/mo).

Other epibionts found on green turtles in Baja California include parasitic leeches (*Ozobranchus* sp.), acorn barnacles (*Balanus* sp.), unidentified bryozoans, and Gammarid amphipods (Table 6).

Threats

The main threats to green turtles in Baja California are directed hunting and incidental catch (Chapter 3). It is often difficult to distinguish between the two, as most green turtles that are captured are not returned to the sea—rather they are eaten locally. The popularity of green turtle meat in the region has resulted in a high level of demand for this species, particularly during holiday seasons (Garcia-Martínez and Nichols 2000). Annual mortality of green turtles in Baja California alone is greater than 7,800 animals and may be as high as 30,000. Despite long-term protection efforts on green turtle nesting beaches, mortality on feeding grounds has deterred population recovery. Olguin-Mena (1990) noted that based on surveys and captures for green turtles in Baja California, the number of mature relative to immature turtles is much lower than in years past (Caldwell 1962). Protection of turtles on developmental and foraging areas will result in marked population gains.

The National Marine Fisheries Service (1998) cites water pollution, boat collisions, and incidental capture by coastal fisheries as the major threats to green turtles in U.S. waters. I am aware of some reports of green turtle being served at restaurants in southern California. However, the meat most likely comes from Baja California.

Harvest of marine algae in the Bahía de los Angeles region may be an obstacle to population recovery if it continues unchecked (Seminoff 2000a).

The proposed mega-tourism development, Escalera Nautica (or Nautical Ladder) proposes the expansion or development of 24 marinas in northwestern Mexico and threatens to destroy many near-pristine sea turtle foraging areas along the coast of Baja California and the Gulf of California. The potential impact to sea turtles, the region's most endangered group of marine animals, and their benthic habitat should be considered one of the major environmental concerns of the project.

Loggerhead turtle, *Caretta caretta*.

The loggerhead turtle is the second most common species of sea turtle in Baja California waters (Table 3). Considering that there are no loggerhead turtle rookeries in the eastern Pacific, the number of turtles in Baja California is surprising, and was once a prominent enigma in sea turtle biology. While not nearly as economically or culturally as important as the green turtle, the loggerhead turtle is frequently hunteded for its meat in Baja California.

Distribution and Population Size

The vast majority of loggerhead turtles are encountered along the Pacific coast of the Baja California peninsula, particularly the central portion from the Vizcaino peninsula to the southern end of Bahía Magdalena. Our surveys have focussed primarily in the offshore regions near Laguna San Ignacio and Bahía Magdalena (Figure 2). However, loggerhead turtles are known to range into the Gulf of California.

The Seri Indians referred to two ethnospecies of loggerhead in their region, but indicate that the species has been rare since at least the 1940s and only juveniles have been seen (Felger and Moser 1985). The loggerhead turtle was not considered good eating, and therefore was not harpooned by the Seri as the green turtles were.

The first valid reports of loggerhead turtles in the Gulf of California or along the Baja California coast were by Shaw (1947) from the northern Gulf of California and Schmidt (1953) tentatively included it in a species list for the region. Other early records of *Caretta* in the eastern Pacific, particularly along the Central American coast, are thought to be errant reports of *Lepidochelys* (Frazier 1985).

Carr (1961) questioned the early reports of loggerhead turtles along this coast. Caldwell (1962) reported that he was unable to confirm their presence, but had encountered small specimens near Los Angeles, California, USA, and concluded that the species must occur along the outer coasts of the Baja California peninsula as well. The following year Caldwell (1963) reported the second record of a loggerhead turtle from the Gulf of California.

Later, Márquez (1969) confirmed that loggerhead turtles were very “sparse and vagrant” along the coast of the peninsula, reporting data for 7 turtles with carapace lengths between 25.6 and 92 cm, captured between 1963 and 1966. The lack of more reports can be attributed to the observation that loggerhead turtles are often located 5 to 20 km offshore and rarely near the coast.

Clearly, studies of loggerhead biology got off to a relatively late start in this region, with fewer than a dozen records of individual turtles in the literature by 1970.

Along the Pacific coast of the peninsula loggerhead turtles are rarely encountered in the bays or lagoons, rather they are typically seen basking at the surface several km from shore. On calm, warm days it is possible to encounter up to ten turtles basking within an hour’s time. Some fishermen report that one particularly calm, hot days the turtles float about “like pumpkins”.

Loggerhead turtles are most commonly encountered off the Pacific coast of Baja California during spring and summer months, and the size of the population has been estimated at 10,000 turtles. The turtles may be present year round, however, it is exceedingly difficult to sight them at sea unless conditions are ideal (Beaufort 0 or 1, clear sky, warm air temperature).

In the Gulf of California, divers occasionally encounter loggerhead turtles as the turtles rest along reefs. In 1999 Guillermo Murillo, a fisherman from Bahía de los Angeles, caught a 110 kg loggerhead turtle while he was diving for sea cucumbers in the Gulf of California. The turtle was subsequently satellite tracked as it migrated towards its natal beaches.

The loggerhead turtles encountered in Baja California waters are nearly always immature. It is rare to encounter a turtle larger than 90 cm (SCL) (Chapter 3), and most turtles are in the 45 to 80 cm range (SCL). To date, no mature turtles bearing eggs have been reported from this region, nor have any mature males been encountered (Cliffton et al. 1982, Márquez 1990, Olguin-Mena 1990).

It is difficult to estimate the number of loggerhead turtles in Baja California waters based on at sea surveys. However, estimates have been made of the Japanese loggerhead turtle stock, based on numbers of nests, remigration intervals, and mean numbers of nests per turtle each season (Chapter 3). Based on surveys at sea, Villanueva estimated the Baja California loggerhead population at approximately 10,000 turtles.

Recent surveys at sea resulted in sightings of loggerhead turtles during all seasons. However, peak numbers occurred during the summer of 1997 (Table 7). On average for all months, approximately one turtle was sighted every 3 hours. During the 1998 summer and fall surveys *P. planipes* were not observed and fishermen indicated that the waters were especially warm and that the fishing was poor.

Stranding data indicate a peak occurrence in late spring and summer followed by a decline in numbers of stranded turtles in the fall and winter. Stranded turtles encountered in winter months showed advanced decomposition and had likely been present on the beach for up to several months. None of the stranded turtles appeared to have suffered any type of trauma. The range in size for all turtles encountered along the Pacific coast of Baja California during this study was 35-80 cm (SCL) with a mean of 61 cm (N=58). Eleven turtles were captured in the Gulf of California with a mean SCL of 49 cm (28-93 cm) (Nichols et al. in press). Stinson (1984) summarized 43 records, most were immature and from southern California.

Loggerheads may be present year round in Baja California waters, however, most sightings occur in spring and summer (Table 4)

Loggerhead turtles are reported as far north as Alaska (Bane 1992) and as far south as Chile (Frazier and Salas 1982). Generally, they are rare except for near Baja California (National Marine Fisheries Service 1998)

Migration and Movement

Immature loggerhead turtles are frequently sighted offshore of southwestern Baja California. It is now known that these turtles have dispersed from Japanese nesting beaches, across the North Pacific Ocean. In the waters near the Pacific coast of Baja California the most common sea turtles appear to be juvenile pelagic loggerheads moving in a generally southwestward direction with the currents. In the spring, with the winds from the north, the cold California Current runs along the Baja California coast, weakening thorough the summer and into the fall and allowing for the influence of the Davidson Current from the south along the coast (Wyrtki 1965). This pattern of the surface currents may have been disrupted and/or enhanced during the recent El Niño event, resulting in anomalous warm surface waters and lower productivity—by summer 1998 conditions had begun to return to “normal”.

Immature loggerhead turtles, once they have dispersed to Baja California waters, may remain along the coast of the peninsula for several years as they feed and grow. At maturity, the turtles return to their natal beaches, in this case 12,000 km across the Pacific Ocean in Japan. Thus, the North Pacific gyre may approximate the outline of a transpacific loggerhead turtle developmental migration that spans more than 20 years. Flipper tagging, molecular genetics and satellite telemetry have filled in many details of this international life history (Chapter 4).

Diet and Foraging Ecology

Nine stomach content samples of stranded or incidentally captured loggerhead turtles were obtained from Bahía Santa Maria and offshore of Bahía Magdalena, Baja California Sur, Mexico, in the summers of 1998-2000. All samples contained only *Pleuroncodes planipes*, the pelagic red crab, except for one stomach, which contained a fragment of *Callinectes* sp. Interviews with fishermen who regularly capture and consume loggerhead turtles in the region support the observations that the primary diet item for loggerhead turtles in this region is *P. planipes*. Fishermen also report consumption of agua mala" or jellies, but I have not documented this. During summer of 1998,15 Humboldt squid (*Dosidicus gigas*) were also examined and were found to be feeding entirely on *P. planipes*. The abundant crabs are food for a variety of sea birds, fish and marine mammals, including resident gray whales (Nichols, unpublished data).

Twelve km offshore of Punta Abreojos, Baja California Sur, where fishermen set traps for grouper and other bottom fish, I have observed loggerheads eating cast-off fish floating at the surface. It is not known whether loggerhead turtles actively hunt live fish.

Nevertheless, the loggerhead turtles in this region appear to be feeding primarily, if not exclusively, on *P. planipes*, or "langostilla", and turtles are likely to be found closer to shore during the spring and summer when aggregations of their prey are most abundant on the continental shelf (Figure 13). The standing stock of the benthic phase of this species is estimated to be from 300 to 500 thousand metric tons with densities to 40 crabs/m^2 (Aurioles-Gamboa and Perez-Flores 1997). The crabs reproduce in spring and the pelagic phase may last for up to two years. After the third year crabs become predominantly benthic and retreat to cooler, deep water in the late summer when the influence of the Davidson Current prevails along the coast. Stomach content analyses, specifically the size of the crabs consumed, support the observation that loggerhead turtles feed on pelagic phase crabs during summer months. Villanueva (1991) also described *P. planipes* as the predominant diet items in 8 *C. caretta* stomachs examined from Baja California waters.

Another location where loggerhead turtles are occasionally found is the Midriff Island region of the Gulf of California, an area known for occasional "blooms" of *P. planipes*. Felger (unpublished data) reported that loggerheads in the Canal de Infiernillo region, between mainland Sonora, Mexico and Isla Tiburón, also feed on bivalves such as *Laevicardium elatum*, *Modiolus capax* and *Dosinia ponderosa*. However, the turtles in that region were generally not found as close to shore as *Chelonia* commonly are.

Growth

Growth data are not available for loggerhead turtles from Baja California waters. However, Zug et al. (1995) estimated growth rates of pelagic loggerhead turtles in North Pacific waters rates using skeletochronology. They estimated that a 46.6 cm (SCL) loggerhead turtle is approximate 10 years of age. Age-specific growth rates for the first 10 years averaged 4.2 cm/y. The smallest size class found in Baja California waters (~30 to 40 cm) are estimated at 5-8 years of age. These data are consistent with estimates of dispersal times from Japanese rookeries, based on a small number of flipper tag returns. Zug et al. suggest that growth rates for loggerhead turtles in the North Pacific may be considerably lower than for other regions. However, if the growth rate calculated for the first 10 years remained constant, turtles would reach mature sizes in approximately 20 years. The abundance of red crabs may make that possible for turtles reaching the central Baja California coast.

A captive loggerhead turtle at CRIP-ECITM grew 53.5 cm (29.9 to 83.4 cm) in 10.2 years, a mean growth rate of 5.2 cm/y. Based on the published data (Zug et al. 1995) for North Pacific turtles, the turtle was approximately 17 years of age when it was released, and subsequently tracked to Japanese waters (Chapter 4).

Reproduction

There is no known loggerhead turtle nesting activity in the eastern Pacific Ocean. The loggerhead turtles feeding in Baja California waters originate primarily on Japanese, and to a lesser extent Australian, feeding grounds (Bowen et al. 1995). The majority of nesting occurs in southern Japan (Kamezaki and Matsui 1997).

Epibionts

The most common epibionts found on loggerhead turtles are barnacles: *Chelonibia testudinaria*, *Lepas anatifera*, and *Platylepas hexastylos*. Table 6 includes a complete list of epibionts encountered on loggerhead turtles captured near the Baja

California peninsula. Of note, terns (*Sterna* sp.) were often seen resting on top of carapaces of basking loggerhead turtles. On three occasions *Remora* sp. were found attached to the plastron of basking turtles. Remora may have been more common, however, in the process of capturing pelagic loggerheads they may be lost. Other species encountered included crabs (*Planes cyaneus*), filamentous red algae, and leeches (Table 6).

Threats

The threats to loggerhead turtles are similar to those for green turtles. However, the loggerhead turtle's meat and organs are less commonly used as food, due to the strong taste and smell. Nevertheless, several Pacific coast communities have active loggerhead fisheries and supply northern markets with the meat.

Loggerhead turtles are the species most likely to be found stranded on the Pacific coast of Baja California. They become entangled in gillnets used in a variety of fisheries, shrimp trawls, and on hooks set by pelagic shark fishers (Chapter 3).

Olive ridley turtle, *Lepidochelys olivacea*.

The olive ridley turtle is one of two species of sea turtle known to regularly, in relatively small numbers, nest on Baja California beaches. It is the third most common turtle species found in coastal waters (Table 3).

Distribution and Population Size

Estimates of the size of the olive ridley reproductive population in Baja California have decreased over the years. Márquez (1976) estimated the population at between 1,000 and 500 individuals, Fritts (1982) at 360 and in 1989 Peña (unpublished data) estimated it at only 29 individuals. Recent surveys suggest that the number of nests on Baja California beaches may range from several hundred to nearly 1,000 annually (ASUPMATOMA, unpublished data). However, this may only represent the reproductive efforts of 50 to 200 mature females. High levels of exploitation of this species continued through the late 1980's. It is possible that we are now beginning to witness the results of recent conservation efforts. Elsewhere in Mexico, such as Escobilla, Oaxaca, the olive ridley turtle has shown strong signs of recovery (Márquez, pers. comm.).

It is certain that olive ridley rookeries were once much larger in Baja California as older fishermen remember enormous quantities of the species being captured. Indeed, a vast number of carapaces are piled at the abandoned slaughterhouse at Punta Lobos, Baja California Sur. Vargas-Molinar (1970) tagged 46 olive ridley turtles near Isla Margarita, Baja California Sur, considering it an important nesting area and the species the most common in southern Baja California waters. It is curious that apart from one turtle tagged at Isla Serralvo, Isla Margarita is the only location where the author found olive ridley turtles. It is possible that the presence of a slaughterhouse on Isla Margarita may have influenced the data collecting methods.

Olive ridley turtles are also known from pelagic waters along the Pacific coast of Baja California as well as occasionally from within the Gulf of California. The olive ridley turtle is the third most common species encountered in near and offshore waters along the peninsula. Like the loggerhead, it is more commonly found along the Pacific coast. We have seen numerous olive ridleys basking offshore of Bahía Magdalena, Baja California Sur. Size ranges include both immature and mature animals (Chapter 3).

During a year-long study Olguin-Mena (1990) reported a single adult female olive ridley turtle during March 1988, near Puerto San Carlos, Baja California Sur.

Olive ridley turtles are rarely encountered in bays, lagoons, and esteros.

The Baja California olive ridley rookeries are of marginal importance relative to the rest of the Mexican population, but represent the northern end of the range, which is interesting from a biological perspective. Furthermore, the rich offshore waters of Baja California provide important feeding grounds for immature and mature turtles from other rookeries.

Migration and Movement

Tag recoveries from eastern Pacific olive ridley turtles, tagged in southern Mexico, suggest a northward post-nesting migration (Vargas-Molinar 1970). suggest a pattern Results of satellite tracked post-nesting olive ridley turtle from San Cristobal, Baja California Sur support previous observations that this species spends much of its time foraging in pelagic waters.

Diet and Foraging Ecology

Only one stomach sample has been obtained for an olive ridley turtle. It contained only remnants of *P. planipes*, the pelagic red crab.

Growth

I have collected no growth data for olive ridley turtles in Baja California waters. One 56 cm olive ridley turtle tagged in 1966 near Manzanillo, Colima, and recaptured 1.5 years later near Mazatlan, Sinaloa grew 2 cm (0.75 cm/y)(Molinar 1970).

Reproduction

The olive ridley turtle is one of two species that nests regularly on Baja California beaches—the other is the leatherback turtle. The two species' nesting beaches overlap considerably. However, the nesting seasons differ. Olive ridleys nest primarily from July through December with peak nesting August through October (Márquez et al. 1982, Olguin-Mena 1990, ASUPMATOMA, unpublished data). The range of nesting for this species extends from Bahía Magdalena, Baja California Sur around the cape region to La Paz, Baja California Sur (Figure 14).

Vargas-Molinar (1970) described an 8 km stretch of coast (23º 45' N, 110º 30' W), north of Todos Santos, as the principal nesting beach of the olive ridley turtle in Baja

California. Of "secondary" importance were beaches at Ensenada de los Muertos, Cabo an Lucas, and Espiritu Santo.

I have documented olive ridley nesting from the Todos Santos region, Cabo San Lucas, San Jose del Cabo, Bahía los Frailes, Cabo Pulmo, and Los Barriles. Nesting peak densities occur near Punta San Cristobal and south of Bahía los Frailes.

In 1985, Olguin-Mena (1990) documented 29 females nesting in the Todos Santos, Baja California Sur, area.

In one aerial survey of the region (between Cabo Pulmo and Punta Gorda) I recorded 71 tracks or false crawls and counted 13 turtles basking in the nearshore area (within 400 m of shore), presumably awaiting nightfall to nest. Sporadic nesting of olive ridley turtles has been confirmed in Bahía de los Angeles, Baja California; Punta Chivato and Loreto, Baja California Sur; and Bahía de Kino, and Puerto Peñasco, Sonora, although nesting in these regions is considered rare. Baja Californian and Sonoran nesting beaches represent the northernmost extension for this species. The aridity of the area may limit nesting in the region to areas near arroyos and likely influences nesting behavior (Lopez-Castro, pers. comm). It's likely that as olive ridely populations recover, many more such solitary nesting will be documented.

The olive ridley is the only species that fishermen report capturing with eggs, be they fully developed white eggs or small yellow eggs. R. Felger (unpublished data) reiterates this in his accounts of interviews with Seri Indian fishermen of Sonora. A translation of a Seri song by Coolidge and Coolidge (1971) describes sea turtle nesting in the Bahía de Kino, Sonora area:

The Giant Turtle Sings
I come from the deep water,
To find the eggs
Which the female has laid.

On the sand dunes I find her nest
And uncover many eggs.
They will hatch next month
So I cover them up again.

The Coolidge's describe the male turtle coming to the beach to seek the nest and the female guarding the eggs. While this may be a description of basking behavior, it is more likely that it is an error or simply a story.

Male olive ridleys are rare in Baja California waters. This pattern suggests that males remain in pelagic offshore waters, far from the coast and that mating may occur in those areas.

Epibionts

Epibionts found on olive ridley turtles are generally identical to those found on *Caretta caretta* (Table 6).

Threats

Like the loggerhead turtle, olive ridley meat is not favored in Baja California. As such, there is not a large commercial market for the species. However, in some Pacific coast communities olive ridley turtles are consumed opportunistically, and a few people even prefer them. They are captured easily while basking at the surface—fishers consider them "foolish", they are so easy to obtain. Along the Sinaloa and Sonoran coast the olive ridley turtle is consumed more frequently, likely a factor of their higher abundance due to the proximity to large nesting aggregations. The olive ridley is also vulnerable to bycatch in a variety of fishing tackles, not limited to but including gillnets shrimp trawlers, and pelagic hook sets. Unlike the other four species found in Baja California waters, the olive ridley turtle is in the least danger of being extirpated from the eastern Pacific. Discussions of when and how to reopen the legal commercial hunting of this species and the collection of its eggs have begun.

Hawksbill turtle, *Eretmochelys imbricata*.

There has been considerable confusion regarding the eastern Pacific hawksbill turtle stocks. All contemporary reports indicate that this species has been rare in Baja California waters (Table 3). However, there are signs that it was once abundant and that its carapace supported a lucrative industry. With the additional citations presented here, I think that it can safely be said that the hawksbill turtle was once far more common than it is now. Nevertheless, the dire straits of eastern Pacific hawksbill stocks has received virtually no attention. By all estimates, there is little hope for their recovery.

Distribution and Population Size

The hawksbill turtle was once moderately abundant along the Baja California coast, and the Pacific coast of Mexico in general, especially about the Islas Tres Marias (Parsons 1962) and southern parts of the Gulf of California (Townsend 1916). This is particularly true in areas where rocky reefs occur, near Loreto and Bahía de La Paz (Clifton et al. 1982). Miguel del Barco, a Jesuit priest who explored the Baja California peninsula in the18th century, wrote of two species of sea turtles, *Chelonia mydas* and the one whose "shell is *carey*" (*Eretmochelys imbricata*). Del Barco described how "the beach Indians catch them by going out to sea in a canoe or raft". Referring to the hawksbill turtle, he writes: "in the carey type the Indians have the additional profit of the shell which, when there is someone to buy it, they sell. From this carey, they make in the said city [Guadalajara] little boxes for snuff, cigarettes, and other various small things" (del Barco 1980).

Another early account of hawksbill turtles in the Gulf of California comes from Padre Norberto Ducrue, a Spanish missionary (O'Crouley 1774 translated by Aschmann 1966). Padre Ducrue reported the abundance of hawksbill turtles in the southern Gulf and Pacific coast of the cape region of the peninsula, and as far as 27 1/2 º N latitude, approximately the north end of Bahía de la Paz.

Records in the Pablo Martinez State Historical Archives in La Paz, Baja California Sur, suggest that the hawksbill turtle carapace was an important component of the regional economy in the early 1900s. In a 1925 letter, the director of the penal colony on the Islas Marias, off the coast of Nayarit, Mexico, wrote to the governor of Baja California Sur, requesting an industrial school and a professor to teach “trabajos de carey”, or techniques of working with hawksbill shell. The request was denied. Sea turtle trade (*carey*) is mentioned in correspondence as far back as 1827, in a letter from Fernando de la Toba to Luis Cuevas. A July 1910 report, “Zoologia y Botanica del Distrito Sur de la Baja California”, also from the state archives, indicates that *carey* and *caguama* are *abundantissimo*—very abundant.

A monograph on sea turtles from the archive (1922, no. 204, v. 787, exp. 65f) suggests that the hawksbill shell was already receiving much attention and that by the early 1900s the exploitation of hawksbill shell was well underway. “…the articles made of hawksbill shell have a high demand and pay at very high prices…the cities of the interior of the country as well as foreign cites are markets that may possibly consume as much hawksbill shell as can be sent…the turtle meat can be used to make food for cattle or chickens.”

The report continues, however, and the overexploitation of the hawksbill turtle is discussed. “Harvest of the hawksbill shell in our country has a great future, the industry is just starting, though, and in the distant peninsulas of Yucatan and Baja California there are three or four small workshops where objects of limited variety are manufactured; the main business is the export of hawksbill shell... No one is concerned about the conservation of this species or for the care of the young turtles, and very soon these precious animals will disappear from our coasts. The scientific and systematic exploitation of the hawksbill turtle is very simple…"

At the signs of overexploitation, the government considered the hawksbill turtle threatened by overexploitation, and offered possible management solutions, including the establishment of turtle ranches. Hawksbill turtles, it was proposed, could be raised in fenced pens, slaughtered at three years of age, and the *carey* worked on site.

Steinbeck (1951) is his *Log from the Sea of Cortez*, describes the capture of a 2 1/2-foot hawksbill turtle ("tortoiseshell turtle") in the Bahía Magdalena region.

Seri Indians report that the hawksbill turtle was relatively abundant as recently as the 1950s in their territory, the Midriff Island region (Felger and Moser 1985).

Our current experience suggests that conservation efforts were too late and that the directed hunting of hawksbill turtles nearly extirpated eastern Pacific populations. After commercial extinction, even opportunistically encountered turtles were hunted for their shell—which was increasingly valuable. There are still a few older fishermen who remember the end of the trade in hawksbill shell, which apparently continued, albeit at a reduced level and at specific locations, into the 1960s. Now, when a fisherman encounters one of the remaining juvenile hawksbill turtles it is never returned to the water. It is considered good luck when a stuffed hawksbill turtle is hung about a doorway.

Annual numbers of hawksbill turtle nests are now extremely low. For the past 5 years fewer than 20 hawksbill nests have been reported annually along the entire Pacific coast of Mexico (A. Abreu, pers. comm.). Nesting of the species is considered to be rare in the eastern Pacific Ocean, and only occurs sporadically throughout the hawksbill's range (Witzell 1983). The origins of the large numbers of hawksbills foraging in Baja California waters are unknown. Overhunting of this population on its foraging grounds during the earlier part of the 20th century seems to have contributed to their overall sparseness in the eastern Pacific.

Townsend (1916) obtained two specimens of hawksbill shell in La Paz measuring 34 and 31 inches along the top. Caldwell (1962) mentions hawksbill turtles captured in the central Gulf of California and west coast of the peninsula, suggesting that the species was an occasional visitor, but generally of immature sizes. In modern times, the highest abundance of hawksbill turtles is known from Loreto and Bahía de La Paz (Cliffton et al. 1982, Olguin-Mena 1990) and Márquez et al. (1982) suggest that illegal captures have further reduced the size of the population. Olguin-Mena (1990) indicates that he knows of no reports of *E. imbricata* for Baja California between 1983 and 1990, and that veteran fishermen hadn't seen the species for some 15 years. Adult sizes have not been reported in recent years. The few hawksbill turtles (n = 10) that we have encountered during the past seven years have all been immature (Chapter 3). We have recorded hawksbills from Bahía Magdalena, Cabo Pulmo, Loreto, and Bahía de los Angeles, mostly during summer months (Table 4). It now seems that the majority of the hawksbill turtles to be found in Baja California are hanging on the walls of homes, restaurants and cantinas.

Migration and Movement

Very little is known about the movements and reproductive migrations of Baja California hawksbill turtles. Other populations exhibit predominantly coastal habits, remaining around rocky areas and reefs, and occasionally venturing into bays and mangrove estuaries.

Diet and Foraging Ecology

Likewise, I have virtually no information on foraging of hawksbill turtles in Baja California waters. In other regions they are known to be omnivorous, consuming invertebrates, including sponges, coelenterates, sea urchins, gastropods, bivalves, crustaceans, and fish. Hawksbill turtles will also eat algae, leaves, bark and wood of the red mangrove (Ernst and Barbour 1989). Steinbeck (1951) reported that the gut of a 2 1/2-foot hawksbill turtle harpooned in the Bahía Magdalena region was “crammed with small bright-red rock-lobsters (*Pleuroncodes planipes*); a few of those nearest the gullet were whole enough to preserve.”

Growth

I have no data on growth rates for wild hawksbill turtle in Baja California waters. Captive studies have produced poor data as hawksbill turtles held at the CRIP-ECITM, in Bahía de los Angeles fared poorly during winter months. However, one 27 cm turtle grew 1.3 cm in approximately 10 months (1.6 cm/y).

For comparison, growth rates of 19 hawksbill turtles from Fog Bay, Australia (between 35 and 70 cm (SCL) ranged 1.4 to 3.2 cm/y (mean = 2.3 cm/y, sd = 0.5)(Walsh and Beusse 1998). These growth rates are faster than those reported for the Great Barrier Reef, Australia (Limpus 1992), and slower than those reported for the Bahamas (Bjorndal and Bolten 1988).

Reproduction

There are no rookeries remaining for the hawksbill turtle in the eastern Pacific. Sporadic nesting still occurs, however, along the Pacific coast of the Americas. The nearest beaches with recurrent nesting are in Nayarit, Mexico. However, nesting levels are very low. There are unconfirmed reports of hawksbill nesting in the cape region of Baja California.

Recently, several apparent hawksbill-green turtle hybrids have been found (A. Abreu and A. Resendiz, pers. comm.). This may be an indication that there are too few mature hawksbill turtles for females or males to find mates during the reproductive seasons. I have never seen a live, mature-sized hawksbill turtle in Baja California waters.

Epibionts

The single sea turtle with the highest diversity of epibionts that I have collected in Baja California waters was a small hawksbill turtle caught in Estero los Cuervos, Bahía Magdalena, Baja California Sur in July 1998. The turtle carapace was infested with several varieties of algae and barnacle (Table 6), as well as a species of oyster, sponge, and several polychaete worms. The imbricate scutes of the hawksbill carapace may provide enhanced fouling surface for epibionts, in particular hiding places for worms. Steinbeck (1951) reported hydroids and a pair (male and female) of *Planes* sp. crabs from a hawksbill turtle collected in Bahía Magdalena.

Threats

The hawksbill turtle is immediately threatened with extirpation from the eastern Pacific, more so than any other species. Alarmingly, the conservation community has not discussed this, perhaps because of a misunderstanding of former hawksbill abundance. Exploitation had been so thorough prior to any systematic surveys of the region that some researchers have adopted the perspective that hawksbill turtles were never very common in the eastern Pacific. This is an unfortunate state of affairs, and there may now be little to be done to recover stocks.

The hawksbill, owing to its scarcity, is infrequently hunted. Though, when it is, it is eaten, kept for its carapace, or—if very small—stuffed and hung over a doorway.

Leatherback turtle, *Dermochelys coriacea*.

The leatherback turtle is the species least likely to be encountered in Baja California waters, although it is one of two species—the other is the olive ridley turtle—that commonly nest on Baja California beaches (Table 3).

Distribution and Population Size

Nesting is known in the cape region from as far north as Cabo Tosco on the Pacific coast of Baja California and north to La Paz in the Gulf of California. Unsubstantiated reports have been recorded for the Colorado River delta region in the northern Gulf of California. Feeding is best known in upwelling areas north of Isla Tiburón and Isla Angel de la Guarda in the Gulf of California. Fishermen have reported sporadic sightings at virtually all locations along the peninsula, however they are rare. Tad Pfiester, director of the Prescott College field station in Bahía Kino, Sonora, reported a post-hatchling leatherback from that region in 1995. Between 1995 and 1999 I have seen only 2 leatherback turtles in the water, both immature animals in the Bahía de Loreto National Marine Park. Most leatherback turtle sightings are remembered clearly, as the turtles are surprisingly large and drastically different from all other sea turtle species. In some cases fishermen harpooned the animals and dragged them ashore, only to realize that the meat is spongy and generally distasteful to the local palate.

Migration and Movement

Virtually no information is available on the movement of leatherbacks from Baja California waters as studies have been limited to nesting beach surveys alone. A single leatherback turtle was tracked for 3 months between January and March 2000, following nesting near Todos Santos, Baja California Sur. The turtle moved approximately 2,000 km southwest of the release location (ASPMATOMA 2000).

Based on the results of analyses of mtDNA from turtles sampled at rookeries and high seas and coastal fisheries, Dutton (1999) suggests that leatherback turtles make trans-oceanic migrations and that animals originating on both eastern and western Pacific rookeries may forage together on eastern Pacific foraging grounds.

Diet and Foraging Ecology

I have not obtained stomach contents, nor observed leatherback turtles foraging in Baja California waters. There are no published accounts from the region. However, a few fishermen from the Pacific coast of the peninsula have confirmed that leatherback turtles eat jellyfish and salps.

Growth

There are no growth data, captive or wild, available for leatherback turtles in Baja California.

Reproduction

Leatherback turtles are one of the two species of sea turtle known to nest regularly on Baja California beaches. In January 1999 we counted nine leatherback turtle nests on approximately 20 km of beach near Todos Santos, Baja California Sur—the extreme northern limit of their nesting range (Figure 14). These observations are supported by descriptions of nesting activity of this species by (Fritts et al. 1982) who report nesting activity from Punta Márquez on the west coast to La Paz on the Gulf of California coast.

Interviews with fishermen suggest that leatherbacks may also nest in the northern Gulf of California near San Felipe, Baja California. Caldwell (1962) reported hatchlings in this vicinity and there have been reports of hatchling-sized leatherback turtles in the Bahía de Kino, Sonora region (T. Pfiester, pers. comm.). As the major leatherback turtle nesting beaches in the eastern Pacific, mainly in Michoacan and Oaxaca, Mexico, have declined sharply in recent years the leatherback nesting populations in Baja California have taken on a new light. Their numbers may now represent a much larger percentage of the total reproductive population in the Pacific. It has been suggested that the Baja California leatherback populations have grown in recent years (Olguin 1990). In 1990, Peña and Villanueva (unpublished data) estimated the population of nesting female leatherbacks in Baja California at 65 individuals. Scott Eckert (Hubbs-SeaWorld) documented more than 50 body pits along the west coast of the peninsula during January 1998, with peak nesting along the coast north of Todos Santos (Eckert, pers. comm.).

The nesting season for leatherbacks in Baja California is from approximately October through January (Fritts et al. 1982) and hatchlings emerge well into March after a 60 day incubation period (Table 4). Personal observations and interviews with fishermen from the region indicate that hatchling emergence is rare. Manuel Orrantes (ASUPMATOMA) noted in January 2000 that the only leatherback hatchling to emerge from nests were those kept in coolers indoors. Francisco Cota, a long term resident of a ranch north of Todos Santos near the area of most *D. coriacea* nesting activity, indicated that in his years observing sea turtles, and formerly collecting eggs, he hasn't seen a single leatherback hatchling. He has dug up several nests only to find dead, partially formed embryos. The factors affecting low hatchling development in the region are most likely related to low temperatures during winter and spring and the inadequate moisture content of the sand.

Incidentally, in 1994, recognizing the severity of egg poaching in the region, officials initiated plans to establish a permanent sea turtle conservation program in Todos Santos, to be coordinated by the "Todos Santos" and Punta Lobos" fishing cooperatives, in conjunction with the state (Baja California Sur) and SEMARNAP. The project passed through various levels of approval, but ultimately was never realized. ASUPMATOMA has recently reinitiated the protection effort.

While leatherback nesting is well known in Baja California, the occurrence of male leatherbacks is exceedingly rare. I have never encountered a male leatherback in the field and virtually all fishermen interviewed noted their absence. It seems likely that copulation occurs at sea far from the nesting areas and that males rarely enter coastal waters.

Epibionts

No information was found concerning leatherback turtle epibionts from Baja California waters.

Threats

The main threats to leatherback turtles in Baja California waters, as far as I have documented, are on the nesting beaches. Turtles that emerge to nest are most vulnerable to poachers, as are their eggs. Developers are steadily converting the beaches themselves, from pristine wilderness to subdivisions and resorts.

Fishermen have reported that leatherbacks occasionally become entangled in trap or buoy lines or swim into nets. This is an infrequent occurrence, likely related to the sparseness of the leatherback turtles in the region.

Pacific leatherback turtle populations are in serious decline. Data obtained through satellite telemetry (Eckert, unpubl. data) show that many turtles leaving Mexican beaches migrate to foraging areas off the coast of South America where long-line fisheries for swordfish are implicated in the bycatch of thousands of leatherback turtles.

SUMMARY

Baja California waters provide foraging habitat, and to a lesser extent nesting beaches, for all five of the sea turtle species found in the Pacific basin. Two species, the leatherback and olive ridley turtles, are known to nest regularly on Baja California beaches. However, the nesting habitat is rapidly being compromised by tourist development. Similarly, foraging areas in the region, while vast, are heavily disrupted and threatened by commercial fishing activities, clandestine sea turtle hunting, and proposed mega-tourism developments (e.g. Escalera Nautica).

Hawksbill turtles have been nearly extirpated from Baja California waters and the eastern Pacific more generally. My findings suggest that the population was once robust, providing employ for fishermen and artisans, but early in the 20th century were fished to commercial extinction. Continuing black markets for turtle meat haven't permitted the stocks to recover. Green and loggerhead turtles foraging in Baja California originate on beaches as far away as Japan an, Hawaii and southern Mexico. Despite their complete protection by Mexican law, remnants of both species are still steadily exploited. Soon they may follow the dismal trajectory of the hawksbill turtle.

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Table 1. Scientific, English and Spanish names for sea turtles occurring in Baja California waters. Most frequently used Spanish common names are underlined.

Family Dermochelyidae

Dermochelys coriacea

SPANISH: tortuga laud, tortuga siete filos, tortuga tres filos, tortuga de altura, tortuga galapagos, tortuga garapacho, parlama, toro, tortuga de canal, tortuga baula, tortuga de piel, tortuga tinglado tortuga de cuero
ENGLISH: leatherback turtle, trunkback turtle

Family Cheloniidae

Caretta caretta

SPANISH: tortuga amarilla, tortuga javalina or javelin, tortuga caguama, tortuga perica, tortuga cabezona, tortuga boba, rarely tortuga golfina
ENGLISH: loggerhead turtle

Chelonia mydas

SPANISH: tortuga prieta, tortuga negra, tortuga frijolilla, caguama (a name used for sea turtles in general), tortuga verde (literal translation of English), tortuga blanca (Atlanic green turtle)
ENGLISH: green turtle, east Pacific green turtle, black turtle

Eretmochelys imbricata

SPANISH: tortuga carey, tortuga pico de halcon, tortuga perica
ENGLISH: hawksbill turtle

Lepidochelys olivacea

SPANISH: tortuga golfina, tortuga mestiza, tortuga amarilla
ENGLISH: olive ridley turtle, Pacific ridley turtle

Table 2. Simplified key to the sea turtle species of Baja California waters (modified from Pritchard and Mortimer 1999).

1. Leathery carapace with seven longitudinal ridges, dark in color with small white patches: *Dermochelys coriacea* (Figures 3 and 4)

1a. Hard carapace with large, distinct scutes: see 2.

2. One pair of prefrontal scales (between the eyes and nostrils): see 3.

2a. At least two pairs of prefrontal scales: see 4.

3. Plastron white or yellowish, size large (to 250 kg), no incurving of shell margin above hind limbs, dorsal coloration variable but not black (except in hatchlings): *Chelonia mydas* ("green" turtle form[1]) (Figures 9 and 10).

3a. Plastron infused with moderate to intense gray pigment, size small (to about 100 kg), indentation present in margin of carapace above each hind limb, dorsal coloration generally largely black, although variable: *Chelonia mydas* (East Pacific green, or "black" turtle, form[1]).

[Note: see Chapter 7 for clarification of *Chelonia* nomenclature]

4. Four large scutes (costals) on each side of carapace: *Eretmochelys imbricata* (Figures 11 and 12).

4a. More than four pairs of costal scutes: see 5.

5. Five pairs of costal scutes; reddish-brown upper body surface, plastron with three pairs of small scutes (inframarginals) making contact with both marginal scutes and principal plastral scutes: *Caretta caretta* (Figures 7 and 8).

5a. Gray of olive upper body surface; plastron with four pairs of small scutes (inframarginals): *Lepidochelys olivacea* (Figures 5 and 6).

[1]Note that immature turtles of both the "green" and "black" form have similar morphologies.

Table 3. Relative abundance of sea turtles in Baja California waters (1994-1999).

	Feeding areas		Nesting beaches
Gulf of California	**Pacific coast**		
Cm	+++	+++	—
Cc	+	+++	—
Ei	+	+	—
Dc	+	+	++
Lo	+	++	+++

+++ most abundant, ++ moderately abundant, + rare, — not known

Cm = *Chelonia mydas*, Cc = *Caretta caretta*, Ei = *Eretmochelys imbricata*. Dc = *Dermochelys coriacea*, Lo = *Lepidochelys olivacea*

Table 4. Months when sea turtles have been sighted in Baja California on feeding grounds (F) or nesting beach (N). 0 = not reported, + = reported. Based on surveys, interviews, and published reports (see text for citations).

Species	Jan N/F	Feb N/F	Mar N/F	Apr N/F	Jun N/F	Jul N/F	Aug N/F	Sep N/F	Oct N/F	Nov N/F	Dec N/F
Cm	0/+	0/+	0/+	0/+	0/+	0/+	0/+	0/+	0/+	0/+	0/+
Cc	0/0	0/+	0/+	0/+	0/+	0/+	0/+	0/+	0/+	0/+	0/0
Ei	0/0	0/0	0/0	0/0	0/+	0/+	0/+	0/+	0/+	0/0	0/0
Lo	0/0	0/+	0/+	0/+	0/+	+/+	+/+	+/+	+/+	+/+	+/+
Dc	+/0	+/0	+/+	0/+	0/+	0/+	0/+	0/+	0/0	+/0	+/0

Table 5. Sightings of green turtles, *Chelonia mydas*, during aerial surveys of the Midriff Island region, Gulf of California, Mexico, 1994-1995.

Date	Size class (approx.)	Location	Latitude/ Longitude
24 Oct 1994	Juvenile	NW of Is. Angel de la Guarda	28˚ 38.2N, 112˚ 00.2W
24 Oct 1994	Juvenile	S of Puerto Refugio, Is. Angel de la Guarda	28˚ 34.9N, 112˚11.0W
6 June 1995	Juvenile/Adult	S of Is. Tiburon	28˚ 42.1N, 111˚ 59.5W
15 Oct 1995	Juvenile	El Rincon, Bahía de los Angeles	28˚ 40.8N, 112˚58.8W

Table 6. Epibionts recorded on Baja California turtles:

Polysiphonia sp. (CC, EI, LO) on carapace only, often in mat that may cover 50% of carapace and provide habitat for amphipods.

Enteromorpha sp. (CM, EI) on carapace, in a patchy mat.

Bryozoans (unid. sp.) (CM, EI) found on carapace and pastron.

Chelonibia testudinaria (CM, CC, LO, EI) on carapace, plastron, head, neck, and occasionally flipper. Small *C. testudinaria* more common on flippers, tail and head. Up to 70 mm diameter.

Platylepas hexastylos (CM, CC, LO) on neck and flippers, typically leading edge of fore flippers.

Lepas anatifera (CC, EI, LO) on carapace and rarely plastron (pelagic turtles), rare in bays but see EI. Usually growing in mass, anchored by *C. testudinaria*.

Stephanolepas muricata (EI) found on one hawksbill in Bahía Magdalena

Planes cyaneus (CC, CM, LO) on rear flipper, tail area. Typically on pelagic turtles. usually male and female, often gravid female.

Ozobranchus sp (CC, CM, LO) on neck and flippers, very abundant

Amphipods (unid. sp., family Gammaridae). (CM, CC, LO) on carapaces that have algae.

Ostrea lurida (EI) on one hawksbill in Bahía Magdalena. Found on plastron, flat, compressed bivalve.

Polychaete worm (unid. sp.) (EI) found in algae and under scutes of hawksbill (Bahía Magdaena).

Remora sp. (CC, LO) on plastron, usually fall off in water when turtle is collected. Only on pelagic turtles.

Table 7. At-sea sightings of loggerhead turtles, *Caretta caretta*, in Baja California, Mexico, 1997-1999.

Date	Location	Total hours of survey	# of Sightings	Mean sightings/h
July 1997	Bahía Magdalena, BCS	13	5	0.38
August 1997	Punta Abreojos, BCS	30	20	0.67
July 1998	Bahía Magdalena, BCS	15	4	0.27
August 1998	Punta Abreojos, BCS	24	1	0.04
November 1998	Punta Abreojos, BCS	28	1	0.04
July 1999	Bahía Magdalena, BCS	75	24	0.32
Total		185	55	0.30

Figure 1. Visual guide to the five sea turtle species occurring in waters of the Baja California peninsula, Mexico. The bilingual guide and a similar poster have been distributed throughout northwestern Mexico.

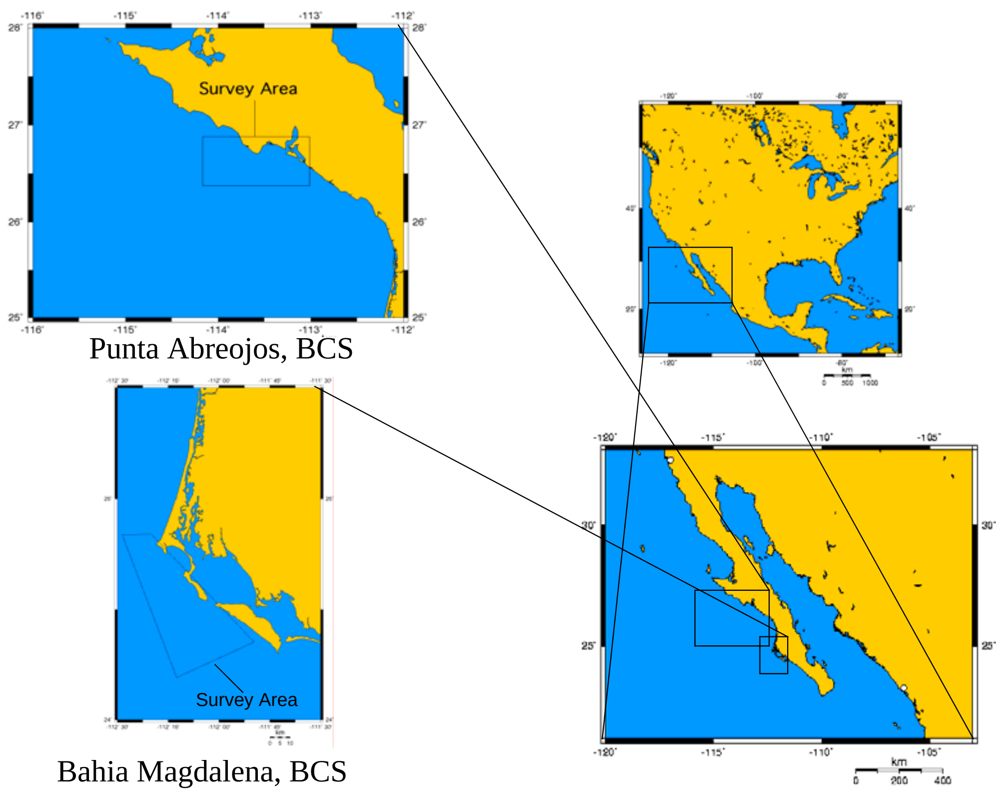

Figure 2. Primary areas of *Caretta caretta* surveys near Punta Abreojos and Bahía Magdalena, Baja California Sur, Mexico.

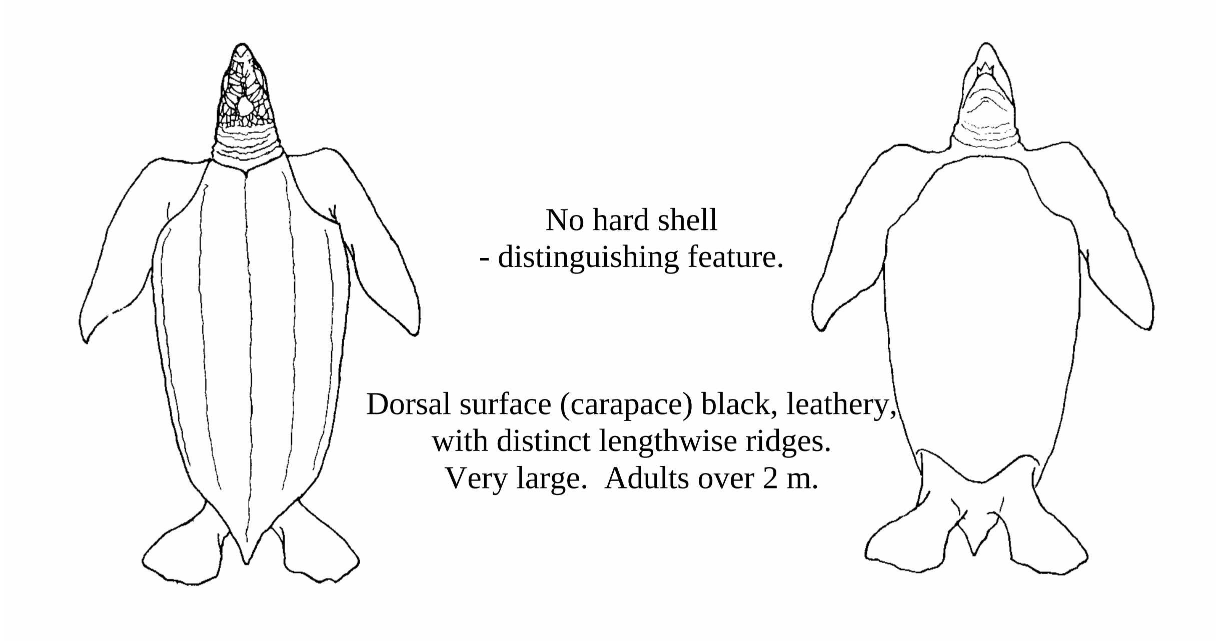

Figure 3. Distinguishing features of the leatherback turtle, *Dermochelys coriacea.*

Sea turtle diagrams were provided by the Seattle Aquarium.

Figure 4. Leatherback turtle, *Dermochelys coriacea*, nesting at night.

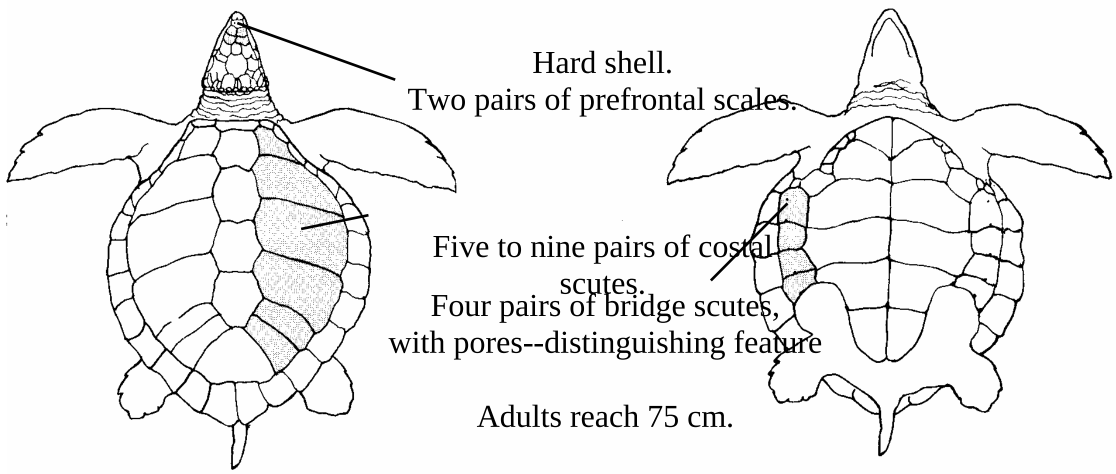

Figure 5. Distinguishing features of the olive ridley turtle, *Lepidochelys olivacea.*

Figure 6. Olive ridley turtle, *Lepidochelys olivacea*, nesting near Cabo San Lucas, BCS. Note two pairs of prefrontal scales (distinguishes from *Chelonia mydas*).

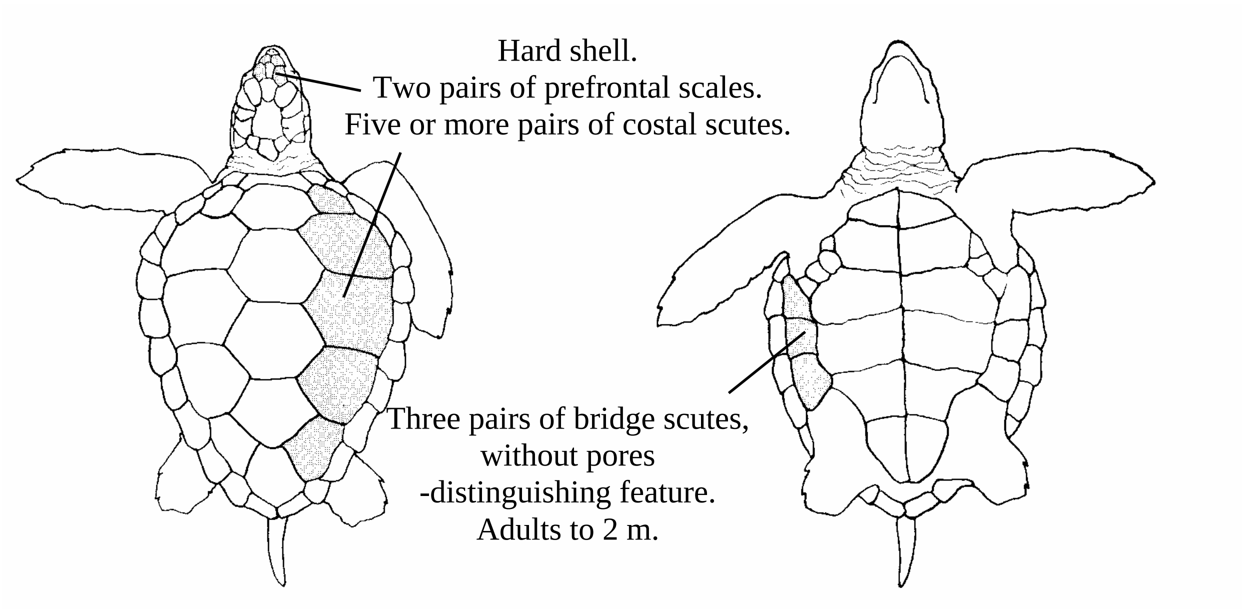

Figure 7. Distinguishing features of the loggerhead turtle, *Caretta caretta.*

Figure 8. Loggerhead turtle, *Caretta caretta,* swimming near Channel Islands, California, USA.

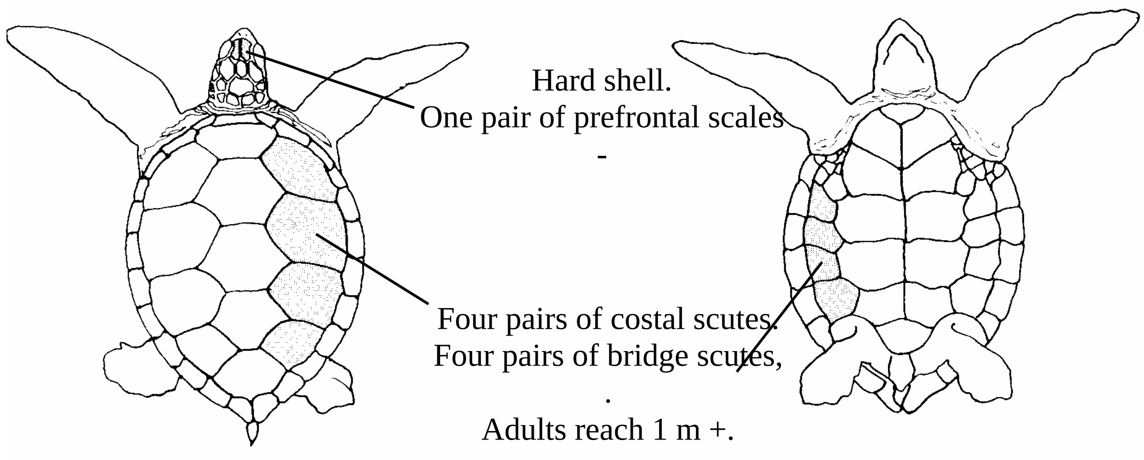

Figure 9. Distinguishing features of the East Pacific green turtle, or black turtle, *Chelonia mydas*.

Figure 10. East Pacific green turtle, *Chelonia mydas*, nesting in Colola, Michoacan, Mexico.

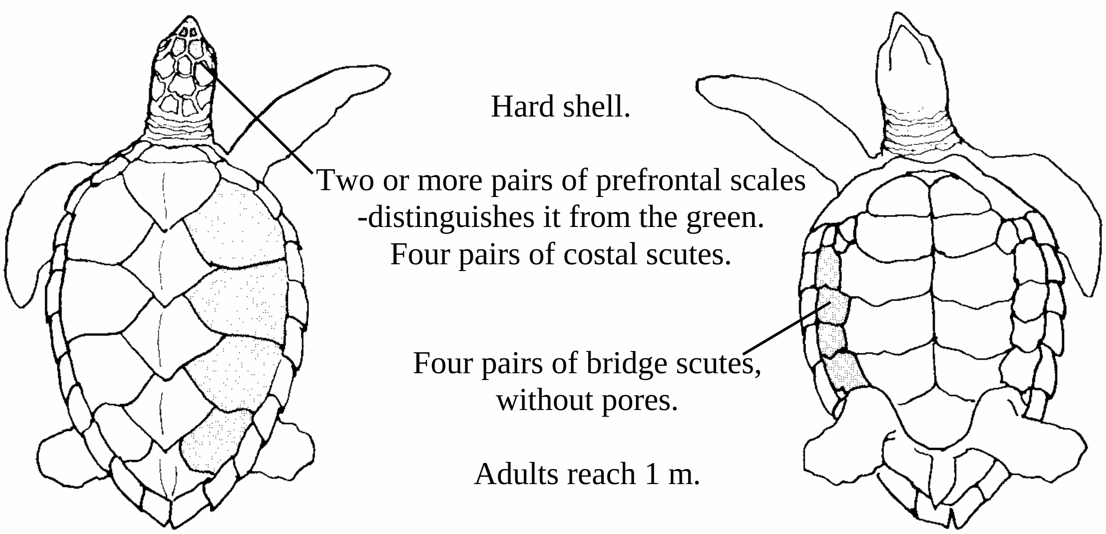

Figure 11. Distinguishing features of the hawksbill turtle, *Eretmochelys imbricata.*

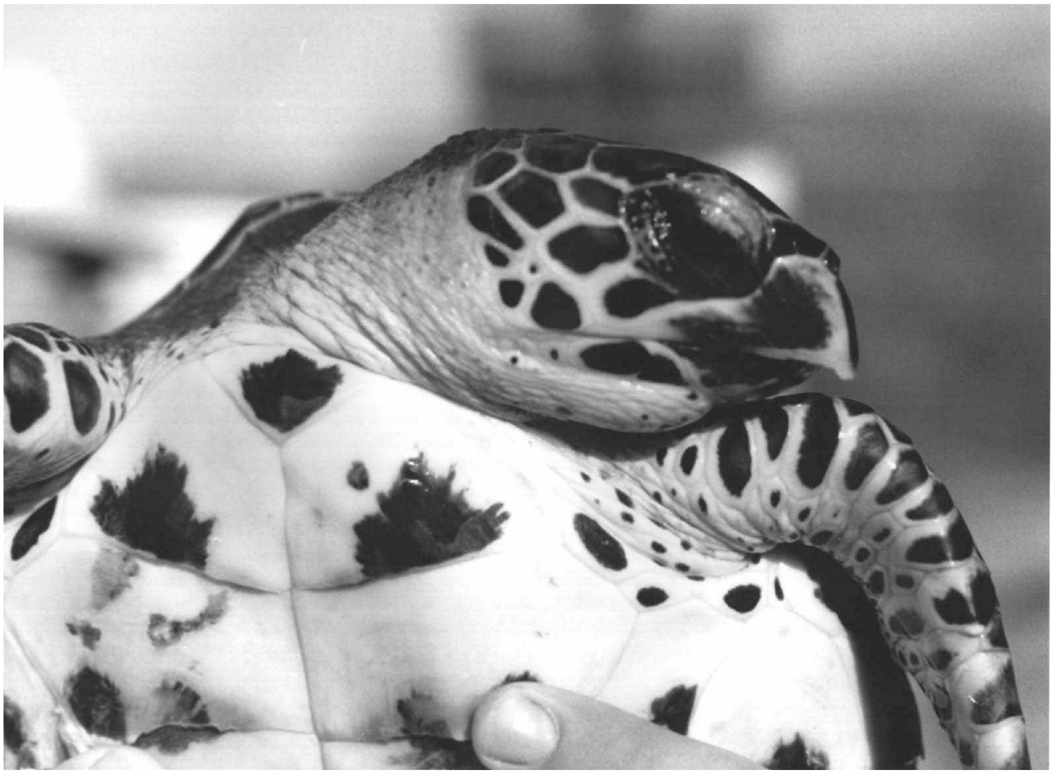

Figure 12. Immature hawksbill turtle, *Eretmochelys imbricata.* Captured at Bahía de los Angeles, Baja California, Mexico. Note shape of beak and pattern of the plastron.

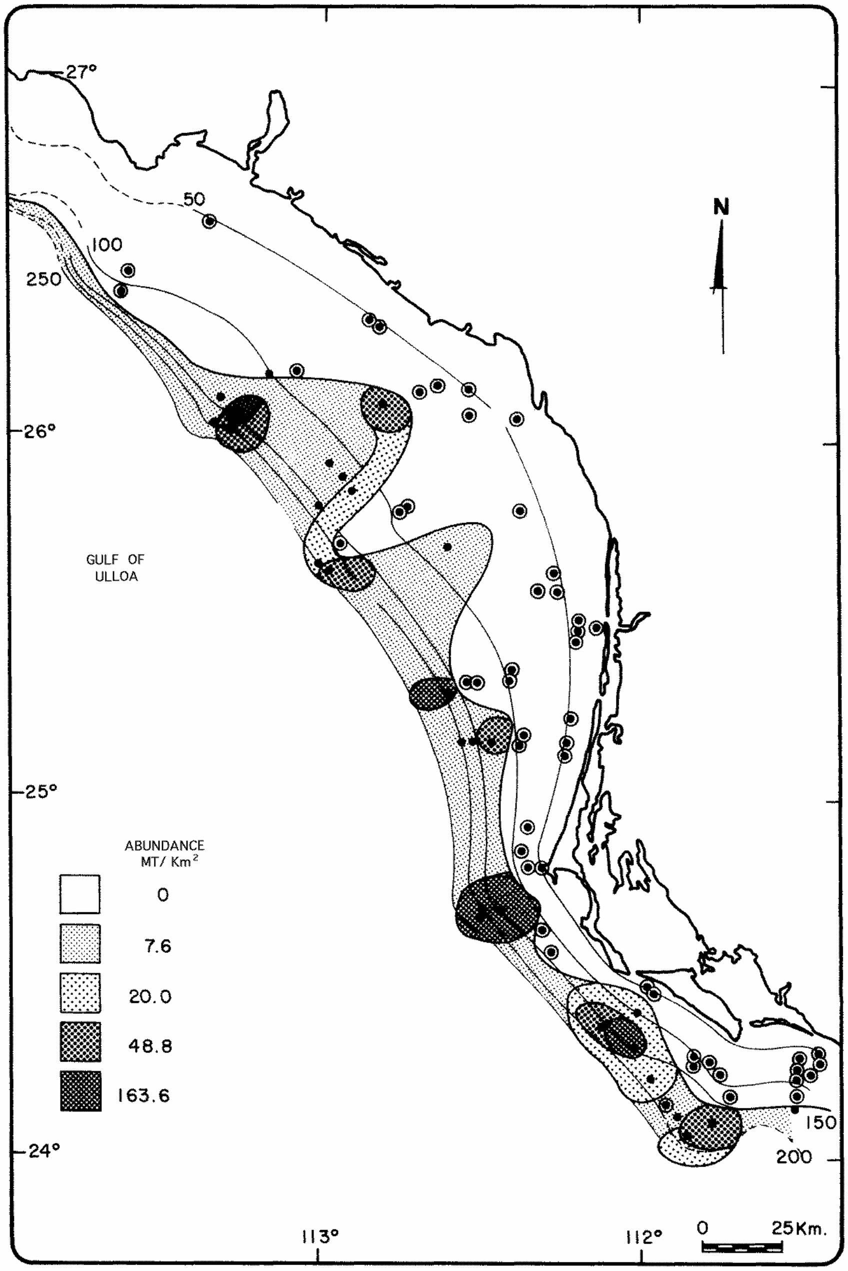

Figure 13. Distribution and density of benthic pelagic red crabs, *Pleuroncodes planipes,* on the continental shelf near Bahía Magdalena, Baja California Sur, Mexico, in summer-autumn, 24˚–27˚ N (Aurioles 1995). Abundance is in metric tons per square km.

CHAPTER 2

FROM BLACK STEER TO SACRED COW: HISTORIC AND CONTEMPORARY SEA TURTLE USE IN BAJA CALIFORNIA, MEXICO

ABSTRACT

Baja California waters were formerly the most important feeding grounds in the eastern Pacific for several species of sea turtle. Since the early 1900's sea turtles have been hunted commercially and for household use in Baja California for their meat, hides, and shells. This traditional fishery can be traced to the earliest inhabitants of the region and has been a part of the regional culture for centuries. The fishery began with the use of simple harpoons thrown from sailboats and canoes. Approximately thirty years ago Baja California sea turtle fisheries were near their production peak. Caldwell (1962) referred to the East Pacific green, or black turtle (*Chelonia mydas*) as the "black steer" in reference to its coloration, abundance and importance as "the chief source of meat in that barren peninsula". Other species that were hunted included the hawksbill (*Eretmochelys imbricata*), loggerhead (*Caretta caretta*), and olive ridley (*Lepidochelys olivacea*) turtles. Fewer than 20 years later regional turtle populations had been nearly extirpated resulting in drastic management efforts and ultimately a complete ban on turtle products in 1990. The adoption of nets by turtle fishermen, expansion of the market through increased international demand, and increased access to the resource—facilitated by shipping, outboard motors, and a new transpeninsular highway—led to the drastic decline of populations. Since the 1990 ban on all sea turtle products, annual numbers of green

turtles nesting in Mexico have continued to decline. This may be partially the result of contemporary bycatch of sea turtles, furtive hunting for black markets, and continued local use of turtle products. Turtle meat continues to occupy its traditional place as the food of choice for holidays and special events as well as use in folk remedies. If sea turtle populations are to recover, those working on conservation and protection efforts must understand, document, and address the human dimensions—both historical and contemporary—of the problem. This is particularly true relative to the strong, continuing, tradition of sea turtle consumption, the political motivation to maintain the status quo, and the increasing impact of artisanal and commercial fisheries must be recognized.

INTRODUCTION & HISTORY OF SEA TURTLE FISHERIES

Before overhunting radically decreased their numbers, five of the world's seven species of sea turtle thrived in Baja California waters. Four of the species were formerly hunted for their meat, shell, and leather. Until 1990, the green turtle, *Chelonia mydas*, (also known locally as the black turtle or *tortuga prieta*) accounted for the bulk of annual landings. Turtles were reported to be so abundant by early missionaries and explorers, that navigators complained that they were slowed by the massive flotillas of migrating turtles (Cliffton 1990). This plethora of green turtles—once one of the most abundant large marine vertebrates in the eastern Pacific Ocean—were for many centuries a core source of protein for inhabitants and visitors to the Baja California peninsula—they were the "black steer" of this hot, arid region (Caldwell 1962). As occurred in other parts of the world in earlier centuries (Nietschmann 1995) the demand for green turtle eventually outstripped the ability of this slow-growing species to regenerate.

Native Mexicans have traditionally utilized sea turtles and their products on a subsistence basis. Some coastal indigenous communities continued using turtles until modern times, including the Seris, Huaves, and Pómaros (Marquez 1990). In Baja California, the human-turtle relationship dates back to the earliest records from the region.

The Seri Indians who inhabited the coast of Sonora and Gulf of California islands were skilled in obtaining marine resources and may have been the first to utilize sea turtles. Studies by anthropologists offer the most well documented information about indigenous use of turtles. The Seri hunted sea turtles from balsas, or reed boats, also known from other locations in the Baja California region (Wagner 1925). They used long harpoons—up to 10 m in length—made of ironwood (Figure 3). A small leather stopper prevented the head of the harpoon from penetrating deeply and causing mortal injury. When a turtle was caught, the flippers were bound and the hole filled with mud or seagrass to stop bleeding. Virtually all parts of the turtle were eaten, if not immediately, then within days after capture. The turtle carapace has multiple reported uses, including shelter, cistern, cradle and coffin (McGee 1898).

The relationship to the sea turtle among the Seri was complex, with a strong spiritual component. The four principle Seri clans were the Pelican, Turtle, Moon, and Sun (A. Astorga, pers. comm.). A rich body of songs, dances, and traditions related to the sea turtle has been recorded (McGee 1898, Felger and Moser 1985, Nabhan et al. 1999), however much traditional knowledge is being lost. Although it is likely that much of this knowledge of the animals and many of the Seri hunting techniques were assimilated into the Mexican culture after the coming of the Europeans.

Other indigenous groups in Baja California apparently used sea turtles, but possibly at a lower level than the Seri (Aschmann 1959). O'Donnell (1974) suggests that indigenous groups in Bahía de los Angeles, Baja California, likely utilized sea turtle resources, but cites several conflicting reports by missionaries in the region. Regardless, missionaries' records indicate "turtles in abundance in both seas" (Aschmann 1966).

Records indicate that, as in the Caribbean Sea, 17th century pirates caught "turtles that swarmed about", and utilized turtle meat while sailing the coast of Baja California and adjacent waters (Gerhard 1963). There are several other accounts of expeditions stocking up on turtles (apparently green turtles), on beaches and at sea as the turtles mated and basked, as the sailors voyaged up the coast of Mexico to Baja California (O'Donnell 1974). While sailing near Cabo San Lucas in October 1793 Captain James Colnett reported that "the sea, at this time, was almost covered with turtles, and other tropical fish" (Colnett 1798). Despite these intriguing reports, information is relatively sparse and particularly vague on the numbers of turtles, species, and the level of the take during the period between 1600 and 1800.

Whalers and sealers also wrote of the abundance of sea turtles in the region and relied heavily on the ever-available turtle meat. Commercial exploitation of marine mammals began along the shore of Baja California at the start of the 19^{th} century (Dedina 1996). The hunters of the gray whales in Bahía Magdalena provide several accounts of the numerous sea turtles along the shores. The green, loggerhead, and possibly the hawksbill turtles are described with reference to one as being good to eat and another's shell having commercial value. The descriptions of whaling boats stocking up on sea turtles provide a glimpse of the utility of such a high quality and abundant source of food: 'At sundown the starboard and larboard boats returned "with 8 noble large turtle." The waist and bow boats, having camped out overnight, returned at 2 p.m. the next day with fifty-five turtles.' (in O'Donnell 1974, quoted from the log of the Saratoga, Kendall Whaling Museum, Sharon, MA, Log 180). Stocking up on dozens of sea turtles prior to leaving Baja California's Pacific lagoons was commonplace, and easy (Scammon 1970).

Turtles were considered an inexhaustible resource due to their seemingly endless abundance. At the start of the 20^{th} century, their abundance was yet apparent: "Green turtles are plentiful about the southern coast, especially from Cape San Eugenio south to beyond Santa Margarita Island [Bahía Magdalena] and also along most of the Gulf shore" (Nelson 1921). Townsend (1916) reported that "in a single haul of a seine 600 feet long [they] brought to shore 162 green turtles…probably half as many more escaped". Commercial turtle hunting followed whaling, despite the fact that whalers had hunted turtles for decades. Hunting of sea turtles continued through the early years of the century, supplying abundant salable meat to whaling and sealing ships and as a substitute resource following the demise of whale and seal populations. Turtles were shipped from Baja California to canneries and restaurants in California and Arizona, USA, and on to inland cities such as Chicago. Reports of up to 1,000 turtles being shipped to San Diego each week, considering the sheer numbers of animals on feeding grounds in Baja California, are not surprising. Several small communities, including Bahia de los Angeles, Baja California, and Bahía Tortugas, Baja California Sur, were settled along both the Gulf of California and Pacific coasts, their inhabitants focusing almost entirely on hunting sea turtles in order to meet growing demand. The Luceros, a founding family of the town of Puerto Adolfo Lopez Mateos on Bahía Magdalena, moved from their ranch in the Sierra de la Giganta in the early 1920s to Matancitas, a ranching community 10 km from where Puerto Adolfo Lopez Mateos stands today. A few years later the family moved to the bay shoreline and made a living by fishing for sea turtles and sharks (Dedina and Young 1995). Turtles were trucked or shipped by the tens of thousands, primarily from northern Gulf of California and Pacific locations, due to the proximity to the border.

The development of canneries, large turtle fishing vessels, and the use of 300 to 1200 foot nets, which were spread across the mouths of lagoons after flood tide, resulted in a surge in turtle captures. Row boats were launched to retrieve turtles from the massive nets and then unloaded the catch to a launch that shuttled turtles to the schooner which, filled with 350 turtles, returned to San Diego (Averett 1920). Turtles were held in ponds in San Diego until slaughtered. Up to two tons of turtle were produced per day—canned meat and rendered oil were the main products.

Craig (1926) described the turtle fishery in the northern Gulf of California in a report on the new "totuava" (*Cynoscion xanthulus*) fishery:

> "During the spring months there are numbers of large sea turtles caught at San Felipe. Most of them are harpooned, although a few are taken alive and shipped out to Los Angeles or San Diego. These turtles are very rich in fat and the principal object of their capture is to secure this oil. The turtles are cut up and the flesh and fat placed in large pans filled with water. After being cooled, it has about the consistency of soft lard, and is light yellow in color. It is packed in five-gallon oil cans and sold for a good price to druggists. The turtle meat remaining is salted and dried in the sun and used for food."

This trade in turtle products flourished through the early twentieth century but by 1925 turtle fisheries had declined, concern for the resource grew, and the California markets closed. In 1925, less than 10 kg of turtle meat were received in Los Angeles and none was received in San Diego, compared to 35,000 kg reported in 1920 alone (O'Donnell 1974). O'Donnell considers that a reduction in demand for the turtle meat may have also contributed to the reduced catch. Although, in 1929 an article noted that the rare turtles that remained on feeding grounds had become wary and difficult to catch and that "today even Turtle Bay, Lower California, is fairly barren of the animals"

(Anonymous 1929). Regardless, the market for sea turtles in California declined, and turtles brought across the border reportedly were commonly sent back to Mexico for a lack of American buyers. International trade was drastically curtailed, however, a strong market for the turtles continued along the peninsula. When the Carl Hubbs-Erol Flynn expedition visited Laguna San Ignacio, only turtle fishermen were working at the lagoon (Walker 1949). Interviews with fishermen who are still living confirm that turtles were still present, and though diminished in number, easy to catch. The market for the turtles was primarily in Ensenada and Tijuana, Mexico.

MODERN SEA TURTLE FISHERIES

Following an active—but relatively slow—respite, turtle hunting began in earnest in the 1950s to meet demands for turtle meat from growing Baja California towns and cities. By the 1960s the fishery reached a new production peak. However, sea turtles were now being provided primarily for domestic use as food in Baja California. Between 1955 and 1961 Baja California made up 39% of Mexico's total turtle landings. By the mid-1960's, due to promotion by the government and a simultaneous decline in crocodile resources, which resulted in increased demand for turtle hides, the turtle fishery had boomed again. Between 1962 and 1967 sea turtle catch in Mexico increased 633% and Mexico was producing more turtle product than any other nation (O'Donnell 1974).

While fishing boats became more secure and small motors permitted longer forays, modern turtle fishing techniques differed very little from aboriginal times. The use of harpoons continued, although they were made of heavy pipe and the heads were made of iron, often forged from automobile axles. A small piece of rubber replaced the leather stopper. The combination of increased mobility on the water and the deft abilities of skilled harpooners meant that ever-increasing numbers of turtles were taken. In an interview, one fisher who once hunted green turtles with a harpoon near Loreto, Baja California Sur, proudly recalled that his harpoon missed its mark fewer than one time in one hundred throws.

Caldwell's (1962) depiction of sea turtle fishing in Bahía de los Angeles describes harpooning as a common technique. He reported the landing of more than 500 turtles during a three-week period in 1962. Sea turtle hunting methods were similar in the

Pacific lagoons of Baja California. During interviews at Laguna San Ignacio, several older fishermen recalled year-round sea turtle fishing, beginning in the 1940s and continuing through the 1970s. They rowed or sailed small boats by lamplight in the lagoon, harpooning turtles at night when the sea was calm. Standing in the bow, the harpooner looked for distinctive bioluminescence in the water or if fishing during daylight, the turtle's gasping head at the surface. Once in the turtle's shell, the head of the harpoon separated from the shaft of the spear. Both were tethered to the boat by a strong cord. A second harpoon was often used to secure the turtle and then the lines were used to pull the turtle towards the boat. Some turtles weighted more than 300 lbs. and fishermen report filling their boat with water in order to heave these animals over the gunwale. It was not uncommon for a single boat to bring in 15 green turtles in a day.

As technologies such as "seda" entanglement nets and outboard motors became common, they replaced harpoons, sails, and oars, allowing fishermen to capture as many as 30 turtles per day with relatively little effort. Nets reduced the expenditure of human energy, and despite their small size (100m length), an average of more than 20 turtles per day were caught per team. Boats were adapted to use larger outboard motors (25 to 50 hp) and the increased mobility and speed they allowed, in conjunction with the nets, proved a formidable and destructive strategy. Cliffton et al. (1982) estimated a take of 375,000 green turtles during the five-year period from 1966 through 1970. A simultaneous take of nesting females and eggs occurred on nesting beaches in Michoacan. No serious attempts had been made up to that point to manage the green turtle fishery (Caldwell 1963). Fishermen report that fishing effort continued and intensified, even as catches declined.

HISTORY OF SEA TURTLE CONSERVATION

In the early 1960s experimental management techniques were initiated on some of the major Baja California turtle fishing grounds. The goal of the Ministry of Fisheries, on a national level, was to manage the fishery for maximum yield, by allowing the populations to recover and simultaneously protecting their known nesting beaches. The temporary seasonal ban on turtle fishing, between May and August—typically the peak of the fishing season—proved useless due to inadequate enforcement and illegal hunting. Tagging programs were initiated in Baja California (Estación de Biología Pesquera-El Sauzal, Ensenada, Baja California) as in several other regions, however, little in the way of conservation occurred. Limited protection of turtles while on their feeding and developmental habitats occurred, as the bulk of attention was focused on a network of camps and research programs located on the nesting beaches. The study of sea turtles in the water, on feeding grounds, proved to be a difficult and expensive endeavor. In one pilot study, several dozen sea turtles were tagged, producing some new information. However, a much more intensive effort was needed (Marquez 1976). In 1968 the Ministry of Commerce elaborated regulations related to the capture, use, and commercialization of sea turtles, emphasizing and obliging use of whole turtles, rather than only the hide, in order to stop the wastage that had become the norm (Cantú and Sánchez 1999).

In the early 1971, as an interim measure and response to diminishing populations, a total ban of turtle fishing was implemented. Quoting Dr. J.R. Hendrickson of the University of Arizona (March 1973), O‘Donnell (1974) writes:

> "So far as I am aware, the thing which led to the total ban on turtle fishing in Mexico was the desperate drop in catch as recorded in the central statistics office in Mexico City. Despite what I suspect was increased fishing effort in the country as a whole, the recorded product dropped alarmingly, and the Mexicans finally began to fear the dire predictions which conservationists in other countries had been making—that Mexico would exterminate her sea turtles, so far as commercial numbers are concerned."

The unenforceable ban was lifted in March 1973, ostensibly due to population increase (Luis García Cacho, pers. comm., Chief Fisheries officer, Ensenada, Baja California, May 1973 cited in O'Donnell 1974). Between 1973 and 1976 annual quotas were established and exclusive permits were granted to fishing cooperatives. In theory, the coops would manage their local turtle fishery and quotas would ensure the effectiveness of the new program. O'Donnell (1974) foreseeing the difficulties of the decades to come, wrote:

> 'How difficult a regulation is to impose on a people depends on the impact it has on those affected by it. A fisherfolk totally dependent on the catch of a certain species will not easily submit to new regulations limiting—not to say completely proscribing—their rights to pursue this catch. The effect on the fishermen of the closed seasons on turtling in Mexico and the complete ban of 1971-1973 has been difficult to discover. One researcher had written of Bahía de los Angeles that the turtling industry there, along with tourism, formed the economic base of the are; in other villages turtles were the sole source of income. "The loss of the green turtle in Baja California, " he wrote, "would constitute a serious hardship to the people of this economically poor area" (Caldwell 1963). Recorded catches of the next few years should indicate the success or failure of the conservation programs being implemented."'

Illegal hunting continued by fishermen who lacked permits, and quotas were routinely exceeded, perhaps at three times the reported levels (Cliffton et al. 1982).

Turtles were still caught at Bahía de los Angeles, San Ignacio, Bahía Magdalena, and Loreto and sent north to Tijuana and Ensenada or south to La Paz. However, turtle populations continued to decline. In Bahía de los Angeles, Baja California, between 1961 and 1971, Resendiz (1985) reports a localized version of the regional crash depicted in Figure 1. The green turtle fishery in Bahía de los Angeles was nearing its peak in 1962 (Caldwell 1963), but declined 74% over the following two decades (Resendiz 1985) (Figure 4). Local fishermen indicate that by the early 1980s it had become commercially infeasible to fish for turtles. Along the Pacific coast, this resulted in an increased fishery for loggerhead turtles, found in offshore waters. Previously, loggerhead meat was considered inferior due to its oily and odiferous qualities.

Government control effectively began in 1977 on the main green turtle nesting beaches in Michoacan (Cliffton, et al. 1982) and in 1978 in Bahía de los Angeles (Resendiz 1985). The coincidence of the construction of the new transpeninsular highway in Baja California during the early 1970s and the new coastal highway in Michoacan hastened the development of a black market for turtle products and resulted in increases in human populations in both coastal regions. Despite ever-increasing protection on the nesting beaches, hunting on Baja California feeding grounds continued. Despite the research programs initiated by the Mexican Secretary of Fisheries (CRIP) in Bahía de los Angeles, unregulated, opportunistic hunting continued in the area, and longer forays were made into the Gulf of California in search of remaining sea turtles. Fishermen devised simple—and occasionally elaborate—ways to evade closed regions, seasons, and size limits, including holding turtles in pens or tying them to mangrove roots, misrepresenting species, and transporting turtles between regions during closures. A new technique, called *hooka*, which utilized a compressor and regulator to collect overwintering turtles, was particularly devastating. Wintering turtles in the Gulf of California were systematically eradicated over a few years (Felger et al.1976).

In 1978 the fishing cooperative Canal de Ballenas in Bahía de los Angeles, Baja California, requested permission from the state fisheries office to conduct a sea turtle aquaculture in a trailer park on land owned by the Ejido Tierra y Libertad. In 1980 the CRIP-Estación e Investigación de Tortugas Marinas was constructed. Due to the cold temperatures in the region, the effort was unsuccessful. However, the infrastructure of the project, which included salt water pumps, two 5m diameter tanks, and a large enclosed storage area, remained active as a research station. Antonio and Bety Resendiz have maintained the facility, conducted sea turtle research, and continue to collaborate with several international researchers. The station, despite sporadic and limited support, has operated without interruption since 1980, remains active, and has produced many important research findings.

Fishermen report that by the mid-1980s the green turtle population had completely crashed and the species was commercially extinct. Those interviewed, from all parts of Baja, indicated that at this time it had become extremely rare to see a sea turtle. Local consumption continued, however, as turtles were occasionally caught in fishing tackle and provided a special meal. In May of 1990 the drastic state of sea turtle populations in Mexico resulted in international pressure on fisheries officials resulting in a complete ban which prohibited the use of all sea turtles and eggs (Aridjis 1990). Stiff fines and jail terms of up to 3 years were to punish those who continued trade in turtle products (Table 2).

Olguin-Mena (1990) wrote that despite the 1990 ban, “in some fishing camps and principally during the period from March to July, the traffic of *Caretta* and *Chelonia* is the most important activity. And while capture of sea turtles is a federal offense, the majority of turtles are slaughtered on islands or beaches far from the fishing camps. Nevertheless, this isn’t the primary problem, if the exploitation fell only on the adults, it would be possible to think about recovery in the long term. Disgracefully, as much in *Caretta* as in *Chelonia*, the species most frequently captured, the fishery is primarily directed at the immature animals (on beaches 90% of the carapaces found have been subadults).”

THE CULTURAL CONTEXT OF SEA TURTLES

When compared with green turtle populations of the Atlantic, Caribbean and Indian Ocean regions, the Baja California turtle populations were spared until relatively recent times—due primarily to the harsh climate, small human population, and remoteness of the peninsula. However, following the expanded markets of the 20th century, human population growth, and commercial fisheries development, turtle numbers have dwindled. In addition to the obvious economic incentives of the fishery, sea turtles were also culturally important in the region, their use dating to pre-Colombian times (Felger and Moser 1985). Turtles were regularly consumed locally in a variety of forms prompting Caldwell's (1962) reference to the green turtle as the "black steer" due to its importance as "the chief source of meat in that barren peninsula".

Just about every family in Baja California relied on sea turtles to earn a living, or worked in some way in the procurement and distribution of the animals. Certainly turtle meat was—and still is for some—an important source of protein. Consumption of turtle meat was equated with good health, physical vitality and stamina, virility, and festive celebrations. Sea turtle blood and oil were thought to have medicinal qualities and were prescribed to cure ailments such as anemia and bronchitis. One would be hard-pressed to locate a native Baja Californian who has not been raised on sea turtle meat and once cured by turtle remedies. These traditions have not abated, and most coastal inhabitants still include sea turtle meat as a regular, if not frequent, part of their diet and culture (Garcia-Martínez and Nichols 2000). As Nietschmann (1995) puts it, referring to the turtle tradition among the Miskito Indians of Nicaragua:

> "Turtling is more than a means to get meat, turtles are more than a simply a source of meat, and turtle meat is more than just another meat…turtling and turtles are a part of a way of life, not merely a means of livelihood. The activity and the product are not elements that can be simply lost or substituted without consequent deep change in cultural patterns."

Turtles are eaten by fishermen, but also by government employees, teachers, military, and virtually anyone who grew up with the tradition of turtle feasts. They remain the region's premier *plato tradicional* at special events, holiday celebration, and to honor visiting dignitaries. The use of sea turtles is associated with neither poverty nor hunger. The cultural inertia to use turtle meat, deep traditions surrounding its use, and its perceived benefits, completely override adherence to strict laws protecting endangered sea turtles. As such, there is no culinary replacement for sea turtle, though some have tried. "Caguamanta" is one such alternative, ray and skate meat prepared in the style of sea turtle.

The long tradition of turtle hunting and consumption runs from the Seri through current inhabitants of the region. The green turtle may be the most important animal in Baja California. There is a deep fondness, respect, and curiosity for the turtles—although the process of butchering of turtles appears brutally cruel. Among the Miskito Indians, Nietschmann describes the movement of the turtle along the chain of cultural levels. Likewise in Baja California, a turtle moves from the fisher to the butcher (typically male) to women who prepare the meat. The meat is then shared with kin and friends. When a sea turtle is hunted, it is an event. Turtle meat is shared among families and friends and the process imbued with symbolism—consciously or not. An offer of a turtle feast is considered among the highest honors and displays of trust. It was only after accepting the offer to eat turtle among turtle hunters that I began to learn from them. The Baja California culture is currently among the only true turtle cultures surviving in North America today.

The loss of sea turtles in Baja California represents a threat to far more than a single commercial species. It's this historic connection to the resource that will help harvest the political will needed to recover turtle populations.

PROBLEMS IN BAJA CALIFORNIA SEA TURTLE CONSERVATION EFFORTS

Despite nearly ten years of complete protection by law, bycatch and hunting of sea turtles in Baja California continue at a rate of between 7,800 and 30,000 turtles annually (Nichols, unpublished data—see Chapter 3)—a level reflected by the findings of other investigators (Cantú and Sánchez 1999, Reforma 19 August 1997). Following a survey of the entire Mexican coastline during 1994-1996, we concluded that Baja California is the region with the highest sea turtle mortality per capita and perhaps in all of North America. Many of the turtles captured accidentally enter the black market, are traded locally, or consumed domestically. At the root of this mortality are several factors—many of which are typical problems related to enforcement of conservation laws faced by many developing countries (Gomez 1982).

Misunderstanding of the law. Many fishermen understand the law to permit local take of sea turtles for domestic consumption, particularly when a turtle has been captured accidentally, or has died in fishing gear (Garcia-Martínez and Nichols 2000). As such, fishermen have been known to kill live turtles by placing rocks in their mouths—hence, the turtle appears to have drowned if the fishing vessel is inspected.

Limited knowledge of the resource. Few residents know where local sea turtle populations migrate and reproduce. Of those who do, most describe egg poaching on nesting beaches—not local hunting—to be primarily responsible for population decline. Fishermen report a recent increase in sea turtles on feeding grounds, particularly the small, or juvenile, size classes. As populations reached all time low levels in the mid

1980s, some perceive the observation of more juvenile turtles in the late 1990's as a "green light" to continue, and expand, the use of these animals. Few are aware of the slow growth rates and delayed maturation in green turtles. While most fishermen wield a deep familiarity with local sea turtle habits, in general, there is inadequate public information available on sea turtle biology.

Lack of adequate enforcement. Due to limited staff, insufficient patrol equipment (trucks and boats), and corruption, enforcement is largely absent or ineffective. In many cases PROFEPA agents report being underpaid and fishermen report that bribery is an alternative to large fines or incarceration when they are caught with contraband. Feeding grounds and nesting beaches where enforcement is absent are continually poached (personal observation & R. Pinal, pers. com.). Turtles are hunted in Baja California waters and transported to regional urban areas such as La Paz, Cabo San Lucas, Ensenada, Mexicali, and Tijuana. It is not uncommon for sea turtle meat to be served at high-level government meetings, among police and politicians (Universal, 24 August 1997). Furthermore, trafficking of protected marine resources often goes hand in hand with trafficking of other illegal substances, potentially placing PROFEPA agents in harm's way. The following quote describes the decidedly hands-off attitude taken with regard to organized poaching and resource piracy: "The cooperatives are not the principal traffickers, we are confronting an authentic mafia with a net of interests that are unknown in their totality and that require a careful and specialized investigation that should not be left in the hands of personnel of the Ministry so as not to risk their security and their life." (INP 1990).

Conflict of interest. In small fishing communities, a conflict of interest may occur when the fisheries inspector is a friend or family member. In addition, it is not uncommon to find that those supplying turtles are doing so for individuals within the community in possession of political influence and economic resources. Discussions of sea turtle conservation are rare in Baja California, even among academics and those enlisted by the government to protect these animals. Sea turtles have become the "sacred cow" of marine conservation in Baja California.

For example, in 1998 approximately 90 green turtles stranded near Laguna Ojo de Liebre, Baja California Sur. Reports indicated the probable cause of death was related to massive osmotic shock due to salt production effluent plumes. This explanation defied all logic, including the observation that the plume would have been relatively localized and the number of turtles exceeds expected densities (PROFEPA 1999). Hypotheses related to commercial fishing were not investigated (see Chapter 7). Now that the initial attention has passed, government managers admit that shrimp trawlers were likely involved (Cantu, pers. comm.). The influence of external political and social motivators often stymies conservation efforts by those entrusted with sea turtle recovery.

During July 2000, in response to a very thorough newspaper article in *La Extra* about sea turtle research and conservation efforts in the Bahía Magdalena region, an article entitled "Presencia de Secta Religiosa" (Cadena 1999) was published on the front page of another newspaper, *La Gazeta* (La Paz, Baja California Sur). The article described a religious cult, dedicated to the protection of sea turtles. The article was allegedly motivated by those involved in black market activities and directed, as a scare or smear tactic, at fishermen and researchers working towards sea turtle conservation in the area. Several people, including the author of the original report, responded to the article, lambasting the Cadena publishers. Nevertheless, the message had been sent to those who would interfere with the tradition: "don't mess with our turtles".

Tradition of overhunting. There are few examples of sustainable use of marine resources in Baja California. On the contrary—most resource use has followed the typical "boom and bust" cycle common around the world. Examples abound of formerly abundant species that are now rare or commercially extinct (oysters, clam, scallops, grouper, seabass, sea turtles and sharks). The recent challenge of ESSA's proposal to build a salt production facility and the resistant responses of the local communities, presents an example that understanding of resource management is increasing (Dedina 1996).

Fundamental lack of integration. Overexploitation is a result of a market driven approach, which places excess value on specific target species in isolation from their place in the ecosystem, or the larger socio-cultural context. The inability to abate the decline in sea turtle populations, despite several attempts at critical junctions, suggests fundamental flaws in the approach. As Piper (1992) states: "the problem of declining sea turtle populations should not be viewed as that of a species that requires "saving" through special conservation action but must be viewed in the deeper context of a breakdown between the economic base and resource use."

RECOMMENDATIONS & POTENTIAL SOLUTIONS

There is a growing appreciation that sea turtle conservation may be "10% biology and 90% managing people". Understanding what people actually do, think, and say will help managers construct strategies that will work, rather than fail. In Mexico, numerous researchers have embraced education over enforcement, and bringing people together over in-fighting and arguing (Tennesen 1999). Over the past two years the Sea Turtle Conservation Network of the Californias (Grupo Tortuguero de las Californias), a grassroots organization composed of fishermen, local residents, researchers, government resource managers and conservationists, has initiated several programs designed to decrease the pressure on local sea turtle populations.

Some of the goals of sea turtle conservation efforts in Baja California include (see also Chapter 8):

<u>Development of alternative income sources</u>. Several NGOs, fishing cooperatives, ejidos, and government agencies in the region are working together to create local wildlife refuges and marine reserves and to develop community-based eco-tourism, adventure tourism, eco-labeling for sustainable fisheries, and sport fishing businesses. In some areas aquaculture is a viable option.

<u>Education</u>. By sharing information about the status of marine resources, sea turtle life histories and current research results, local groups have made tremendous progress. Many residents who were otherwise unaware of the endangered status of sea turtles and the consequences of cumulative local use have changed their habits and have joined the recovery effort. Such efforts should be extended throughout the region and include

development of curriculum describing the history and biology of sea turtles in Baja California.

Research. At the base of any solid recovery plan are studies of both the resources and the community of users. We have initiated several basic life history research projects as well as socially oriented research. Long term efforts to monitor trends in the sea turtle population as well as the perspective of the human community are underway. Application of the social sciences to finding solutions to resource exploitation issues is particularly warranted in this case (Piper 1992).

Community involvement in research projects. Involving fishermen in research is a form of education, for both the research and the fisher. It also is an additional source of income for some. As residents have intimate knowledge of local resources, research activities and results they are more likely to share the experience and knowledge with others and work towards conservation goals (Nichols et al. 2000).

Enforcement. There is no short-term substitute for strong enforcement. Existing highway checkpoints should be enhanced, as it's commonly known that contraband frequently passes along these routes. Resendiz and Hernandez (1993) report on the confiscation of 19 green turtles smuggled from Guerrero Negro to Maneadero, Ensenada, for sale—representing the first reported turtle-related conviction in the area. Thirteen green turtles were also confiscated in 1996 en route from San Ignacio to Ensenada (Resendiz, unpublished data). These events represent only a glimpse of the turtle trafficking that occurs in the region. However, the enforcement regimes that appear to function best are those that are community based, committee oriented and which impart local benefits. In the Punta Abreojos, Baja California Sur, fishing cooperative a committee of residents conducts local enforcement. Punishment for possession of a sea turtle is swift, direct and personal. In 1999 PROFEPA agents, Punta Abreojos fishing cooperative members and Mexican military apprehended Francisco “Gordo” Fisher, a known sea turtle poacher from San Ignacio, Baja California Sur, while transporting 7 live green turtles. During his arrest, he admitted to capturing and selling more than 100 metric tons of green turtle during his eight years as a poacher. His admission was videotaped and appears on the PROFEPA report (C. Mayoral, PROFEPA, pers. comm.). This story highlights the enormous impact a single poacher can have on the region’s sea turtle populations.

SUMMARY

Mexico's Pacific populations of leatherback and hawksbill turtles have been virtually extirpated. Green and loggerhead turtle populations continue to decline year after year on their nesting beaches in Michoacan and Japan, respectively. Without timely protection on critical foraging grounds along the Baja California peninsula in conjunction with ongoing beach protection efforts, it will be impossible to recover these populations. Illegal sea turtle hunting and incidental capture remain serious problems in the region. The combination of a strong tradition of sea turtle consumption, institutionalized corruption the local level, and a lack of an official reaction to the problem has resulted in a conservation stalemate—with the sea turtles losing ground each year. Socioeconomic circumstances in Baja California present unique challenges and obstacles to sea turtle recovery. However, once identified, discussed openly and honestly, and understood, many of these obstacles can be overcome using market incentives and education. The region has undergone tremendous advancements in the area of marine conservation over the past decade. The resources and expertise are available to address the issues related to sea turtle conservation. The formation, rapid growth, and accomplishments of the Grupo Tortuguero de las Californias represent one small step in the right direction.

Writing at perhaps the lowest moment in the history of sea turtle populations in Mexico, Cliffton et al (1982) state:

> "Organization of a private citizen's committee to fund research and conservation programs for sea turtles in Mexico seems a logical step to the protection of these magnificent animals. Excessive take, poaching and loss of habitat have brought sea turtles of Mexico to the brink of extinction. The social and economic pressures that have led to this

> ecological disaster need to be assuaged by setting new priorities in the very near future. We believe that Mexico's sea turtles can probably be saved."

I agree with Cliffton's assessment and the Grupo Tortuguero de las Californias is now working towards realizing those priorities and goals. As Mexico's political culture changes and evolves into a true liberal democracy, the traditions of bribing, extortion, and secret arrangements will give way to the enforcement of contracts, open records, and the protection of personal and property rights. This will have positive implications for environmental protection, including the recovery of sea turtles.

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Table 1. Conservation measures and legislation affecting Baja California sea turtles (Cantú and Sánchez 1999).

1968	Commerce Ministry develops rules for capture, use and commerce in sea turtles.
1971	Ban on all species for two years.
1972	Ban on capture, except for fishing cooperatives.
1979	Total ban for leatherback and hawksbill turtles.
1982	Creation of first environmental ministry (SEDUE)
1986	Seventeen nesting beaches declared reserves.
1986	Enactment of Federal Law of Fisheries.
1990	Agreement that establishes a total ban on all species of sea turtle (may).
1991	Mexico becomes a member of CITES (May).
1991	Creation of Article 254BIS on the penal code that establishes jail penalties for taking, killing, or commercializing sea turtles and their products.
1992	Environment issues become part of Social Development Ministry (SEDESOL)
1993	Agreement that creates the Intersecretarial Commission for the Protection and Conservation of Sea Turtles and National Committee for the Protection and Conservation of Sea Turtles.
1994	Creation of a Total environment Ministry (SEMARNAP) (Dec).
1994	Creation of the Subattorneys Office of Natural Resources in the Federal Attorney General's Office for the Protection of Environment (PROFEPA) (Dec).
1996	First Mexican Official Norm of Emergency that establishes the use of TEDs in the Pacific (March).
1998	Mexico signs the Inter-American Convention for the Protection and Conservation of Sea Turtles (Dec).

Table 2. Administrative sanctions and penalties for the capture, transport, or commercialization of sea turtles in Mexico. Translated from a flyer distributed to fishermen (1990).

- “In accordance with the Fisheries laws, the extraction, capture, possession, transport, or commercialization of sea turtles is considered an infraction according to Article 24 Section XIX.
- Consistent with the same law, this infraction establishes fines of 1001 to 2000 times the minimum daily salary in force in the capital (D.F.), as well as the confiscation of equipment, fishing tackle, or that with which the infraction was committed.
- Independent of this administrative proceeding, Article 254 bis of the penal code, considers the prior conduct a crime.
- …Article 254 bis.—whomever of intentional manner captures, gravely harms, or deprives the life of marine mammals of turtles, or collects or commercializes their products in whatever form without authorization, the appropriate authority will impose between six months and three years of prison.
- The same penalty in the preceding paragraph will be imposed by the authorities on those who intentionally, without authorization, capture aquatic species, declared prohibited (*en veda*).
- The previous penalty is applied without change to the corresponding administrative sanctions.”

Figure 1. Map of Mexico.

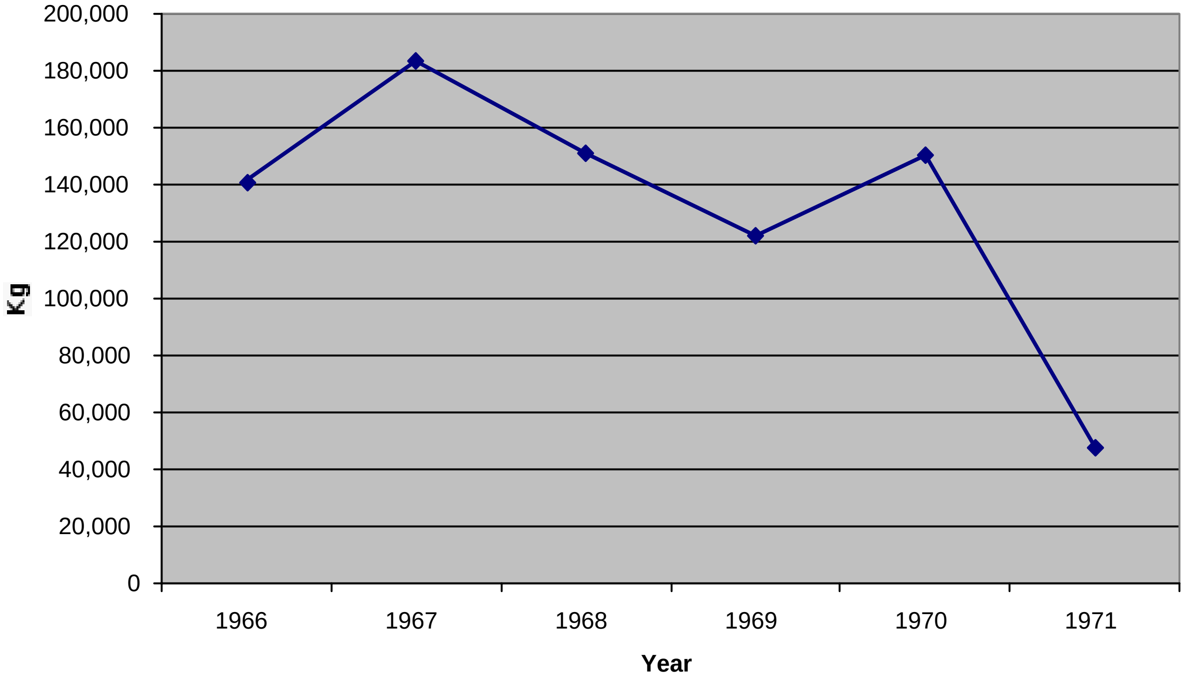

Figure 2. Sea turtles landed (kg) in Baja California, Mexico between 1966 and 1971.

Source: PESCA, Ensenada, Baja California (in O'Donnell 1974).

Figure 3. Seri Indian harpooning a green sea turtle, Canal de Infiernillo, Sonora, Mexico.

(photo: Kim Cliffton).

Figure 4. Green turtles, *Chelonia mydas*, caught, bound, and held in abattoirs to await slaughter or consignment to northern markets, Bahía de los Angeles, Baja California (photo: Kim Cliffton).

CHAPTER 3

Strandings, Incidental Take, and HUNTING:
Mortality patterns of Sea Turtles ALONG the
Baja California PENINSULA, Mexico (1994-1999)

ABSTRACT

I collected data from a total of 1,028 stranded, incidentally captured and/or hunted turtles between 1994 and 1999. The East Pacific green turtle (*Chelonia mydas*)—also referred to by some authors as the black turtle (*Chelonia agassizii*)—and the loggerhead turtle (*Caretta caretta*) are the species with the highest mortality rates in Baja California waters. This is likely a reflection of their relative abundance in the region. Green, loggerhead, and to a lesser extent, olive ridley turtles were consumed in every coastal community surveyed (n = 7). Hawksbill turtles were occasionally used for food or adornment. The primary reasons for sea turtle mortality are incidental capture of animals in a variety of fishing gears and direct hunting for consumption and trade. Annual strandings of loggerhead turtles occurred at an average rate of 2.6 turtles/km on the beaches surveyed. Annual mortality of green turtles is estimated to be greater than 7,800 turtles, and possibly as high as 30,000 turtles, impacting both immature and adult animals. Mortality of loggerhead turtles, based on stranding and capture rates, is estimated at 1,950 turtles annually and affects primarily immature size classes. Continuing research on incidental catch rates and seasonal stranding trends is

recommended in the most intensely fished areas. Educational programs designed to inform fishermen and citizens of the need to protect sea turtles are ongoing in the region.

INTRODUCTION

Five of the world's seven sea turtle species frequent Mexico's Pacific coastal waters and beaches. All five species of sea turtle found in the eastern Pacific Ocean (*Chelonia mydas*, *Caretta caretta*, *Lepidochelys olivacea*, *Dermochelys coriacea* and *Eretmochelys imbricata*) occur along the coasts of the Baja California peninsula and are considered endangered or critically endangered according to the IUCN Red List (2000). These animals migrate and disperse over long distances from their nesting beaches to Baja California waters to feed on the abundant plant and invertebrate resources (Nichols et al. 2000, Seminoff et al. 2000, Nichols et al. 2000). Olive ridley and leatherback turtles are known to nest regularly in small numbers on the beaches of Baja California Sur (Fritts et al. 1982). Molecular genetic markers and satellite telemetry have been used to link loggerhead turtles from natal beaches as far away as Japan and green turtles from southern Mexico to Baja California feeding grounds (Bowen et al. 1995, Nichols et al. 2000).

For most of this century, sea turtles have been commercially exploited in the waters near Mexico's Baja California peninsula (Chapter 2). Mismanagement—and in some cases a lack of management—of the fishery resulted in over-hunting and the subsequent crash of populations of sea turtles on their nesting beaches and feeding areas throughout most of their eastern Pacific range (Olguin 1990, Cantú and Sánchez 1999).

Response to the decline in sea turtle fisheries came after the populations had reached critically low levels.

Programs to protect turtles on Mexican nesting beaches were initiated in the late 1960’s and early 1970’s and continue presently in an effort to stem population declines (Cliffton et al. 1982). However, during the same period high mortality rates continued as turtles were taken for food, black market trade, and as incidental catch in a variety of fisheries. This was especially true in waters off the Baja California peninsula where fishing efforts are intense (Casas-Valdez and Diaz 1996) and sea turtle remains a traditional dish (Garcia-Martínez and Nichols 2000). Cliffton et al. (1982) reported that illegal trade in sea turtles represented at least three times the allowed quota during the 1960's and 1970's.

Simultaneous protection on developmental and feeding grounds, in addition to efforts on the nesting beaches is a requirement for population recovery, yet this basic relationship has been largely overlooked throughout the history of sea turtle conservation and management in the eastern Pacific region. A variety of specific social factors contribute to this situation in Baja California. Cantú and Sánchez (1999), quoting minutes from a 1990 Instituto Nacional de Pesca (INP) meeting, described one major factor:

> “The cooperatives are not the principal traffickers, we are confronting an authentic mafia with a net of interests that are unknown in their totality and that require a careful and specialized investigation that should not be left in the hands of personnel of the Ministry so as not to risk their security and their life.”

Despite recognition of the problem, ten years later little has changed.

Sea turtle recovery efforts in the eastern Pacific require that the main causes of mortality, at least in a qualitative manner, be documented. Such information will help to determine where research, management, monitoring, and protection efforts are most needed (National Marine Fisheries Service and U.S. Fish and Wildlife Service 1998). In some parts of the world, such as the southeastern United States, the mortality of many thousands of marine animals has been documented each year over several decades (Schroeder and Warner 1988, Crowder et al. 1995, Coles 1999, Wilkinson and Worthy *in press*). With the help of extensive observer programs, fisheries-related mortality has been well-documented in selected regions and fisheries (National Research Council 1990, Wetherall et al. 1993). For countries lacking the infrastructure, community resources, finances, and political commitment to conduct such programs, assessing trends in mortality of sea turtles can be exceedingly difficult.

The vast, sparsely populated coastline of the Baja California peninsula and the lack of adequate roads in many areas are barriers to regular surveys. Accurate and complete information on sea turtle fisheries, strandings, levels of incidental catch, and estimates of local consumption and capture rates in the region are sparse in the literature. Notably, Resendiz and Hernández (1993) described the confiscation of sea turtles in Baja California as they were being transported to market. However, such published reports are unusual. Some data can be found in published historical accounts of commercial turtle hunting (Townsend 1916, Caldwell 1963), but assessment of contemporary mortality rates has proven difficult due to financial limitations and socio-political conflicts.

Nevertheless, it is at least possible to identify regions and fisheries of concern based on periodic, localized monitoring. Additionally, long-term collaboration and communication with fishing communities can produce otherwise unattainable information on contemporary consumption levels.

It is now clear that knowledge of mortality on feeding and developmental areas, particularly among large immature and adult size classes, is an important component of our understanding of recent declines of Pacific sea turtle rookeries (Spotila et al. 1996, Heppell 1998). New information on mortality rates and threats to eastern Pacific sea turtles on feeding and nursery grounds can help target limited conservation resources where they are most needed (Frazer 1992). Furthermore, our recent results from molecular genetic (Chapter 5) and satellite telemetry (Chapters 4 and 6) studies suggest that reduction of sea turtle mortality in Baja California waters will aid recovery programs on nesting beaches as far as 12,000 km away (Nichols et al. 2000).

My goal is to determine the main threats and causes of sea turtle mortality in the Baja California peninsula region and to estimate annual mortality rates due to incidental catch, strandings, hunting, and local consumption. The results of this survey are intended to direct attention to those areas which can produce the greatest gains in population recovery, guide enforcement of existing laws, enhance vigilance of fishing vessel activities, and promote solutions for and further investigation of the most urgent threats to eastern Pacific sea turtle populations.

METHODS

Data on strandings and incidental catch of sea turtles were collected opportunistically during beach surveys, surveys at sea, mark-recapture studies and interviews with fishermen between June 1994 and January 1999. The surveys and interviews were conducted at seven primary locations, and outlying fishing camps, on both coasts of the Baja California peninsula: Bahía de Los Angeles, Baja California; Laguna Ojo de Liebre, San Ignacio, Punta Abreojos, Bahía Magdalena, Todos Santos, and Loreto, Baja California Sur; and two locations on the Mexican mainland, Desemboque and Punta Chueca, near Bahía de Kino, Sonora.

All sea turtles, including live (ill, mortally injured or incidentally captured by fishermen), stranded dead (whole or part), or consumed, were assigned an identification number based on the location and date the turtle was discovered or captured. The identification number assigned to the turtle was recorded as LOC-DATE-##. Under this system, “LOC-” signifies the three letter abbreviation for the location/region where the turtle was found, “DATE-” the date the turtle or sample was first captured or collected (19JUL99 = July 19, 1999)), and (##) the sequential number of the turtle caught on that date in the region described. For example, identification number BMA-19JUL99-3, indicates that the turtle was the 3rd turtle recorded in Bahía Magdalena on July 19, 1999. This identification number accompanied samples obtained from the specimen. Monthly and yearly averages of sea turtle mortality were calculated by species. By late 2000, all stranding and sighting data will be added to a regional on-line database <www.wildcoast.net>.

Locations of the surveys and recorded mortality were grouped into two regions and six areas: the Gulf of California [Bahía de Kino (BKI), Bahía de los Angeles (BLA) and Loreto (LOR)] and the Pacific Coast [Bahía Magdalena (BMA), Punta Abreojos (PAO), Laguna San Ignacio (LSI), and Laguna Ojo de Liebre (LOL)] (Figure 1). Mortality was analyzed by cause, year, and species.

Beach and Sea Surveys

Surveys were conducted along stretches of beach where strandings had been reported previously or where fishing activities were intense. Additional areas surveyed included abandoned fishing camps, garbage dumps, and arroyos where turtle carapaces had been discarded. Most surveys were conducted on foot, although occasionally longer distances were surveyed from a dune buggy or the bed of a pick-up truck. On-the-water, surveys were conducted using 8 m fishing skiffs, or *pangas*, with 75-hp outboard motors. Occasionally during surveys at sea, turtles were encountered aboard fishing vessels or afloat at the surface. Information recorded for each turtle encountered included: species, location, cause of death, and straight and curved carapace lengths (Figure 3). Stomach contents and tissue samples were collected when possible. Humeri were collected opportunistically for studies of skeltochronology and trophic ecology (M. Snover, unpubl. data). Many of the turtles were encountered in advanced stages of decomposition and in these cases only a subset of the mentioned information was collected. The condition of stranded turtles was scored on the following scale: 0 – Alive without injuries; 1 – Alive and injured; 2 – Freshly dead; 3 – Moderately decomposed; 4 –

Severely decomposed; 5 – Dried carcass; 6 – Carapace only/Consumed; or 7—Bones only. The final disposition was scored as 1—Painted, left on beach; 2—Buried, on beach/off beach; 3—Salvaged specimen: all/part; 4—Pulled up on beach or dune; 5—Unpainted, left on beach; 6—Alive, released; 7—Alive, taken to holding facility; or 8—Consumed. The cause of mortality was reported when known (Incidental capture, Direct hunting, or Other). These categories often overlap and we recognize that incidentally captured turtles may also end up stranded, consumed or enter into the black market—particularly in the case of green turtles. For this reason individuals are only represented once in the data and are presented in the category that best describes the circumstances at hand when the animal was encountered. Carcass anomalies were also recorded.

Carapaces and extremely decomposed carcasses were the specimens most frequently encountered and sex and maturity status was impossible to determine. In the case of whole or live turtles, lack of procedures such as radioimmunoassay or laparoscopy required the use of external morphological data in order to assess maturity. The mean size of nesting green turtles at the Michoacan, Mexico, rookery (82 cm CCL/ 77.3 cm SCL, N=718, range 60 - 102cm CCL, Alvarado and Figueroa 1990) was used to distinguish maturity status. Turtles with SCL $<$ 77.3 cm were classified as immature and those with SCL $\geq$ 77.3 cm, mature. Similarly, loggerhead turtles smaller than 89.0 cm SCL were considered immature based on the mean carapace lengths (range 72.0 – 107 cm) of 118 nesting loggerhead turtles in Gomoda, Shikoku, Japan (Uchida and Nishiwaki 1982). Carapace length is not considered a reliable indicator of maturity (Miller 1997). However, it can be used to generally describe which life stages may be most severely impacted. In addition, using the mean size of nesting turtles as a gauge for maturity will likely underestimate the proportion of adult animals on feeding grounds.

Mark and recapture studies

Green turtles and a smaller number of loggerhead, hawksbill, and olive ridley turtles were captured by hand at sea or using entanglement nets on their feeding/developmental areas. Each turtle was marked on the flipper using either plastic roto-tags (Dalton Supplies, Woolgoolga, Australia) or Inconel, self-piercing tags (National Band and Tag Co., Kentucky, USA) and released at the capture location. Use of plastic tags was discontinued in July 1996 due to observations of tag-related mortality (Nichols and Seminoff 1998). Recapture and incidental catch information was obtained from fishermen who reported sightings or returned tags during interviews. In one case the use of satellite telemetry (Telonics ST-3 transmitter) provided useful information on fisheries-related interactions.

Interviews

Semi-structured interviews and questionnaires were conducted with fishermen and community members from 7 coastal regions in Baja California: Bahía de los Angeles, Baja California; Juncalito, Bahía Tortugas, Punta Abreojos, Bahía Magdalena, Laguna San Ignacio, and Todos Santos, Baja California Sur, in order to assess the annual take of sea turtles. Interviewees were typically chosen based on their willingness to share information, their level of experience as fishers, and their familiarity with regional life.

In Bahía Magdalena, with the help of Centro para Estudios Costeros (CEC), many interviews with non-fishers were conducted. Interviews began with a discussion of the five sea turtle species occurring in the area in order to appraise familiarity with sea turtle identification and to create rapport. Then we discussed specific aspects of sea turtle biology before addressing questions related to incidental catch, local consumption, enforcement of laws, and strandings. In a semi-structured interview the interviewer uses a general set of questions (Appendix C) to guide the conversation. However, the order or emphasis of the questioning can vary. For example, in areas along the Pacific coast fishermen may be more familiar with nesting sea turtles or the distribution of pelagic loggerhead turtles than are fishermen working in the Gulf of California. The interviewer would, in this case, choose to spend more time discussing specific topics of nesting beach locations and abundance/distribution of loggerhead turtles. Furthermore, interviews may have spanned several days in the form of casual conversation as rapport was built. With time and experience the interviewer can develop a comfortable style that results in the target information being shared and also allows identification of ambiguous or exaggerated reports and information (Tambiah 1999). As new information corroborates information obtained during previous interviews, a realistic picture emerges. Clearly, the best information is supported and confirmed by data collected during field surveys by the researcher (Carver 1990).

Responses to questions posed during the semi-structured interviews were tabulated where possible. However, many responses were in the narrative form. Data from questionnaires were analyzed according to the frequency of response.

As an additional component of these field surveys and interviews, the groundwork was established for a regional marine turtle conservation network that includes a mechanism for reporting sea turtle sightings and strandings. Community leaders were identified for each location and invited to participate in annual meetings to discuss and implement sea turtle conservation strategies, provide training in species identification and field techniques, and coordinate community-based vigilance.

RESULTS

Mortality data on a total of 1,028 individual turtles were collected between 1994 and 1999 (Table 1). Ninety percent of these records were of either green or loggerhead turtles. The majority of the records were collected in 1999 (63%) and along the Pacific coast (Table 2). Where condition was recorded, more than half of the turtles showed signs of having been consumed (Table 3). Size ranges for green and olive ridley turtles include both immature and mature animals, whereas most loggerhead and hawksbill turtles were immature (Table 5, Figures 4 and 5).

Beach and Sea Surveys. Two beaches were repeatedly surveyed: Bahía Santa Maria (10 km long) and the beach between Cabo San Lazaro and Boca de Soledad (60 km long), both on Isla Magdalena (Figure 2). Most of the stranded animals were loggerhead turtles (Table 6). On average 2.6 loggerhead turtles/km/yr were stranded for the area surveyed (Table 4). Relatively few green turtles were stranded compared to the number consumed (Tables 3 and 6). Several turtles were animals encountered while they were being transported to market.

Mark and Recapture Studies**.** Recapture of tagged turtles by fishermen was documented on 17 occasions (Table 7). Two (20% of all tagged and released loggerheads, n=10) of these records were loggerhead turtles and fifteen (9.5% of all tagged and released green turtles, n=158) were green turtles. Two of the tagged green turtles were captured in gill nets in Bahía Magdalena during 1998 and 1999, but were subsequently released unharmed by fishermen with previous affiliations with the project.

Additionally, two tagged green turtles were rescued in 1996 after becoming entangled in gillnets in Bahía de los Angeles.

Both of the tagged loggerhead turtles died in fishing gear the coast of Japan after their transpacific migrations (Resendiz et al. 1998, Nichols et al. 2000).

Cliffton et al. (1982) reported that of 13 tagged turtles released in the Canal de Infiernillo, Sonora, in March 1977, more than 50% of the tags were returned by Seri fishermen by May 1977. We have reason to believe that recaptures of tagged turtles by fishermen in Baja California is much higher than what is indicated by our recent tag recoveries. In some areas, mortality may be as high as 25% annually. This suggests that in an area with 1,000 turtles, assuming no immigration, emigration or natural mortality, after 10 years of steady exploitation at the 25% level, approximately fifty turtles will remain. After the minimum of 16 years required for recruits to reach mature sizes, fewer than 10 turtles will remain. In some regions, such as parts of Bahía Magdalena the predominance of very small size classes and lack of large green turtles suggests that the process of local extirpation is underway, but that recruitment is occurring.

The carapace lengths of stranded and consumed turtles did not differ significantly from those of live-caught green turtles (Chapter 1).

<u>Interviews</u>**.** A total of 263 interviews were conducted with fishermen and other coastal community members (Table 8). The identities of those who have provided information during interviews have not been included in this report. Only results pertinent to assessing mortality rates are presented here. Information such as the cultural significance of the sea turtle, attitudes towards conservation, and observations related to

sea turtle biology and distribution have been presented elsewhere (Garcia-Martínez and Nichols 2000, Nichols et al. 2000, and Seminoff et al. 2000).

Approximately 70% (n=178) of interviewees were fishermen, and the majority were male (85%, n=224). Most fishermen participated in a wide range of fishing activities depending on the season and abundance of the resource. All of the fishermen had used gill nets at one time in their careers.

Approximately 94% of those responding to the question, "Have you ever eaten sea turtle?" responded affirmatively and 73% (106 of 144) indicated that whenever a turtle is captured it is consumed. However, only 3% indicated that a captured turtle would be sold. This suggests that a majority of fishermen consume turtle locally, but a smaller number are involved in sea turtle commerce. Several interviewees pointed out that in each community there are a few well-known individuals dedicated to sea turtle fishing, selling turtles to the black market.

Sea turtles are eaten regularly and evidence of this was apparent in all of the communities where I conducted interviews. At least one person in each community estimated consumption rates to be greater than 1 turtle/wk. Estimates of weekly capture rates varied between 0 and > 20 turtles. On average, for each of the seven communities where surveys were conducted, between 1 and 7 sea turtles were reported consumed each week. A minimum of one turtle, and a maximum of seven turtles, was reported consumed on average per household annually. A similar number of turtles were reported caught but not consumed. The most common response in the Bahía Magdalena region, where the majority of surveys were conducted, was that 1 to 5 turtles/wk are consumed

(92%, 98 of 107 responses). One interviewee in Bahía Magdalena indicated that in 1999 he had regularly captured between 2 and 10 sea turtles per week and had recently captured 8 turtles in one 2-hour session. Another interviewee estimated that during the past 5 years he had hunted approximately 300 adult (> 80 cm, SCL) green turtles in the Bahía Magdalena area and more than 40 during 1999. He also indicated that in the fall many of these turtles carry small yellow eggs. An interviewee in San Ignacio, a known and convicted sea turtle poacher, admitted to hunting more than 100 metric tons of sea turtle during his eight-year career as a poacher. This equates to 3,333 30-kg green turtles (8 turtles/week) or 2,000 50-kg green turtles (5 turtle/week). The majority of green turtles we have encountered in the Laguna San Ignacio region are in this size range.

DISCUSSION

Due to the nature of the data collected, and the vastness of the peninsula, I can only make a preliminary assessment of mortality trends in Baja California waters. This should not be considered an exhaustive survey of sea turtle mortality in the region—mortality studies are ongoing—rather a guide to areas where further studies, monitoring, and enforcement are needed.

The main problems with these data are the temporal and spatial discrepancies of effort in reporting turtle strandings, consumption, and incidental capture. Communities and beaches were not uniformly patrolled as the region is expansive and resources were limited. Beach survey effort was most complete in 1998 and 1999, particularly on the Pacific coast in the Bahía Magdalena/ Isla Magdalena region. This is primarily due to the expansion of the research program to include a stranding network and mortality surveys as well as an increased availability of funds and human resources. My initial goal was to describe broad trends in order to determine where our limited resources should be focussed. Therefore, while some general trends are identified, small-scale temporal and spatial trends may remain hidden. Furthermore, the recorded date of measurement and identification does not always represent the date of death, which may have occurred days, weeks, or even months prior to discovery. I am currently conducting studies of the rate of decomposition with sea turtle carcasses in order to describe temporal characteristics of stranded turtles. Curved carapace length can change by as much as 1 cm as carapaces dry in the sun. The decomposition rate for carapaces is slow--in addition to warping, after approximately one month, oil will still seep from carapaces, scutes will begin to flake, insect infestation decreases, and color will fade to gray/brown. After one year, scutes may be completely lost, and bone can be seen. Decomposition rates will vary greatly depending on exposure.

Various types of sea turtle exploitation remain active (Table 10), including subsistence, household use of turtles and commercial or market exploitation. Overall, sea turtles remain an important resource to the Baja California economy and culture.

Incidental Capture of Sea Turtles in Baja California Fisheries

World-wide, the major sources of sea turtle mortality by fishing gear are: (1) trawling; (2) pelagic and bottom longlines; (3) gill/entanglement nets; (4) entanglements in buoy or trap lines; and (5) hook and line/ recreational and commercial fishing (Oravetz 1999). Virtually all of these fishing gears are known sources of sea turtle mortality in Baja California waters. There are no reliable estimates of fisheries-related sea turtle mortality rates for this region. Categories of gear related to at-sea mortality of turtles include shrimp trawls, gill nets, pelagic longlines and hooksets, and buoy and trap lines.

Shrimp trawling occurs extensively along both the Pacific and Gulf of California coasts and is a likely source of significant sea turtle mortality in the region. Caldwell (1963) reported that "turtles of all species frequently are taken by accident in the bottom trawls used in the Gulf of California shrimp fishery…as many as nine turtles taken in a single haul." In interviews, former shrimp fishermen indicated that several sea turtles were caught during each set in years past. However, turtles are less frequently captured now, due in part to the shrinking population sizes and required use of Turtle Excluder

Devices (TEDs) since 1996 (NORMA Oficial Mexicana de Emergencia NOM-EM-001-PESC-1996). Current capture rates are unknown. Figueroa et al. (1992) report that nearly 40% of known mortality of post-nesting green turtles tagged in Michoacan was due to shrimp trawling. Compliance with laws requiring TEDs appears to be high, based on observations of vessels in port. However, several former shrimp fishermen indicated that on the water that was not always the case.

To catch shrimp in the shallow bays and lagoons fishermen use different gear types. Small trawls, called *changos*, are known to catch sea turtles. Trawl times are generally shorter and handling of turtles is more immediate. However, fishermen report that captured turtles are typically kept, and much of the shrimping occurs illegally.

Gillnets are used along the entire Baja California coast in a wide-ranging variety of fisheries. Gillnets are a known source of sea turtle mortality and incidental capture of turtles in gillnets has been recorded at each field site.

Large numbers of loggerhead turtle carcasses, the seasonality of strandings, and the condition of the carcasses suggest a high level of incidental catch coinciding with the spring/summer halibut (*Paralichthys californicus*) gillnet fishery. According to fishermen, while the waters are still cool in the early spring, many of the entangled loggerhead turtles are consumed when captured. As the water temperature warms in late spring and summer, fewer turtles are consumed as they begin to decompose by the time nets are checked. This may explain some of the seasonal trends in stranding rates.

Pelagic longlines and hook sets (*simbra*) are used to catch sharks and pelagic fish. Fishermen report incidental capture of sea turtles, predominantly loggerheads, on the baited hooks. Turtles, if not consumed, are typically cut loose and released alive without removal of hooks (Anonymous 1995). However, ingested hooks may result in mortality up to several months later.

Buoy and trap lines are known to occasionally entangle sea turtles as they feed on the fouling communities of algae and invertebrates that accumulate on such objects. Lobster fishermen have reported strangled turtles entrapped by the lines to their pots. This seems to be a relatively rare occurrence.

Compared to data for California, USA (Table 9), annual strandings in Baja California, Mexico, waters are considerably higher (Table 6). The conservation gains that may be achieved by restricting fishing activities in California waters are more than lost during the sea turtles' developmental and reproductive migrations due to incidental and direct capture further south along the coast of Baja California. For example, a loggerhead turtle that was rescued, tagged, and released near Dana Point, CA, USA, in July 1996, was subsequently captured and consumed by a fisherman in July 1999 near Boca de Soledad, Baja California Sur.

Sea turtle mortality caused by the Hawaii-based longline fishery recently resulted in closure of over 1,000,000 square kilometers of Pacific Ocean to longline fishing north of the Hawaiian islands [CV. NO. 99-00152 (DAE)]. Observed and estimated annual loggerhead mortality in Baja California, reported here, is at least an order of magnitude greater than reports of observed and estimated annual mortality in the Hawaiian longline fishery (Diaz-Soltero 1995).

Directed Capture and Domestic Use of Sea Turtles

Green turtles are the most sought after sea turtle for food in Baja California. Although protected by strict Mexican laws (Aridjis 1990), the market for them is still strong and they are regularly—and in some cases openly—consumed throughout the peninsula. Their meat is considered standard fare at many festive gatherings, such as Christmas and Easter, or special events such as weddings, and is consumed weekly in many communities (Garcia-Martínez and Nichols 2000). Most of the people I interviewed preferred to eat green turtles. However, residents of several Pacific coastal communities regularly consume loggerhead and olive ridley turtles.

Loggerhead turtles are typically considered to be of “inferior quality as food” and in few places are they directly hunted. In both Cuba and Mexico they have been commercially hunted (Dodd 1988) and in Baja California, Mexico, they are still regularly eaten. While their meat is considered to be much stronger and to be oily relative to the meat of the green turtle, loggerhead turtles are still considered suitable as food and even preferred by some people. In the late 1980’s when green turtles became extremely rare due to overhunting, loggerhead turtles were more frequently consumed in some areas, particularly along the Pacific coast—and the tradition remains intact. Virtually all parts of the turtle are consumed, including the heart, lungs, intestines, flippers, and bones. Occasionally even the carapace is boiled and used in soup. The most common, and favored, way to cook turtle in Baja California is *asada*, or over open fire. The carapace and plastron are placed on edge at either side of a fire. Cooked meat and organs are stewed and served in the carapace. Charred carapaces are commonly found at dumpsites (Figure 6).

Other uses of sea turtles include extracting oil from the fat to aid children suffering from respiratory ailments and drinking turtle blood as a remedy for anemia. Turtle blood, meat, and organs are considered to have aphrodisiac qualities. The carapace is often used as a serving platter for the feast. One interviewee pointed out that her chickens were fed from an inverted carapace, as it helped the chickens to grow faster.

Typically green turtle carcasses were clean, dry carapaces and plastrons as these turtles are almost always collected and consumed when encountered at sea by fishers. Rarely were fresh or whole (1 or 2 on the scale) green turtle carcasses seen. In the Bahía Magdalena region, turtle carapaces were 3.5 times more numerous in the towns and dumpsites of the region than on the uninhabited beaches (Gardner and Nichols, in prep).

Green turtles are captured using a variety of methods. Most commonly they are captured in entanglement nets. While shapes and sizes of turtle nets vary, typical nets are 80 to 100 meters in length, at least 4 meters deep, with minimum mesh sizes of 20 cm. Nets are constructed of monofilament or coated cotton line and have a lightweight lead line which allows captured turtles to breathe and remain alive, even if in the net for several days. Harpooning was previously the main technique used to catch turtles and is still practiced, especially in the Pacific lagoons such as Guerrero Negro, San Ignacio and Bahía Magdalena. The typical harpoon involves a shaft, made of wood or iron, with a detachable, pointed tip. Both the shaft and tip are attached to the boat by a line. Upon entering the carapace of a turtle, the harpoon tip detaches from the shaft and the turtle is pulled to the boat by the line. The resulting wound is often packed with mud or seagrass to stop loss of blood as turtles are kept alive for several days or weeks prior to sale.

Sea turtles are also caught by encircling them with cast gill nets, collecting them while diving with SCUBA gear or compressor, or with spear guns while snorkeling. Divers with pistols and bright lamps hunt sea turtles at night, spearing them and large fish hiding under rocky ledges, where they rest. Many fishermen admit to setting gillnets in areas where sea turtles are known to occur in order to catch a turtle in addition to the target fish species.

Felger et al. (1976) reported the extensive use of compressor, or *hooka*, diving in the Gulf of California as a technique for hunting green turtles during winter months. Divers would collect torpid turtles on the bottom at depths of 10 to 30 m. Overwintering sites were quickly discovered and depleted and by winter 1979-1980 Bahía Kino divers had to travel 3 times the distance to obtain ever smaller catches (Cliffton et al. 1982). This method is still used to catch turtles along the Pacific coast and in the Gulf of California while fishermen dive for abalone, sea cucumbers, and other invertebrates.

Loggerhead turtles are typically captured opportunistically or incidentally at sea while fishing for other species such as rockfish, shark or squid. During midday hours as they bask at the surface, loggerhead turtles are easy to gaff with hooks or capture by hand without need for the fisherman to enter the water. Loggerhead turtles are also occasionally harpooned while basking. In the Gulf of California loggerheads are sometimes collected by hand by scuba divers. However, the taste for their meat is far less developed on this coast. In some Pacific communities there are organized, dedicated fishers for loggerhead turtles, principally during spring and summer months.

Harpoon wounds were noted on four loggerhead turtles, two stranded and two that had been consumed. It is not known whether harpooning was the cause of mortality. Pelagic shark fishermen regularly carry harpoons on their *pangas*.

Olive ridley turtles are regarded much the same as loggerheads—they are consumed and captured opportunistically, but their meat is not considered to be the highest in quality. Once common (Olguin 1990), there was a large market for the meat and skin of the olive ridley turtle and, according to fishermen, their large numbers supported a lucrative fishery in Baja California. Now they are occasionally taken in nets or by hand as food. Additionally, females are occasionally taken as food from nesting beaches in the cape region. Their eggs sometimes are collected and eaten locally.

The hawksbill and leatherback turtles, while once hunted, are now considered inferior in quality for human consumption. Hawksbills were once prized for their shell and large numbers were hunted annually in Baja California waters (Caldwell 1962, Cliffton et al. 1982). However, the sale of *penca*, or hawksbill scute, is now illegal. Hawksbill turtles have become exceedingly rare but when captured are still kept for their shell, which is typically hung on the wall over a doorway. In one Loreto restaurant there are approximately 15 small (35-45 cm, SCL) hawksbill carapaces decorating walls and lamps. One Mulegé restaurant has a large (~70 cm, SCL) hawksbill carapace hanging on the wall, with the harpoon allegedly used to capture it hanging nearby. The owner indicated that it was captured locally during the 1960s and that hawksbill turtles of that size were once far more common in Baja California Sur 40 to 50 years ago.

Eggs of leatherback turtles are occasionally collected on nesting beaches in the cape region. In January 1999 two of eight leatherback nests encountered on beaches north of Todos Santos showed signs of having been poached.

A minimum of one green turtle per week, on average, is consumed in each coastal community where surveys were conducted (Table 8). In some communities the number consumed may be far greater, but in very few communities is the consumption level zero (Cantú and Sánchez 1999, Garcia-Martínez and Nichols 2000). Several interviewees suggested that their community had below average turtle consumption rates due to contact with researchers, eco-tourists, and conservation projects. For this reason, the estimate of one turtle per week for the region is likely conservative and adequately represents a minimum mean mortality level for each community. There are more than 150 permanent, coastal communities along the Baja California peninsula, of varying sizes. At this conservative estimated level of take, it is likely that the minimum mortality rate due to local consumption of green turtles in the Baja California region is at least 7,800 per year. Preliminary results of a region-wide socio-economic study being conducted in conjunction with the Universidad Autonoma de Baja California Sur (La Paz, Baja California Sur) suggest that the actual annual take of green turtles may be three to four times greater than this minimum estimate. Cantú and Sánchez (1999) report the hunting of two to four tons (26-53 turtles) of green turtle per week in Laguna San Ignacio during 1994, up to 30 turtles daily in Santo Domingo, Baja California Sur, in 1996, and

10,000 pounds of turtle meat (60 turtles) hunted weekly in Laguna San Ignacio in 1997. Based on their findings they estimate the annual take of green turtles at ten Baja California fishing camps to be between 4,160 and 9,600 turtles, a number consistent with our preliminary findings.

These estimates do not include turtles killed but not consumed, as incidental catch, such as those stranded near Guerrero Negro in 1997 (Exportadora de Sal 1998). Furthermore, in each coastal community there is typically a small number of people who derive their living exclusively from the hunting of sea turtles for the black market. These turtles are typically meant for northern or mainland markets where turtles are worth up to ten times more in urban areas than they are locally (Cantú and Sánchez 1999). Live turtles and quartered carcasses are transported in trucks and the trunks of cars (Resendiz and Hernández 1993) northward to Ensenada, Tijuana, and Mexicali and southward to La Paz and Los Cabos. Preliminary results suggest that the main buyers of turtle meat are individuals with secure jobs and those in positions of power and influence without fear of retribution. Low wages, corruption, lack of staff, and the vast size and remoteness of the region hinder enforcement (Knudsen 1995).

According to Baja California residents interviewed by Dedina and Young (1995), the isolation of the Pacific lagoons and lack of enforcement personnel have led to an increase in resource poaching. Some semi-permanent local residents and entrepreneurs from elsewhere consider poaching a low-risk, high financial return activity relative to legal commercial fishing. For example, Laguna San Ignacio and Bahía Magdalena are major center for the lucrative sea turtle trade in the region (Cruz 1993). Large concentrations of sea turtle carcasses are present in certain portions of the lagoons used by turtle poachers (e.g., along roads and near fish camps away from shore). Illegal poaching of egg-laden lobster and sea turtles is widespread (Alcantar 1993a, 1993b; Lopez 1994).

Dedina and Young (1995) reported the black market price of sea turtle meat at approximately U.S. $15/kg.

Assessment of mortality related to clandestine markets is extremely difficult. However, available information suggests that inclusion of these animals in the annual mortality estimate will substantially increase the total estimated annual take.

Interviews with residents of San Ignacio provide some insight into the movement of sea turtles from the lagoon to northern urban areas. The value of turtle meat increases greatly as the distance from the capture site expands. For example, on site, a turtle is worth up to US$10/kg (live, whole turtle) and at least US$15/kg for meat. However, in an Ensenada or Tijuana restaurant, a plate of turtle meat is worth at least US$12-15, more than a three-fold increase in value. If an average of 20 turtles is hunted in San Ignacio lagoon each week, and the average turtle weighs 35 kg, the value of the resource exceeds $350,000 annually. On the street, the turtle products from this one location may be worth nearly US$1,000,000 annually. The entire black market sea turtle trade in Baja California may generate more than $20 million annually.

The costs associated with turtle trafficking are not negligible. It is typical to pay 100 pesos ($US 10) per turtle to pass through military checkpoints along the highway. This increased cost, and risk, of transporting live sea turtles is what gives the animal its market value in northern cites. If this isn't possible, the transport vehicle takes the "long way" on desert roads around military checks. Two cars will typically travel together with radios, communicating upcoming roadblocks and military checks. Furthermore, drivers risk being caught, loss of vehicles and jail. Some residents feel that if the benefits from sea turtle trade could be harnessed legally, market incentives would help sea turtle recovery efforts.

Other Causes of Sea Turtle Mortality

Directed and incidental take is the main source of sea turtle mortality in Baja California. However, several other sources of mortality have been identified as moderate concerns.

Boats occasionally strike sea turtles in the water. While I have only encountered three turtles with apparent boat-related injuries (all green turtles), most fishermen report having struck turtles with their boats on several occasions. Recreational, high-speed boating activities are not common throughout most of Baja California waters and don't appear to be a major threat to turtles. The status of this threat should, however, be monitored as tourist activities expand and new marinas are developed.

Ingestion of, or entanglement in, marine debris may be a moderate problem in Baja California. Despite the low human population density of Baja California and Baja California Sur, poor garbage disposal facilities and a propensity to discard plastic waste into the sea create problems for sea turtles. On four occasions, I found live sea turtles entangled in plastic debris. Had they not been freed, they certainly would have died. Seminoff et al. (2000) analyzed fecal contents of turtles in Bahía de los Angeles and found that 20% of green turtles had ingested plastic (7 of 34 samples). When hungry, captive sea turtles at the Bahía de los Angeles research station actively consumed plastic objects (sunglasses) and a wide variety of organic materials accidentally available to them (A. Resendiz, pers. comm.).

Ingestion of plastic objects can result in gut strangulation, positive buoyancy—rendering the turtles incapable of sustaining dives and more vulnerable to predators, fishermen, and boat collision—, and decreased digestive efficiency (Lutcavage et al. 1997, McCauley and Bjorndal 1998). I have encountered two loggerhead turtles apparently with the buoyant condition, one with a portion of the plastic material extending partially from the cloaca. Both turtles were treated by temporarily holding them in captivity and releasing them once the blockage passed.

Three juvenile olive ridleys and one juvenile leatherback turtle have been encountered with plastic sacks entangling the flipper. Association of sea turtles with flotsam and jetsam has been documented in the region and the turtles are likely feeding near the floating garbage or seeking shelter when they become entangled (Arenas and Hall 1991). These plastic sacks, or *costales*, are used by fishermen for a variety of reasons, including bait storage, and are often discarded when they become worn or soiled.

Threats to sea turtles in Baja California are also indicated on nesting beaches in the cape region. Consumption of sea turtle eggs is not traditionally a major concern in Baja California in the way that it is on mainland Mexican nesting beaches. However, with the recent influx of migrants from the mainland to the developing tourist centers near Cabo San Lucas and San Jose del Cabo, egg poaching has increased (M. Orrantes, pers. comm.).

Along with the evolving tourist industry has come development on nesting beaches, the construction of beach walls to protect private property, beach sand replenishment, and a growing number of all-terrain vehicles. Until recently, Baja California had been relatively immune to the threats to sea turtles associated with tourism and residential development. In the future the region will be faced with many of the development-related issues that have stymied conservationists in the southeastern United States.

Point-source pollution is generally not a big problem in the relatively undeveloped Baja California region. However, two reports are worth noting. First is the report of a mass stranding of more than 94 green turtles in late 1997-early 1998 near Guerrero Negro, Baja California Sur (Exportadora de Sal 1998). The report filed by the Procuraduria Federal de Protección al Ambiente (PROFEPA), a Mexican government environmental agency, described the mortality as a direct result of osmotic shock due to a massive spill of salt brine from one of the ponds of Exportadora de Sal, S.A. While the salt production facility has produced a large volume of pollutants over the years, it is not clear that the simultaneous mortality of 94 turtles is directly related to salt production activities. Other factors may have been involved. Several inadequacies of the PROFEPA report suggest that further review of the data is required in order to determine the cause of turtle mortality. Inadequacies include the lack of evidence of a spill, the lack of an estimated volume of the proposed spill, the lack of a report on the density of turtles in waters near the alleged spill, pooling of blood on the ventral surface of the stranded turtles (suggesting that the turtles had been stacked and/or frozen), the lack of other stranded species in the area, and missing analyses of gut contents of stranded turtles (Exportadora de Sal, S.A. 1998). The lack of a thorough discussion of the hypothesis that trawling or another fisheries-related cause may have been involved is a major shortcoming of the report (Chapter 7). The records of 94 dead turtles in such a small area, information obtained through the interviews presented in this report, reports of the high rate of turtle consumption in the Guerrero Negro area, and the observation that the shrimp industry has continued to increase landings in the region for each of the past 3 years suggest that attention should be paid to monitoring the use of TEDs, incidental capture of sea turtles, and the direct hunting of sea turtles in this region. Efforts should be focused on determining the true cause of the 1997 sea turtle mortality and removing or reducing that cause.

Presti et al. (1999) documented a possible point-source impact on sea turtles in Baja California waters. In a study of heavy metal accumulation in green turtle scutes conducted in Bahía de los Angeles, low levels of mercury were detected and considered contamination. Since only one site has been monitored (Bahía de los Angeles), it is not known what mercury levels Baja California turtles in other regions are carrying. Mercury in small levels over time may cause neurotoxicity and immunosuppression. This could have an effect on turtle mortality. However, it would not be characterized by an acute mass die-off. Rather, it may be a compounding mortality factor, as well as a risk factor to monitor at contaminated sites that are known feeding, nesting, or developmental habitats. While the sample sizes were small and heavy metal levels were not available for comparison to other eastern Pacific populations, Presti et al. (1999) made several conclusions based on the Bahía de los Angeles data:

- Mercury was found at relatively low levels in green turtles in Bahía de los Angeles, but, because mercury is a non-essential metal, detection is technically considered contamination.
- Green turtles may be at lower risk for accumulation of mercury because of their largely herbivorous diet. Olive ridley and loggerhead turtles may be at higher risk, as they tend to consume a high percentage of crustaceans.
- Juvenile turtles had proportionately higher levels of mercury than older turtles. This is a cause for concern as it may indicate a higher risk of accumulation while nervous, reproductive, and immunosuppression systems are still developing.
- Illegal gold mining exists in Bahía de los Angeles, although on a small scale. Mercury is still used in this procedure.

Green turtle fibropapiloma has not been reported in Baja California waters to date. However, studies to investigate small anomalies recently discovered in the eyes of green turtles feeding in Bahía de los Angeles and Bahía Magdalena have been initiated.

Mortality Synopsis by Species

Green turtle. The main threat to green turtles in the Baja California region is directed take. A minimum of 7,800 green turtles is hunted annually for local domestic consumption. When black market trade in urban and inland communities is included in this estimate, mortality may be as high as 30,000 turtles annually (F. Zuniga, pers. comm.). This take impacts both immature and mature animals (Table 5 and Figure 5) and likely has resulted in the continuing decline in the number of nesting females on eastern Pacific rookeries. Green turtles are caught accidentally in a wide range of fisheries and turtles, once captured, are rarely returned to the water. Thus, stranded green turtles are rare. Boat collisions, ingestion of plastic debris, and contamination are moderate threats to green turtles.

Approximately 13% of dead turtles were greater than the mean size of nesters in Michoacan (Alvarado and Figueroa 1990). I estimate that a minimum of 1,014 adult-sized turtles die in Baja California waters each year. This mortality has grave consequences when one considers that Figueroa et al. (1993) estimated the total adult Michoacan green turtle population to be 6,331 individuals. Since then, nesting has declined by approximately 50% (J. Alvarado, pers. comm.). In 1998-9 there were fewer than 400 nesting females in Colola, Michoacan—representing approximately 85% of the Michoacan population—the principal nesting region for the East Pacific green turtle. A minimum estimate of the number of adult green turtles (N_{min}) in the Michoacan population can be computed using 1998-1999 nesting data and published life history parameters (Figueroa et al. 1992):

$$N_{min} = \text{\# of nests} \div \text{\# of nests per female} \div \text{proportion of females nesting} \div \text{proportion of females} \div \text{proportion of beaches covered}$$

$$= 1{,}200 \div 2.5 \div 0.33 \div 0.5 \div 0.85$$

$$= 3{,}422$$

To put the green turtle mortality rate in perspective, consider that Gerrodette (1996) conservatively estimated the Potential Biological Removal (PBR)—"the number animals killed should not exceed PBR"—of North Pacific loggerheads at ***28*** adult turtles. The PBR value is based on an estimated minimum population size, using the above equation, of 4,245 adult loggerhead turtles in the North Pacific.

Loggerhead turtle. Loggerhead turtles are less frequently consumed in Baja California due to their pelagic habits, lower catch rate, and the strong taste of their flesh. However, in several Pacific communities a market for their meat exists, and appears to have expanded with the local declines of green turtles. Hunting levels are difficult to quantify, but, based on carapaces encountered, likely result in a minimum mortality of 1,000 turtles annually. Stranded loggerheads are commonly found on Pacific beaches. Annual stranding rates are on average 2.6 turtles/km of surveyed beach. We estimate an average of 950 loggerhead strandings annually along approximately 400 km of coastline. Pelagic shark fisheries, and nearshore gillnet fisheries are implicated in loggerhead mortality.

Nearly all loggerheads encountered have been of immature size (< 89 cm, SCL). Two percent (n = 7) of the loggerhead turtles encountered were larger than 80 cm (SCL). This size distribution is consistent with the hypothesis that loggerhead turtles utilize Baja California waters as developmental habitat and leave the region at mature sizes.

This mortality may have a substantial impact on Pacific loggerhead populations (Gerrodette 1996), which have been declining over the past decade (Kamezaki 1997). A mortality rate of 1,950 loggerhead turtles annually will result in the take of approximately 39 turtles > 80 cm (SCL), based on the proportion of that size class (2%) in the stranded/consumed turtles encountered.

Olive ridley turtle. Olive ridley turtle mortality patterns are similar to those of the loggerhead, although ridleys are encountered less frequently in Baja California waters (Olguin 1990). Olive ridleys are consumed locally, particularly along the Pacific coast, and are occasionally found stranded on Pacific beaches. Entanglement of immature olive ridleys in plastic debris appears to be a moderate problem. Egg poaching and development are moderate threats on olive ridley nesting beaches.

Four of 34 (12%) olive ridleys encountered were larger than 66.0 cm (SCL), the mean size of nesting females (Miller 1997). Mortality in Baja California waters may directly impact local rookeries in the cape region. However, the connection between these rookeries and feeding grounds has not yet been established.

Hawksbill turtle. Hawksbill turtles have become exceedingly rare in Baja California waters due to over hunting in the early and mid 20th century. Still, evidence of hawksbill hunting is noted, although it is unclear if there is trade in hawksbill shell. Hawksbill meat is consumed locally, although rarely, as the animals are infrequently encountered. All of the hawksbill turtles encountered (n = 9) were immature. This species has been nearly extirpated from the region. Older fishermen in the region corroborate this assessment.

Leatherback turtle. In-water records of leatherback turtles in the region are few. Anecdotal accounts suggest that they are occasionally captured in nets or in trap lines. Leatherback meat is occasionally consumed, although it is not preferred. Entanglement in and ingestion of plastic debris may be a moderate threat. The origins of leatherback turtles foraging in Baja California waters are not known.

On their nesting beaches in Baja California Sur, egg poaching and development are primary threats. However, it is unclear whether any embryos survive to eclosion. The nesting beaches may represent the northern limits of the leatherback turtle's range and account for fewer than 100 nests annually. Personal observation and local knowledge indicate that eclosion rates for leatherback nests in Baja California are extremely low. One fisherman, a former egg poacher and life-long resident of a ranch north of Todos Santos, claims that he has never seen leatherback hatchlings emerge. On several occasions, after digging up unhatched nests, he reports putrid eggs and undeveloped embryos.

SUMMARY

1) Immature and adult green turtles are captured year round in Baja California waters, both along the Pacific and Gulf of California coasts.
2) The size composition of stranded and consumed loggerhead turtles suggests that Baja California is primarily a developmental area for immature loggerhead turtles.
3) Mortality of all size classes of green turtle, ranging from pelagic immature to post-reproductive mature turtles, was recorded.
4) Immature and mature-sized olive ridleys were encountered.
5) All of the hawksbill turtles recorded were immature.
6) Presence of turtles, activity levels of turtles, and fishing effort for turtles and fish may be higher during spring and summer, resulting in increased mortality levels.
7) The main threats to green and loggerhead turtles are direct hunting and incidental capture. Specific connections between stranded turtles and fisheries-related mortality have been inconclusive.
8) Ingestion of and entanglement in discarded debris appears to be a moderate problem.
9) Point-source pollution may be a problem in isolated areas and should be monitored.
10) Boat collisions and propeller injuries are relatively minor problems.
11) Ten percent of green turtles and 20% of loggerhead turtles tagged between 1994 and 1999 in Baja California were reported captured in fishing nets.
12) In the context of previous studies of incidental take and mortality of sea turtles in other regions of the Pacific, the levels depicted in this report are extremely alarming.

Anthropogenic mortality in Baja California waters impacts every stage of the sea turtle's life cycle. Sea turtles face loss of nesting beaches, egg poaching, loss of feeding habitat, hunting of juveniles and adults, and entanglement in several gear types. Increasing levels of non-biodegradable waste and coastal pollution are rapidly becoming a concern in the region. Future research *must* produce information that will direct ways to mitigate these losses.

In response to sea turtle declines and this current mortality information, the Sea Turtle Conservation Network of the Californias was established. The network includes a mechanism for reporting sea turtle sightings and strandings via an online database. The network is promoting community-based initiatives to reduce poaching and protect critical sea turtle foraging grounds (Chapter 8). The network holds annual meetings in Loreto, Baja California Sur, Mexico (Nichols and Arcas 1999).

RECOMMENDATIONS

The results of this study highlight several areas where considerable progress remains to be made towards the recovery of Baja California, and, indirectly, Pacific-wide, sea turtle rookeries. The following recommendations may help guide future sea turtle recovery efforts:

1) Fishermen should be encouraged to report incidental catch of sea turtles without fear of retribution and should be provided with the means to do so.
2) Critical foraging grounds and coastal areas near nesting beaches should be provided permanent or seasonal reserve/refuge status.
3) Community-based enforcement should be developed, supported, and rigorously extended throughout Baja California.
4) The use of turtle excluder devices (TEDs) on Baja California shrimping grounds, required by Mexican law since 1996, should be monitored and enforced.
5) A communicative and consolidated sea turtle stranding network for the Baja California region should be established and made accessible to fishermen, managers, researchers and recreational visitors in order to report mortality in a timely fashion.
6) Fishermen should be encouraged to report and return sea turtle flipper tags and a reward system should be implemented for such reports.
7) Research on fisheries interactions, by-catch, and hunting of sea turtles in Baja California should be continued and expanded.

8) Research on the behavior and ecology of sea turtles on feeding and developmental areas in Baja California waters, particularly as they migrate through areas of high density fishing activities, should be continued.

9) Fishermen involved in this work should be invited to regular conservation and management meetings.

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Table 1. Recorded sea turtle mortality by species during 1994-1999 on the Gulf of California coast and the Pacific coast of Baja California, Mexico.

Species	Gulf of California	Pacific	Totals
Chelonia mydas (CM)	30	276	306 (30%)
Caretta caretta (CC)	3	617	620 (60%)
Lepidochelys olivacea (LO)	1	35	36 (3.5%)
Eretmochelys imbricata (EI)	1	7	8 (<1%)
Dermochelys coriacea (DC)	1	0	1 (<1%)
Unidentified (UNID)	0	57	57 (6%)
TOTAL	36	992	1028

Table 2. Sea turtle mortality by region and year during 1994-1999 on the Gulf of California and Pacific coasts of Baja California, Mexico.

	REGION							
Year	BLA	BKI	LOR	LSI	BMA	LOL	PAO	Totals
1994[1]	0	0	0	0	210	0	0	210
1995[2]	0	0	0	0	0	0	0	0
1996	1	6	0	0	0	0	0	7
1997[3]	7	0	4	7	43	40	2	98
1998	6	0	5	0	41	0	0	47
1999	4	1	2	0	649	0	0	649
Totals	18	7	11	7	943	40	2	1028

[1]Survey conducted by Serge Dedina and Emily Young in July 1994.
[2]No mortality data were collected in 1995, and were opportunistically collected in 1996..
[3]Initiation of sea turtle mortality surveys.

BLA = Bahía de los Angeles, BC; BKI = Bahía de Kino, Son.; LOR = Loreto, BCS; LSI = Laguna San Ignacio, BCS; BMA = Bahía Magdalena, BCS; LOL = Laguna Ojo de Liebre, BCS; PAO = Punta Abreojos, BCS.

Table 3. Condition of sea turtles when encountered during mortality studies in Baja California, Mexico, (1994-1999).

Condition	SPECIES						
	CC	CM	LO	EI	DC	UNID	Total
0 = Alive	6 (1%)	13 (4%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)	19 (2%)
1 = Mortally injured	0 (0%)	6 (2%)	2 (6%)	2 (25%)	1 (100%)	0 (0%)	11 (1%)
2 = Freshly dead	20 (5%)	5 (2%)	1 (3%)	0 (0%)	0 (0%)	6 (11%)	32 (4%)
3 = Moderately decomposed	18 (4%)	42 (14%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)	60 (7%)
4 = Severely decomposed	73 (18%)	5 (2%)	2 (6%)	0 (0%)	0 (0%)	33 (58%)	113 (14%)
5 = Dry carcass/carapace	67 (16%)	2 (1%)	6 (17%)	4 (50%)	0 (0%)	0 (0%)	79 (10%)
6 = Carapace only (consumed)	224 (55%)	228 (75%)	25 (69%)	2 (25%)	0 (0%)	11 (19%)	490 (60%)
7 = Bones only	2 (<1%)	5 (2%)	0 (0%)	0 (0%)	0 (0%)	7 (12%)	14 (2%)
Totals	410* (50%)	306 (37%)	36 (4%)	8 (1%)	1 (<1%)	57 (7%)	818* (100%)

*This total does not include the 210 stranded loggerhead turtles reported by S. Dedina and E. Young in 1994.

CC = *Caretta caretta* = loggerhead turtle; CM = *Chelonia mydas* = green turtle; LO = *Lepidochelys olivacea* = olive ridley turtle; EI = *Eretmochelys imbricata* = hawksbill turtle; DC = *Dermochelys coriacea* = leatherback turtle; UNID = unidentified species.

Table 4. Stranded loggerhead turtles, *Caretta caretta*, on Isla Magdalena, Baja California Sur, Mexico (1994-1999).

Date	Location (Distance surveyed)	# of Turtles	# Turtles/km	Mean SCL (cm)	Size Range (cm)
May 1994[1]	Pacific coast, N. of Cabo San Lazaro (60 km)	210	3.5	NA	NA
June 1997	Bahía Santa Maria (10 km)	32	3.2	59.5	35.3-80.4
May 1998	Bahía Santa Maria (10 km)	7	0.7	63	53-73.2
August 1998[2]	Pacific coast, N. of Cabo San Lazaro (10 km)	>40	>4.0	NA	NA
November 1998	Bahía Santa Maria (10 km)	11	1.1	60.1	46.8-76.5
January 1999	Bahía Santa Maria (10 km)	3	0.3	59.4	57-62.4
April 1999	Bahía Santa Maria (10 km)	6	0.6	43.6	32.2-52
June 1999	Bahía Santa Maria (10 km)	4	0.4	50.7	28.1-66.0
August 1999	Pacific coast, N. of Cabo San Lazaro (60 km)	*112	1.9	62.1	42.5-81.4
1994 Cumulative Total		210	3.5	NA	NA
1997 Cumulative Total		32	3.2	59.2	35.3-80.4
1998 Cumulative Total		>58	>1.9	61.2	46.8-76.5
1999 Cumulative Total		125	1.8	61.1	28.1-81.4
Grand Totals/Averages		385	2.6	*61.2	28.1-81.4

[1] Reported by Serge Dedina; [2] Reported by Francisco Cota; *many of these turtles were severely decomposed and may have stranded several weeks prior to the survey; overall mean calculated from SCL of whole, measured turtles, N=143, sd=9.3

Table 5. Size distribution of all stranded and consumed sea turtles in Baja California, Mexico, 1994-1999, reported by species.

	Straight Carapace Length$_{n-t}$ (cm)		
Species	***Gulf of California*** (N, range, s.d., mean)	***Pacific*** (N, range, s.d., mean)	***Overall*** (N, range, s.d., mean)
CC	5, 27.7-92.7, 29.05, 61.2	341, 26.6-90.2, 10.56, 60.2	346, 26.6-92.7, 11.06, 60.4
CM	20, 35.9-78.4, 11.83, 61.3	212, 22-94.2, 14.09, 61.6	232, 22.0-94.3, 13.88, 61.6
LO	1, - , - , 62.4	33, 21.2-70.0, 11.72, 57.6	34, 21.2-70.0, 11.57, 57.8
EI	1, - , - , 42.2	8, 35.4-52.2, 5.54, 42.3	9, 35.4-52.2, 5.19, 42.3
DC	1, - , - , 50.0*	-	1, - , - , 50.0*

*Approximate straight carapace length (notch to tip).

CC = *Caretta caretta* = loggerhead turtle; CM = *Chelonia mydas* = green turtle; LO = *Lepidochelys olivacea* = olive ridley turtle; EI = *Eretmochelys imbricata* = hawksbill turtle; DC = *Dermochelys coriacea* = leatherback turtle.

Note: carapace lengths were not recorded for all of the 1,028 turtles documented.

Table 6. Apparent causes of sea turtle mortality recorded in Baja California, Mexico, 1994-1999.

	SPECIES						
Cause/ Species	CM	CC	LO	EI	DC	UNID	Total
Incidental catch	27	421	7	2	0	52	509 (49%)
Domestic consumption	238	199	26	*6	0	5	474 (46%)
Water pollution	40	0	0	0	0	0	40 (4%)
Debris entanglement	0	0	3	0	1	0	4 (<1%)
Boat impact	**1	0	0	0	0	0	1 (<1%)
Total	306	620	36	8	1	57	1028

*Two of these hawksbills were used as decorations
**In 1999 two additional live turtles were encountered with broken carapaces due to boat collisions in Bahía de los Angeles, Baja California. They were treated and released.

CC = *Caretta caretta* = loggerhead turtle; CM = *Chelonia mydas* = green turtle; LO = *Lepidochelys olivacea* = olive ridley turtle; EI = *Eretmochelys imbricata* = hawksbill turtle; DC = *Dermochelys coriacea* = leatherback turtle; UNID = unidentified species.

Table 7. Summary information on sea turtle bycatch in gillnets for turtles tagged near Baja California, Mexico, 1995-1999.

Species	SCL_{n-t} (cm)	Date & Location tagged/released	**Date & Location of recapture**	# of days at large
Cc	85.6	19 Jul 1994, Santa Rosaliita, BC	November 1995, near Shikoku, Japan	478
Cm	NA	12 Jan 1995, Campo Archelon, BLA, BC	March 1995, Near town, BLA, BC	~63
Cm	72.1	6 May 1996, El Cardon, BLA, BC	2 August 1997, Bahía Guadelupe, BC	459
Cm	69.2	30 Jun 1996, El Cardon, BLA, BC	22 July 1996, El Cardon, BLA, BC	22
Cm	58.6	12 Jul 1996, Campo Archelon, BLA, BC	15 July 1996, La Silica, BLA, BC	3
Cc	83.4	10 Aug 1996, Santa Rosaliita, BC	13 August 1997, vicinity of Isohama, Japan	368
Cm	48.2	12 Jul 1996, Campo Archelon, BLA, BC	16 July 1996, La Silica, BLA, BC	4
Cm	56.4	12 Jul 1996, Campo Archelon, BLA, BC	16 July 1996, La Silica, BLA, BC	4
Cm	imm	Summer 1997, Juncalito, BCS	Spring 1998, near Juncalito, BCS	~300
Cm	adult	Summer 1997, Juncalito, BCS	Spring 1998, near Juncalito, BCS	~300
Cm	imm	Sept 1997, Estero Coyote, BCS	Summer 1998, Estero Coyote, BCS	~220
Cm	68.2	9 Oct 1997, El Barco, BLA, BC	15 January 1998, Bahía San Rafael, BC	98
Cm	57.2	24 Jan 1998, Estero los Cuervos, BMA, BCS	14 March 1998, Estero los Cuervos, BMA, BCS	50
Cm	68.1	25 Jan 1998, Estero los Cuervos, BMA, BCS	2 April 1998, Estero los Cuervos, BMA, BCS	98
Cm	53.6	2 Jun 1998, Estero los Cuervos, BMA, BCS	27 June 1998, Estero los Cuervos, BMA, BCS	25
Cm	65.2	12 Aug 1998, El Bajo, BLA, BC	15 December 1998, Bahía San Rafael, BC	115
Cm	imm	no date, BMA, BCS	Summer 1999, Estero el Muerto, BMA, BCS	NA
			Mean; range of days at large for *C. caretta*, *n = 2*	423; 368-478
			Mean; range of days at large for *C. mydas*, *n = 14*	152; 3-824

Note: fishermen reported several tagged turtles with no ID#. These turtles were confirmed to be from our project through tag descriptions. Cm = *Chelonia mydas*; Cc = *Caretta caretta*; SCL(n-t) = straight carapace length (notch to tip).

Table 8. Summary information on green turtle (*Chelonia mydas*) hunting in the Baja California region, Mexico, obtained through semi-structured interviews, 1995-1999.

Question/ Region (number of interviews)	Bahía de los Angeles, BC (n=13)	Juncalito, BCS (n=4)	Bahía Tortugas, BCS (n=4)	Punta Abreojos, BCS (n=7)	Laguna San Ignacio, BCS (n=7)	Bahía Magda-lena, BCS (n=213)	Todos Santos, BCS (n=4)	Totals/ Averages (n=263)
% of those surveyed employed as fishermen.	100%	100%	100%	100%	100%	65%	100%	70%
% of those surveyed who have eaten sea turtle meat	100%	100%	100%	100%	100%	91%	100%	94%
Reported # of turtles captured for consumption per month in the community (mean; range)	3; 2-5	7; 2-40	8; 4-12	2; 1-4	10; 4-60	16; 4-80	3; 2-4	49; 19-205/ 3-29
Reported personal/household turtle consumption per year (mean; range)	1; 1-5	1; 0-4	4; 3-8	1; 0-5	2; 1-14	3; 0-20	1; 0-3	13; 5-49/ 1-7
Reported sea turtle mortality (non-consumed) due to bycatch per month (mean; range)	5; 4-8	3; 1-8	5; 2-8	2; 1-4	7; 4-16	23; 8-120	6; 4-16	51; 24-180/ 3-26
Total estimated monthly mortality (mean; range)	8; 6-12	10; 3-48	13; 6-20	4; 2-8	17; 8-76	39; 12-200	9; 6-20	100; 43-485
Total estimated annual mortality (mean; range)	96; 72-144	120; 36-576	156; 72-240	48; 24-96	204; 96-912	468; 144-2,400	108-72-240	1,200; 516-5,720

Table 9. Sea turtle strandings reported to the California Sea Turtle Stranding Network, 1990-1998.

Species	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	Totals	Annual Mean*
Dermochelys coriacea	11	8	2	9	4	1	3	0	2	10	50	5
Chelonia mydas	10	2	8	0	4	3	5	7	3	6	48	5
Caretta caretta	4	0	3	5	2	1	2	1	3	0	21	2
Lepidochelys olivacea	2	1	1	1	1	0	2	2	1	1	12	1
unidentified	5	2	0	0	0	0	0	1	0	0	8	1
Totals	32	13	14	15	11	5	12	11	9	17	139	14

Source: California Sea Turtle Stranding Network, National Marine Fisheries Service, Long Beach, CA.

Table 10. Types of sea turtle exploitation in Baja California (categories adapted from Nietschmann 1995).

Subsistence

1. Use of sea turtles is socially and nutritionally important and part of an indigenous culture.
2. Exploitation and consumption primarily by individual households in fishing communities.
3. Opportunistic catch of turtles by subsistence fishers.
4. Meat is exchanged or sold for small sums of money within communities.

Market

5. Sale of live turtles, meat, and/or eggs to regional markets.
6. Sale of live turtles to buyers for export or transport to urban centers.
7. Opportunistic catches by divers and fishers for market sale.

Incidental

8. Incidental catches by commercial fishers (shrimp trawlers, longliners, etc.).

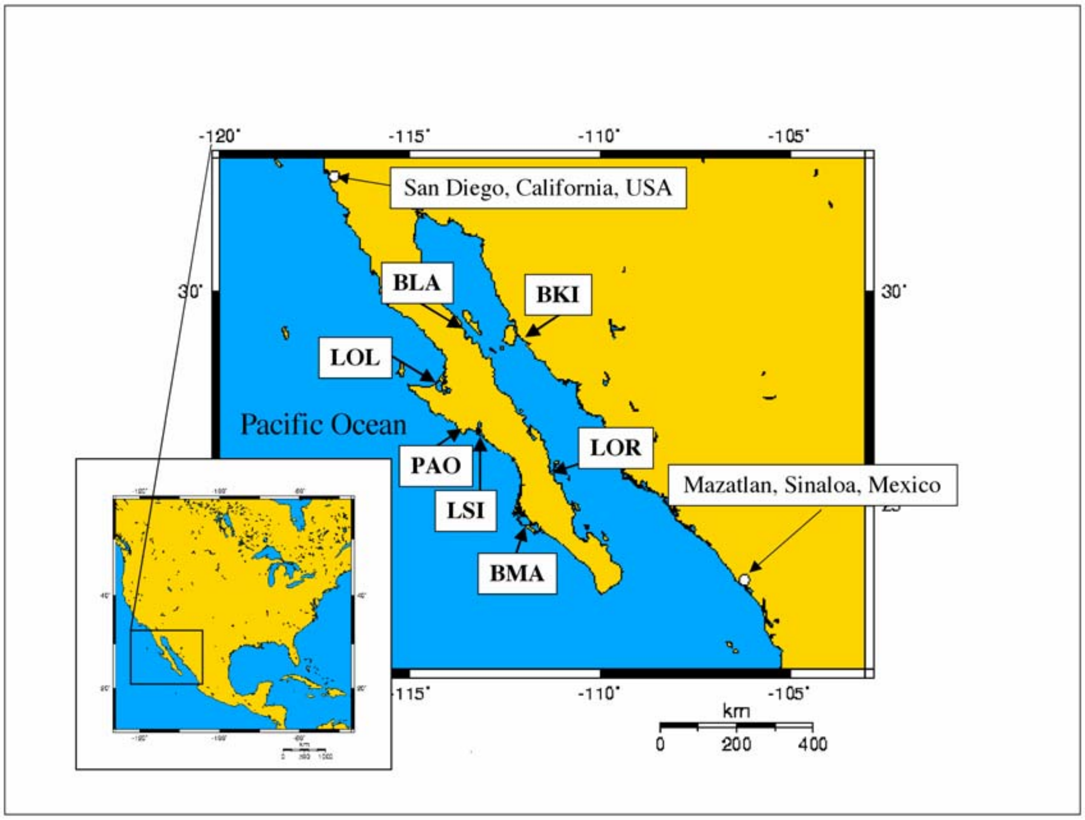

Figure 1. Study areas and principle collection sites in Baja California and Baja California Sur, Mexico. BC = Baja California; BCS = Baja California Sur; BLA = Bahía de los Angeles, BC; BKI = Bahía de Kino, Sonora; LOR = Loreto, BCS; LSI = Laguna San Ignacio, BCS; BMA = Bahía Magdalena, BCS; LOL = Laguna Ojo de Liebre, BCS; PAO = Punta Abreojos, BCS. San Diego, CA, USA, and Mazatlán, Sinaloa, Mexico, are added as reference points.

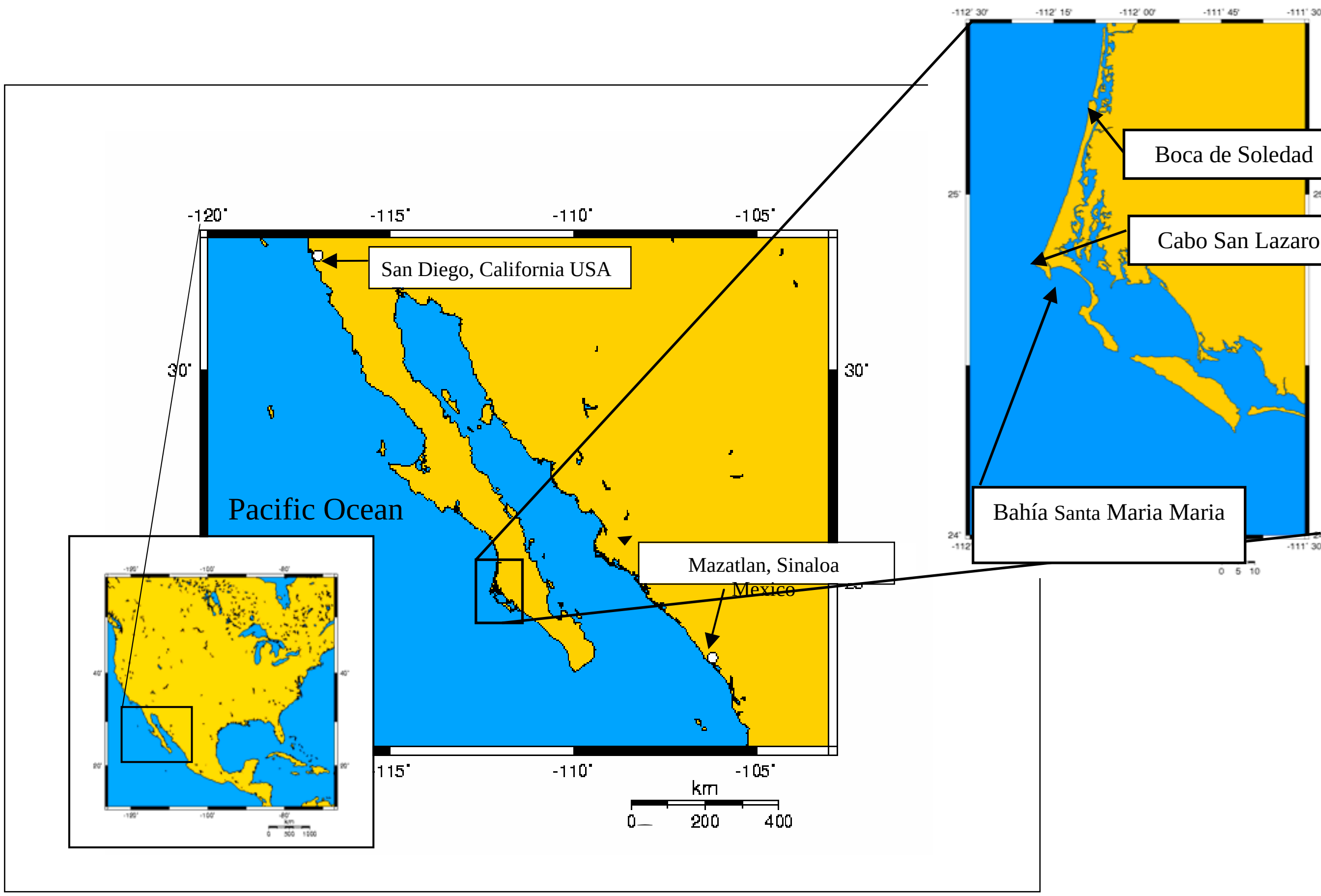

Figure 2. The two main beaches on Isla Magdalena, Baja California Sur, where stranding surveys were conducted. The northern beach from Boca de Soledad, to Cabo San Lazaro, is about 60 km in length and Bahía Santa Maria beach is 10 km.

Figure 3. Stranded loggerhead turtle, *Caretta caretta*, encountered during survey of Isla Magdalena, Baja California Sur, Mexico, July 1999. Note that the turtle had recently stranded and is bloated due to decomposition.

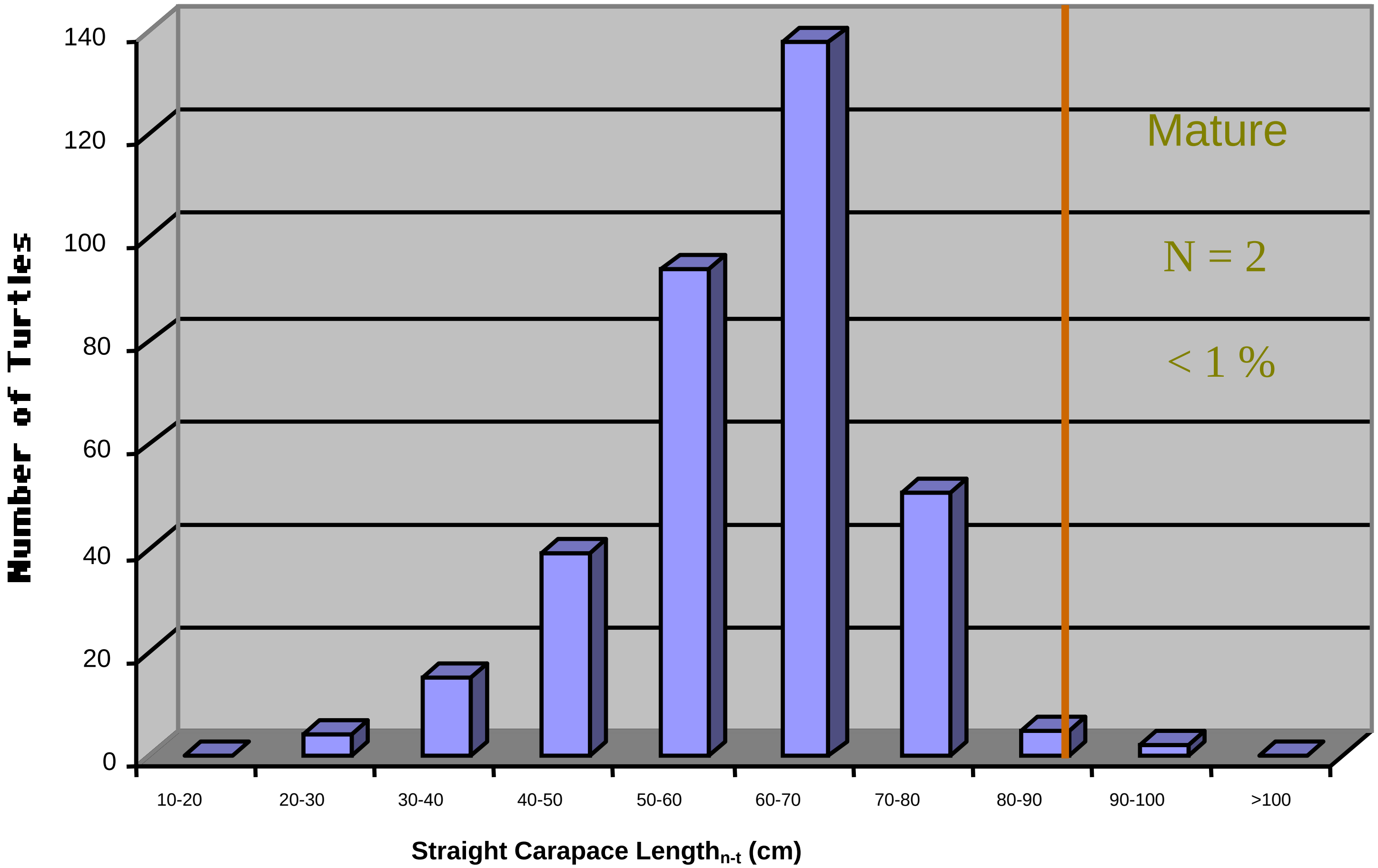

Figure 4. Histogram of size frequency distribution of stranded/consumed loggerhead turtles (*Caretta caretta*) in Baja California, Mexico, 1994 –1999, (n = 346). Turtles greater than 89 cm (SCL) were considered mature.

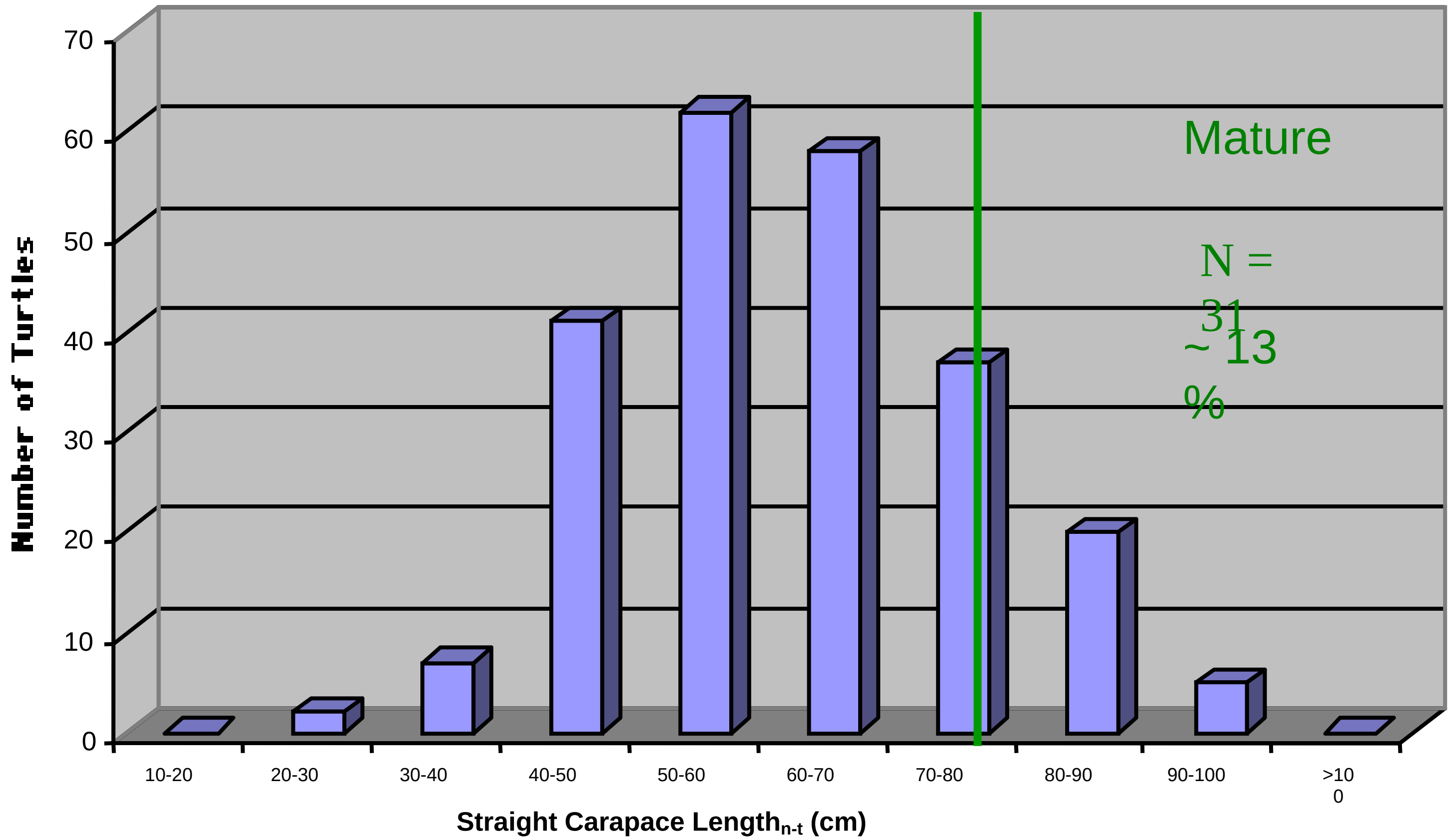

Figure 5. Histogram of size frequency distribution of stranded/ consumed green turtles (C*helonia mydas*) in Baja California, Mexico, 1994-1999, (n = 232). Turtles greater than 77.3 cm (SCL) were considered mature

Figure 6. Collecting sea turtle carapaces near Puerto San Carlos, Baja California Sur, Mexico, July 1999. Carapaces are measured, marked and piled near the Centro para Estudios Costeros to avoid recounting.

CHAPTER 4

TRANSPACIFIC MIGRATION OF A LOGGERHEAD TURTLE MONITORED BY SATELLITE TELEMETRY

ABSTRACT

The oceanic movements of a captive-raised adult loggerhead turtle (*Caretta caretta*) were monitored with satellite telemetry for 368 days from 10 August 1996 to 12 August 1997. During this time the turtle migrated across the Pacific Ocean, covering more than 11,500 km between Santa Rosaliita, Baja California, Mexico (28°40’N, 114°14’W), and Sendai Bay, Japan (37°54’N, 140°56’E). The average speed during migration was 1.3 km/h and the maximum recorded speed was 1.84 km/h. These findings are consistent with the hypothesis that loggerheads feeding in the eastern Pacific eventually return to nest on western Pacific beaches, a relationship previously inferred from molecular genetic analysis and flipper tag returns. We conclude that loggerhead turtles are capable of transpacific migrations and propose that the band of water between 25˚and 30˚ N, the Subtropical Frontal Zone, may be an important transpacific migratory corridor.

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INTRODUCTION

Juvenile loggerhead turtles, *Caretta caretta*, in the 20 - 85 cm straight carapace length (SCL) size range have been observed in the offshore waters along the Pacific coast of California, USA, and the Baja California peninsula, Mexico (Pitman 1990, Nichols, *in press*). Bartlett (1989) suggested that these turtles might be of western Pacific origin, migrating 10,000 km and feeding on pelagic red crabs (*Pleuroncodes planipes*) along the Baja California coast. Subsequently, Baja California loggerhead turtles have been shown, through molecular genetic analysis (Bowen et al. 1995) and flipper tag returns (Uchida and Teruya 1988, Resendiz et al. 1998), to be primarily of Japanese origin.

Pacific loggerheads appear to utilize the entire North Pacific during the course of development in a manner similar to Atlantic loggerheads' use of the Atlantic Ocean (Bolten et al. 1998). After a period of more than 10 years (Zug et al. 1995), mature turtles evidently cross the Pacific Ocean from pelagic waters and foraging areas along the Baja California coast to return to natal beaches, a journey of more than 12,000 km in each direction. Recent findings (Polovina et al. 2000) indicate that juvenile loggerheads in the North Pacific move westward against weak (0.1-0.3 km/hr) eastward geostrophic currents, demonstrating that passive drift may not entirely explain the dispersal of loggerheads.

At each stage of this developmental migration, loggerhead turtles face anthropogenic hazards such as high-seas longline fisheries (Wetherall 1996) and coastal California halibut (*Paralicthys californicus*) and pelagic shark (*Alopias* sp., *Prionace* *glauca, Sphyrna* sp.) fisheries in Mexico (Holts et al., in press; Nichols, pers. obs.). Japanese (Uchida and Nishiwaki 1982, Kamezaki 1997) and Australian (Limpus and Couper 1994) nesting populations have experienced declines in recent decades and, as human populations have grown, fishing activities have increased in both pelagic and coastal areas along with associated incidental capture of sea turtles. It is likely that juvenile and subadult populations in the eastern Pacific Ocean have suffered similar declines, although no studies have addressed this issue. Little biological information exists on life history and movement patterns of Pacific loggerhead turtles (National Marine Fisheries Service and U.S. Fish and Wildlife Service 1998) and sparse experimental evidence exists regarding open ocean migrations and the sensory mechanisms and cues used by the turtles to accomplish them (Lohmann et al. 1999).

This is the first effort to document pelagic movements of North Pacific loggerheads from feeding grounds to nesting areas using satellite telemetry. Previous telemetry studies of loggerhead turtles have documented post-reproductive movements (Stoneburner 1982), pelagic movements (Polovina et al. 2000), home ranges (Renaud and Carpenter 1994), navigational abilities (Papi et al. 1997) and homing behavior (Luschi 1996). However, few studies of sea turtles have documented pre-nesting movements from feeding grounds to breeding areas. Notably, Renaud and Landry (1996) documented movement of a Kemp's ridley turtle (*Lepidochelys kempii*) from feeding grounds in Louisiana, USA, to its successful nesting in Rancho Nuevo, Mexico.

A unique opportunity to track the movements of an adult-sized loggerhead turtle—rarely encountered along the Baja California coast—emerged in 1996. The turtle had been raised in captivity and used in the initial genetic analysis of Baja California loggerhead turtles (Bowen et al., 1995). Its mature size (Kamezaki and Matsui, 1997), genetic affinities with Japanese turtles, and the existence of a previous tag return from Japanese waters of a captive-raised, Baja California loggerhead turtle (Resendiz et al., 1998) were the deciding factors in choosing this particular turtle for the study.

The objective of my study was to monitor the oceanic movement, using satellite telemetry, of a Pacific loggerhead turtle initially captured on feeding grounds along the Baja California coast. Movement data also were examined with respect to oceanographic and meteorological information in an effort to gain insight into the navigational cues that guide adult sea turtles and to identify possible transpacific movement corridors. The results reported here are from a single telemetered turtle that was captive-raised for ten years and released from the coast of Baja California, México.

METHODS

A captive-raised adult loggerhead turtle (BLA099) was monitored following release at Santa Rosaliita, Baja California, México (28°40’N, 114°14’W). The turtle was first captured in October 1986 by sport fishermen in Bahía de Los Angeles, Baja California, and maintained in captivity at the Centro Regional de Investigaciónes Pesqueras, Sea Turtle Research Station (CRIP-STRS). At the time of capture, it had a straight carapace length (SCL) of 29.9 cm and weighed 4 kg. The turtle was used in a study of captive growth rates and in genetic analysis of Pacific loggerhead stocks. Genetic studies suggested that this individual was of Japanese origin (Bowen et al. 1995). At the time of release, the turtle measured 83.4 cm (SCL) and weighed 95 kg. The tail measured 3.5 cm from the edge of the carapace to the tip.

A model ST-3 backpack transmitter manufactured by Telonics, Inc. (Mesa, AZ, U.S.A.) was programmed with a duty cycle of 6 hours on, 6 hours off. The transmitter was attached to the second vertebral scute (counting from the anterior) of the turtle’s carapace using a modified version of the attachment technique described by Balazs et al. (1995). Specifically, we substituted a thin layer (<1 cm) of tinted two-part marine epoxy (Marine-Tex; Montgomeryville, PA, USA) for Silicone Elastomer. Epoxy was also used to create a small faring on the leading and trailing edges of the transmitter to reduce drag (Watson and Granger 1998). Release of the telemetered turtle occurred about 2 km offshore of Santa Rosaliita, Baja California, Mexico (28°40’N, 114°14’W), on 10 August 1996, 10 years after initial capture (Figure 1).

Transmission data were received via the Argos/NOAA satellite-based location and data collection system, which interprets and classifies signal locations in categories called location classes (LC). In addition to the date and location, data included surface time for each 12-hour period, average dive time for each 12-hour period, last dive time and temperature. Only positions with LCs of 0,1, 2 or 3 were included in the analysis of distances traveled and swim speeds. LCs of 1 or greater have known error factors of <1,000 m and accuracy increases with location class (LC = 2, accuracy within 350 m; LC = 3, within 150 m). Turtle locations were plotted using Generic Mapping Tools (GMT) software. Distances and headings were calculated using variations of the Great Circle Equation (Dunlap and Shufeldt 1969). Each segment of the track, or distance traveled between quality locations, is presented and swim speeds for these segments are calculated by dividing the distance traveled by the time between locations (Table 1). The straightness index, or the ratio between the great circle distance (shortest line between the release location and the final location) and the calculated distance traveled, was calculated using endpoints of the track. The turtle's trajectory for the entire track was qualitatively compared to available surface current velocities derived from annual mean TOPEX/Poseidon Satellite Altimeter and NOAA/NESDIS World Ocean Atlas 1998 data (Lagerloef et al. 1999).

RESULTS

Detailed open-ocean movements of the turtle were recorded for 368 days. During this period, Argos reported a total of 405 transmissions providing assessed locations. Of these positions 32% provided location data of LC ≥ 0, 21% LC ≥ 1 and 8% LC ≥ 2. Using only the most accurate data (LC ≥ 2), we calculated the total distance traveled to be 11,512 km and the overall average swim speed for the entire track to be 1.30 km/h. Even if we assume the maximum error for each position (350 m), less than 25 km of distance (0.2%) is added to the track. Including LC=1 data increases average speed by less than 4%. Thus, use of only the high quality (LC ≥ 2) positions may slightly underestimate average distances and swimming speeds (Table 2). Inclusion of lower accuracy data (LC=0 or 1) increases the estimated distances traveled, in this case by 8% and 3%, respectively. Average swimming speed for segments of the track between high quality positions more than 24 hours apart range from 0.90 km/h (21.6 km/d) to maximum levels of 1.84 km/h (44.2 km/d) for the segment near 129°W latitude and 1.79 km/h (43.0 km/d) near 172°E latitude. It should be emphasized that these speeds do not represent maximum burst speeds, rather an average speed between positions where LC ≥ 2. The net distance traveled, using only the endpoints of the great circle, is 9,276 km. The overall distance traveled and mean swimming speed, for the entire track, calculated using only LC ≥ 2 positions, was 11,512 km and 1.30 km/h (31.2 km/d), respectively, and increased as additional location classes were included (Table 2). The turtle's average heading for the entire track was 309.8° and the headings for each segment ranged between 180° and 330° (Figure 2). The straightness index was 0.81 for LC ≥ 2, 0.78 for LC ≥ 1 and 0.74 for LC ≥ 0.

The final recorded location for the turtle was on 13 August 1997 near Isohama, Japan, a small fishing port in northeastern Honshu (37˚ 54.12’ N, 140˚ 55.98’ E). The scarcity of locations for the 2 weeks prior to this date, the sequence of four high quality positions during the final 18 hours of transmission (LC ≥ 2), and the direct movement towards Isohama during the final day of transmission suggest that the turtle may have been caught by fishermen in waters northeast of Japan (39˚ 49.26’ N, 142˚ 36.48’ E). The final 256-km segment of the track should be considered cautiously. When this final segment of the track is excluded, the total distance traveled is 11,251.3 km and the overall average swim speed is 1.34 km/h (32 km/d).

DISCUSSION

Pacific loggerhead hatchlings entering the waters off of their nesting beaches in Japan may embark on a large-scale developmental migration that encompasses the entire North Pacific Ocean. Carried northward by the Kuroshio Current and its extension (N. Kamezaki, pers. comm.), many enter the pelagic environment where the turtles may remain until they return to their natal beach at maturity. A large number of loggerhead turtles arrive along the coast of the Baja California peninsula (Ramirez Cruz et al. 1991), apparently transported by the cold, wide California Current from the north. Pelagic sightings of these animals and the rarity of their occurrence near shore suggest that some turtles may skip the subadult benthic stage described by Musick and Limpus (1997).

Massive amounts of debris from the north and northwestern Pacific coast, including redwood trees, ships, Japanese fishing buoys, and World War II artifacts, have accumulated over the years along Baja California's Pacific coast, particularly in the vicinity of Malarrimo Beach, Bahía Sebastian Vizcaíno (27˚55'N 114˚25'W), an area known locally for juvenile and subadult loggerhead turtles. The same forces that deposited this flotsam are likely responsible for carrying juvenile loggerhead turtles to the region.

It is not clear how long loggerhead turtles remain in Baja California waters. However, our results suggest that upon reaching maturity and reproductive condition loggerhead turtles are capable of migrating from Baja California to natal beaches in Japan. While the details of which endogenous or exogenous factors trigger migration to nesting areas are not clear, the life cycle and high lipid content (Aurioles-Gamboa and Balart 1995) of their main food source, *Pleuroncodes planipes*, likely play an important role. Observations suggest that loggerheads do not return to the eastern Pacific waters after reproducing, remaining on western Pacific foraging grounds (Kamezaki et al. 1997). Few turtles larger than 85 cm (SCL) have been encountered in Baja California waters and, according to fishermen, mature males are rarely or never encountered (Nichols et al., *in press*) (Chapter 1).

These data provide the first details of a return migration across the Pacific Ocean. However, because this turtle had been held in captivity at the foraging area for 10 years, conclusions regarding the timing of such a migration must be cautiously extended.

<u>Swimming speeds of migrating turtles</u>. Calculated swimming speeds of migrating sea turtles are prone to error due to assumptions of straight-line movement between mark and recapture positions, satellite location error, and assistance or hindrance due to currents. The data from this track provide a unique opportunity to calculate average swimming speeds over extended periods with high accuracy due to: (1) highly reliable data, (2) clear and consistent straight-line movement of the animal being tracked, and (3) known currents for large sections of this ocean area.

Loggerhead turtles are certainly capable of obtaining bursts in swimming speeds far greater than 1.84 km/h, the maximum recorded here (Meylan 1982a, Stoneburner 1982). However, this study demonstrates that they are able to maintain average speeds in excess of 1.0 km/h over longer periods of time such as several weeks to months. The resolution of positions reported in this study is not sufficient to detect short bursts in swim speed. Ten years in captivity would be expected to result in an animal's inferior physical condition, yet swimming speeds are similar to those reported for wild loggerhead turtles (Byles and Dodd 1989, Papi et al. 1997).

When the turtle's track is compared to mean surface current data (Lagerloef et al. 1999) for the North Pacific during the tracking period (August 1996 to August 1997) it is apparent that at times the turtle swam against weak prevailing currents, which flow in a ESE direction in some areas (Figure 1). However, current speeds along the migration path were typically less than 5 cm/s (0.18 km/h) and seasonal means may differ from annual means. The wide California Current would carry a turtle with a due westward orientation, swimming at approximately 1.0 km/h (30 cm/s) slightly southward as it pursued its transpacific goal. At the western end of the track the strong Kuroshio Current apparently carried the turtle excessively northward. It is clear from a comparison of this track with oceanographic data that this turtle was not simply transported passively across the ocean on surface currents as its swimming speed greatly exceeds that of the 1996-1997 average surface currents.

<u>Migration path</u>. The turtle appears to have maintained a relatively constant swimming speed and heading for the entire track. All of the locations occurred in pelagic waters of depths greater than 3,000 m, except for those near the Baja California and Japanese

coasts. The great circle connecting the endpoints of the track (i.e., the shortest distance path) would be further to the north than the track of this turtle. This shortest distance passes through the eastward-flowing North Pacific Current (NPC) and thus taking that path would require swimming against prevailing currents. Further to the south, the turtle's path passes through a convergence area of the Northern Equatorial Current (NEC) and the NPC likely to be relatively rich in plankton (Polovina and Moffit 1995). The turtle appears to have traveled along a constant westward trajectory, only being deflected to the south and north by currents near continental coastlines, in particular the strong California and Kuroshio Currents.

Wetherall et al. (1993) report that turtles ranging from 10 to 90 cm (CCL), most of which were of immature size, were taken in the north Pacific high-seas driftnet fisheries in an area between longitudes 154°W and 150°E and latitudes 28°N and 39°N. Our surveys of strandings and incidentally captured turtles suggest that the majority of loggerhead turtles along the Baja California coast are of immature size classes (45-70 cm) (Chapter 3). These findings combined with the current data suggest a general model: the northern Pacific gyre provides eastbound dispersal for immature Japanese loggerhead turtles as they reach Baja California feeding areas and may aid in westbound homing of loggerhead turtles returning to their natal beaches. It is likely that pelagic convergence zones also serve as forage habitat and that the distribution of loggerheads is continuous across the Pacific (Polovina et al. 2000).

Navigational cues. These data provide further insights into the abilities of sea turtles to make long oceanic migrations and possibly into their navigational ability in the open sea during long range movement between feeding and nesting areas. The tracked turtle swam in a consistently westward direction and the simplest explanation is that it moved with surface currents. However, segments of the track are occasionally at 90-180˚ to mean annual surface current vectors, particularly during the initial segment near the coast of Baja California. It is therefore possible that this turtle followed some sort of directional homing instinct and fixed on a single compass heading (west) during its movement towards Japan, its known natal area (Bowen et al., 1995). The guidance cues used during the migration, however, are not known. Celestial navigation (use of moon and stars) seems unlikely due to turtles' poor eyesight above the surface of the water (Ehrenfeld and Koch 1967). Comparisons of the track to lunar phase and meteorological data indicate that the turtle was able to maintain its westward trajectory under diverse conditions that included cloudy or moonless nights, dusk, dawn, etc. Furthermore, anyone who has spent time on the high sea will recognize the difficulties associated with using visual cues through a pair of eyes positioned just above the sea surface. If celestial cues are used in sea turtle navigation it seems that a variety of factors must be used in synchrony and that an ability to maintain a heading in the absence of such cues remains a requirement.

The use of chemosensory cues seems unlikely as the turtle did not appear to display wandering movements typical of gradient assessment (Dusenbery 1992) and the distance from the release site to the source or destination is great. Furthermore, currents near the Japanese nesting beach run to the northeast, away from this turtle's migratory path. While chemical cues may play a role in turtle homing this seems most likely at close range of nesting beaches (Grassman and Owens 1987) and probably not very useful in long-distance navigation.

Experience-based behavior seems equally unlikely as the turtle had been in captivity for 10 years and the route taken from Japan to North America as a juvenile likely differs from the return route. Transpacific migration of loggerhead turtles may be an example of *vector navigation*, a term used to describe the innate movement of a young animal from natal to developmental areas (Able 1996). If this is the case these turtles may be making their first, and possibly only, circum-oceanic journey.

This track is consistent with the hypothesis that adult turtles utilize a magnetic map sense and have a capacity for true navigation that allows them to maintain headings towards homing locations despite current drift or displacement (Papi and Luschi 1996). The nature of this "map sense" has not been determined. Hatchling loggerhead turtles have the ability to detect magnetic inclination angle (Lohmann and Lohmann 1994) and field intensity (Lohmann and Lohmann 1996), two geomagnetic features that vary across the earth's surface and might be used to approximate geographic position (Lohmann et al. 1999). Such a system seems to be the most reasonable explanation of transpacific navigation abilities of loggerhead turtles, although a variety of additional cues and interacting mechanisms may also be used at various stages of the movement.

Conservation implications. The area traveled by this turtle overlaps with several commercial fisheries that use gill nets, drift nets and longlines, known sources of loggerhead mortality (Yatsu 1990, Wetherall et al. 1993, National Marine Fisheries Service and U.S. Fish and Wildlife Service 1998, Nichols et al. *in press*). Especially along the coast of Baja California, fisheries-related mortality data are few, illegal poaching difficult to quantify and post-capture survival rates are largely unknown. Research should be expanded in order to estimate the impact of these activities on loggerhead populations. The results can substantiate mitigation needs such as modification of fishing practices and if this turtle's path represents a heavily used corridor, the area could be better protected through the establishment of international open-ocean reserves (Morreale et al. 1996).

The relationship between feeding and developmental areas along the Baja California coast and the loggerhead populations nesting in southern Japan has been firmly established. Therefore, efforts to reduce incidental catch of loggerheads in Mexican coastal fisheries, particularly those in the large subadult size classes, will produce measurable conservation and population recovery rewards on Japanese nesting beaches (Heppell 1998). Similarly, conservation efforts in Japan should result in increasing numbers of juvenile loggerheads on Baja California feeding grounds.

The data obtained from the single yearlong transpacific movement of an individual turtle contribute to our sparse knowledge of the pelagic migratory phase of sea turtle life history and specifically to the Baja California population of loggerhead turtles.

These results demonstrate the ecological link between two seemingly disparate loggerhead populations in Japan and Baja California, and emphasize the need for continuing research and multilateral marine conservation efforts. Future telemetry studies of juvenile, wild-caught turtles on the Baja California feeding grounds are recommended.

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Table 1. Distances and swimming speeds for the transpacific movement of a loggerhead turtle (Longitude: "-" = W; "+" = E).

Date	Time[1]	Relative Day	LC[2]	Latitude	Longitude	Distance between locations[3] (km)	Cumulative Total distance (km)	Ave. Swim Speed for segment (km/hr)
11.08.96	01:15:00	0.00	3	28.668	-114.237			
28.08.96	14:39:16	17.56	3	26.726	-118.412	463.95	463.95	1.10
29.08.96	3:33:18	18.10	3	26.767	-118.484	8.47	472.43	0.66
25.09.96	3:45:22	45.10	2	25.028	-124.641	644.99	1117.42	1.00
06.10.96	17:06:29	56.66	2	24.995	-128.834	422.23	1539.65	1.52
07.10.96	15:05:57	57.58	2	25.143	-129.202	40.53	1580.18	1.84
07.10.96	16:45:17	57.65	3	25.131	-129.206	1.39	1581.57	0.84
12.10.96	16:38:32	62.64	3	25.146	-131.106	191.14	1772.71	1.59
13.10.96	14:36:15	63.56	2	25.138	-131.353	24.86	1797.57	1.13
24.10.96	15:31:29	74.59	2	25.684	-135.241	394.91	2192.48	1.49
25.10.96	16:53:06	75.65	2	25.643	-135.579	34.16	2226.63	1.35
07.11.96	17:06:55	88.66	2	25.528	-140.267	470.00	2696.63	1.51
12.12.96	17:46:29	123.69	2	25.151	-153.173	1296.30	3992.94	1.54
02.01.97	4:16:53	144.13	2	24.840	-158.447	532.25	4525.18	1.09
31.01.97	5:26:23	173.17	2	24.095	-170.467	1218.13	5743.32	1.75
27.02.97	15:00:04	200.57	2	21.951	-179.880	991.46	6734.77	1.51
13.03.97	17:55:07	214.69	3	23.456	174.868	563.71	7298.48	1.66
21.03.97	19:59:23	222.78	3	23.457	172.692	221.81	7520.29	1.14
25.03.97	7:46:31	226.27	2	24.134	171.417	149.88	7670.17	1.79
07.04.97	3:43:39	239.10	2	25.841	166.609	520.03	8190.20	1.69
07.04.97	6:24:11	239.21	2	25.829	166.608	1.34	8191.54	0.50
07.04.97	8:01:40	239.28	3	25.830	166.605	0.32	8191.86	0.20
09.04.97	15:54:08	241.61	3	26.081	166.026	64.22	8256.08	1.15
15.05.97	19:53:33	277.78	2	31.838	154.058	1326.59	9582.68	1.53
24.05.97	19:57:08	286.78	2	33.229	152.672	201.86	9784.54	0.93
10.06.97	20:23:36	303.80	2	33.080	148.745	365.68	10150.22	0.90
06.07.97	16:35:01	329.64	2	39.717	146.511	764.01	10914.24	1.23
19.07.97	3:28:43	342.09	2	39.633	144.631	161.06	11075.29	0.54

Table 1, continued.

Date	Time[1]	Relative Day	LC[2]	Latitude	Longitude	Distance between locations[3] (km)	Cumulative Total distance (km)	Ave. Swim Speed for segment (km/hr)
19.07.97	5:11:38	342.16	2	39.634	144.642	0.95	11076.24	0.55
26.07.97	7:58:23	349.28	2	39.821	142.608	175.06	11251.30	1.03
13.08.97	8:02:24	367.28	2	37.929	140.923	255.82	11507.12	0.59
13.08.97	16:19:49	367.63	3	37.902	140.933	3.13	11510.25	0.38
13.08.97	17:58:32	367.70	3	37.904	140.925	0.74	11510.98	0.45
13.08.97	20:19:46	367.79	3	37.902	140.933	0.74	11511.72	0.31

[1]Time is Greenwich Mean Time
[2]Location Class (LC) 2 is estimated at +/- 350m, LC 3 is estimated at +/- 150m
[3]Distances were calculated using the Great Circle Equation (spherical earth model)
The final four reported locations should be interpreted cautiously, as the turtle may have been caught or the transmitter removed. *See text for details.*

Table 2. Comparison of total distance traveled and swimming speeds by a loggerhead turtle during its transpacific migration over a period of 368 days.[1]

Locations[1]	# of positions	Net dist. (km)	Ave. speed[3]	Max. speed
LC≥0	131	12,483 km	1.41 km/h	3.94 km/h
LC≥1	84	11,883 km	1.35 km/h	2.39 km/h
LC≥2	34	11,512 km	1.30 km/h	1.84 km/h
Great circle[2]	2	9,276 km	1.05 km/h	--

[1]A total of 405 locations were reported, 274 were unreliable (LC = A or B) and not used in this analysis.
[2]Great circle distance calculated for the arc between Santa Rosaliita, Baja California, Mexico and Sendai, Japan.
[3]Average speed was calculated by dividing the total distance by the total time.

Figure 1.   August 10, 1996, release of loggerhead turtle with carapace-mounted satellite transmitter, Santa Rosaliita, Baja California.

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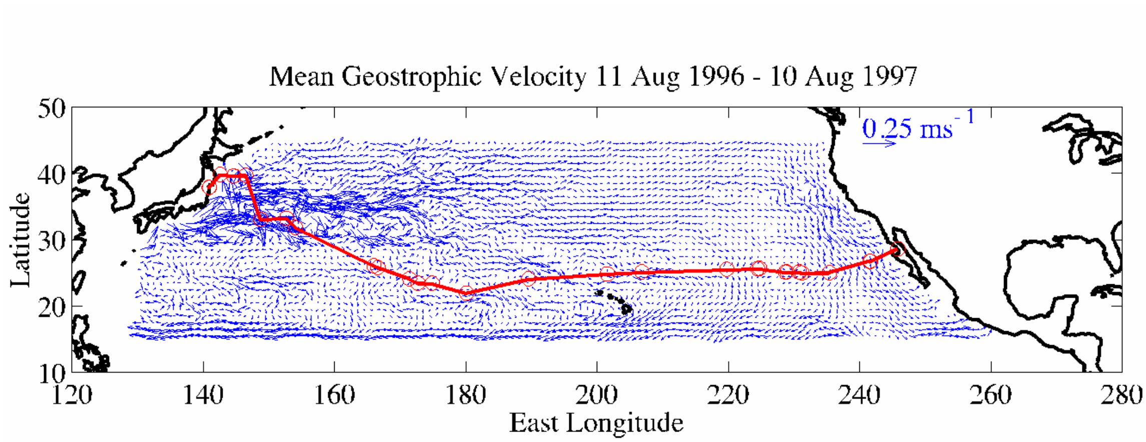

Figure 2. Track of transpacific movement of loggerhead turtle (07667) from Mexico to Japan, during 1996-1997, monitored using satellite telemetry. All positions shown are LC≥2. Mean current velocities for 11 August 1996 through10 August 1997 were derived from TOPEX/Poseidon Satellite Altimeter and NOAA/NESDIS World Ocean Atlas 1998 data (Lagerloef et. al 1999).

CHAPTER 5

HOMING MIGRATIONS OF EAST PACIFIC GREEN TURTLES, *CHELONIA MYDAS*, INVESTIGATED BY SATELLITE TELEMETRY

ABSTRACT

The movements of nine green turtles (*Chelonia mydas*) from eastern Pacific waters were investigated using satellite telemetry during 1996-1999**.** Minimum distances traveled between foraging areas in Baja California, Mexico, and rookeries in Michoacan, Mexico, were calculated using high quality locations (LC $\geq$ 1) from the tracks of three homing turtles. Total distance traveled by migrating turtles ranged from 1,211 to 2,027 km over 56 to 111 days. The mean swimming speeds for track segments during homing movements ranged from 2.0 to 95.2 km/d with an overall mean of 44.8 $\pm$ 1.5 km/d. Swimming speeds during station keeping on feeding grounds (n = 9) were significantly lower than those of homing turtles (mean = 15.8 $\pm$ 1.7) as were station-keeping movements (n = 3) of turtles at nesting beaches (mean = 33.9 $\pm$ 3.0). Homing migrations followed the mainland Mexico coastline, remaining primarily on the continental shelf except to cross open bodies of water. These results suggest that green turtles must depart Baja California feeding grounds in late summer on a migration that can take up to three months in order to arrive on Michoacan nesting beaches during the fall/winter breeding season. Data from this satellite telemetry study support the conclusions of tagging programs and molecular genetic analyses that adult green turtles on feeding grounds in

Baja California originate on rookeries in Michoacan, Mexico. These tracks represent the first complete feeding area to nesting beach migrations for *Chelonia* in the eastern Pacific recorded using satellite telemetry. These data also provide insight into navigational mechanisms used by marine turtles, support for natal homing models, and basic life history information necessary for conservation of this endangered species.

INTRODUCTION

Research into sea turtle migration has been motivated by a general interest in the underlying navigational mechanisms of marine animals (Luschi et al. 1998) as well a need to identify adult feeding grounds and migratory routes for management and conservation purposes (Eckert and Sarti 1997, NMFS and USFWS 1998, Bjorndal 1999). Information on sea turtle migration will ideally inform studies of natal homing, energetics, optimal foraging strategies, growth rates, breeding periodicity, and ultimately increase the accuracy of population models. Satellite telemetry (Figure 1) has been used extensively to describe the migratory patterns of green sea turtles (*Chelonia mydas*) and has resulted in tremendous breakthroughs in our understanding of their long distance movements (Balazs 1994, Papi et al. 1995, Luschi et al. 1996)—knowledge previously based primarily on flipper tag recoveries (Carr et al. 1978, Balazs 1980, Meylan 1982, Green 1984). Adult green turtles are known to shuttle between feeding and nesting areas, which are often separated by thousands of kilometers of open ocean (Balazs 1994). Green turtles are particularly known for their ability to pinpoint isolated locations (Luschi et al. 1996, Papi et al. 1996). In many of these studies, satellite telemetry has been used to collect information on post-reproductive movements of green turtles from nesting beaches to feeding grounds. Nesting turtles, as they come ashore to lay eggs, are a common and convenient starting point of many investigations of sea turtle migration. For example, green turtles nesting on remote Ascension Island have been tracked to Brazilian feeding grounds more than 2,000 km away (Luschi et al. 1998). Papi et al. (1995)

described the long distance movement of nesting green turtles to their feeding grounds in the South China Sea. However, few studies have documented the return, or homing migrations, of green turtles from feeding grounds to nesting beaches. This is due to the difficulty in capturing turtles on feeding grounds immediately prior to departure (but see Renaud and Landry, 1996 for the satellite track of a homing Kemp's ridley and Nichols et al. (in press) for a description of a homing Japanese loggerhead). Tracking homing turtles may provide the best opportunity to study the turtles' ability to pinpoint a specific location as green turtles are known to exhibit natal homing (Meylan et al. 1990, Allard et al. 1994) and a high level of nest site fidelity (Miller 1997). The imperative of returning to a natal beach to reproduce may be a far more compelling goal than that of moving to a specific foraging area.

Several authors have speculated on the origins and migratory pathways of green turtles—also known locally as black turtles—foraging along the Baja California peninsula (Carr 1961, Caldwell 1962, Cliffton et al. 1982). However, the extensive migrations described for other *Chelonia* populations have not been adequately investigated or described in the eastern Pacific populations. Tagging studies conducted at rookeries in Michoacan, Mexico (Alvarado and Figueroa 1992), indicate post-nesting migrations to feeding grounds in Baja California to the north and Central America to the south (Figure 2). While flipper tagging has produced much of the basic information on the distribution and migrations of East Pacific green turtles, such studies are typically hindered by tag retention problems (Alvarado et al. 1993), infrequent tag returns

(Alvarado and Figueroa 1992), and the static nature of the data—typically movement endpoints. Recently, molecular markers have overcome some of the limitations of physical tags, providing evidence that the majority of green turtles foraging in Baja California waters are of Michoacan origin (Nichols et al. 2000, Chapter 6). Molecular studies have the additional benefit of providing a population-level perspective. However, details on the habits of individual turtles and migratory routes are lost. Furthermore, molecular markers can be effectively used to develop hypotheses about sea turtle migration (Bowen 1995) to be later supported or refuted by physical evidence.

I present the tracks of three homing green turtles on their migrations from feeding grounds in Baja California to their Michoacan nesting beaches, which were their hypothesized source rookeries based on molecular markers. The results are compared to movements of adult turtles on feeding grounds and near nesting beaches, as well as to results from previous studies. By combining results from tagging, molecular genetics and local telemetry studies, the most complete description of sea turtle movement emerges. This project is one aspect of a regional research program, which contributes to the recovery and conservation of this endangered species.

METHODS

Baja California, Mexico, is a 1,500 km-long peninsula that extends from the southern border of California, USA, southeastward between latitudes 33°N and 23°N, resulting in the formation of the Gulf of California (Figure 3). Due to the coast’s large quantities of benthic macroalgae and seagrass beds, Baja California waters provide exceptional developmental and foraging habitat for large numbers of green turtles. Regional eastern Pacific rookeries for green turtles are concentrated primarily in southern Mexico, 1,000 km southeast of Baja California, in the states of Michoacan and Oaxaca, with nearly 85% of nests occurring on the beaches of Colola and Maruata, Michoacan (J. Alvarado, pers. comm.).

During the 1996-1998 summer field seasons green turtles were captured on their feeding grounds in Bahía de los Angeles, Baja California, and the Bahía de Loreto National Marine Park, Baja California Sur, (Figure 3) using turtle entanglement nets. Nets were of 25 cm mesh (50 cm stretched), 8 m in depth and 100 m in length. Study sites near Bahía de los Angeles and Bahía de Loreto were chosen as they are known areas of green turtle foraging and former sites of large-scale sea turtle fisheries (Chapter 2). All captured turtles were measured, sampled for genetic analysis (Dutton 1996), tagged on both rear flippers with self-piercing inconel tags (Limpus 1992) and released immediately at the site of capture. DNA obtained from tissue samples was analyzed at the National Marine Fisheries Service-Southwest Fisheries Science Center, La Jolla, CA, to determine the natal origins of each turtle (Nichols et al. 2000, Chapter 6).

A sub-sample of captured turtles was chosen for satellite tracking based on an external assessment of health, adult size, and suitability of their carapace for transmitter attachment. Two of the turtles (H and I) used in this study had been previously captured and were being held in captivity at the Centro Regional de Investigaciónes Pesqueras-Estación de Conservacion e Investigación de Tortugas Marinas (Bahía de los Angeles, Baja California) (CRIP-ECITM).

Turtles were fitted with either Telonics (Mesa, Arizona, USA) model ST-6 or Wildlife Computers (Seattle, Washington, USA) model SDR-SSC3 satellite transmitters using a standard attachment technique (Balazs et al. 1995) with modifications as described by Nichols et al. (2000). A faring was created with epoxy along the leading and trailing edges of transmitters in order to reduce drag (Watson 1998). Total transmitter package weights, including attachment materials, were approximately 500g and 750g respectively.

Transmitter locations for the monitoring period were determined using the Argos satellite system (French 1994), which classified locations into six classes of decreasing accuracy. Location classes with accuracy estimates of less than 1,000 m (LC $\geq$ 1) were used in the calculation of threshold swimming speeds (4.0 km/h). Additional location classes (0, A, and B) were edited, utilizing only those did not result in swimming speeds exceeding the threshold level. Location classes with higher message numbers (Nb mes) took priority in editing such that, 0 > A > B. The resulting data sets were used to determine the distances traveled between locations, calculate swimming speeds, and to enhance graphical representation of the tracks. For each turtle, total distance traveled was calculated by adding the great circle distances between consecutive valid fixes. The straightness index, which varies between 0 and 1, was calculated as the ratio of the beeline distance between the release location and the final fix, and the total distance traveled (Batschelet 1981).

Turtle movements were separated into three phases: 1) station keeping on feeding grounds, 2) homing migration, and 3) station keeping at nesting beaches. Turtles were determined to be in the homing migration phase from the outset of directed movement away from feeding areas, which resulted in arrival in the vicinity of a known nesting beach. The termination of the homing migration phase and the initiation of station keeping at the nesting beach was signaled by a change in direction of greater than 90º in the vicinity of a known rookery. A t-test (Batschelet 1981) was used to compare swimming speeds recorded for each phase.

RESULTS

A total of nine green turtles were tracked from their feeding areas in Baja California, Mexico (Table 1). Three turtles (F, H, and I) departed the feeding grounds and migrated to the vicinity of known rookeries in Michoacan, Mexico (Figures 7-10). Six turtles remained on feeding grounds in Baja California. However, one of these turtles (C) moved extensively northward within the Gulf of California. All but one of the turtles were determined through molecular analysis to have haplotypes known from the Michoacan rookeries. The turtle with the unknown ("G") haplotype was hypothesized to be from the Islas Revillagigedos rookery (Nichols et al. 2000, Chapter 6).

Using only high quality locations ($n = 58$, LC ≥ 2) from the three homing turtles, the threshold swimming speed was determined to be 4.0 km/h. This threshold speed was used to edit lower quality locations, excluding those that resulted in swimming speeds exceeding the threshold level. Editing resulted in a five-fold increase in usable locations.

Tracking duration for all nine turtles ranged from 14 to 111 days (mean = 46 $\pm$ 11 d) during which time the turtles traveled total distances of between 99 and 3,811 km (mean = 976 $\pm$ 414 km) (Table 2). Homing turtles departed coastal feeding grounds and migrated in a southeasterly direction to the vicinity of nesting beaches in Michoacan, Mexico (turtles F, H and I). Mean swimming speeds for the entire tracks (total distance/duration) of homing turtles ranged from 26.0 km/d to 34.0 km/d (mean = 31.0 $\pm$ 2.5 km/d) (Table 1). However, the mean swimming speed for the homing segment of the tracks was 44.8 km/d. The six turtles remaining in the Gulf of California had average swimming speeds ranging from 3.6 to 21.2 km/d (mean 10.3 $\pm$ 2.5 km/d) (Table 2). Means of track segments during homing movements were significantly greater than those for both station-keeping at feeding and nesting grounds ($p < 0.05$).

Turtle A (03795) female, haplotype E. This turtle remained in the Bahía de los Angeles area for the entire tracking duration and had the lowest average swimming speed (2.40 km/d). The straight-line distance between endpoints of the station-keeping movement on feeding grounds was 12 km with an average heading of 157.1º (SSE). The track had a straightness index of 0.06. Locations of turtle A are included in Figure 6.

Turtle B (PTT05522) male, haplotype E. Turtle B remained in the Bahía de los Angeles region for more than three weeks. The final location indicates that the turtle may have moved to the vicinity of the west coast of Isla Angel de la Guarda, approximately 30 km to the east of Bahía de los Angeles. The straight-line distance between endpoints of the station-keeping movement on feeding grounds was 32 km with an average heading of 51.9º (NE). The straightness index of the track was 0.33. Locations of turtle B are included in Figure 6.

Turtle C (PTT03847) female, haplotype F. From the release site in Bahía de los Angeles, turtle C moved north along the west shore of Isla Angel de la Guarda to the northern Gulf of California where the signal was lost (Figure 4). Turtle C had the highest mean swimming speed for a non-homing turtle (21.2 km/d). The straight-line distance between endpoints of the turtle's movement on feeding grounds was 214 km with an average heading of 346.2º (NNW). The straightness index of the track was 0.67, the highest for a non-homing turtle. The turtle may have been *en route* to northern Gulf of California feeding areas when captured in Bahía de los Angeles.

Turtle D (PTT03848) female, haplotype G. Turtle D remained in the vicinity of Bahía de los Angeles for the duration of the two week tracking session. This turtle was recaptured the following year on 23 April 1998 at the location where it was released. It had grown 1.9 cm and 13.5 kg in approximately 10 months. The straight-line distance between endpoints of the turtle's movement on feeding grounds was 13 km with an average heading of 267.2º (W). The track's straightness index was 0.15. Locations of turtle D are included in Figure 6.

Turtle E (05520) female, haplotype E. This turtle was initially captured at Playa Notri, within Bahía de Loreto, slightly north of the Juncalito release location. Turtle E moved south past Puerto Escondido (7 km) within the first 24 hours. The turtle continued south as far as Ligüí, Baja California Sur, during the 20 days of tracking. Anecdotal information provided by a local fisherman suggests that this turtle was incidentally captured. Turtle E remained within the Marine Park, in water of less than 100 fathoms, for the duration of the tracking period. The straight-line distance between endpoints of the turtle's movement on feeding grounds was 12 km with an average heading of 141.8º (SE). The track had a straightness index of 0.20. Locations of turtle E while on Bahía de Loreto feeding grounds are included in Figure 5.

Turtle F (05523) female, haplotype E. This turtle remained in Bahía de Loreto for approximately 24 days prior to beginning its homing migration to Michoacan. Location data indicate that the turtle remained in the vicinity of Playa Notri, south of Loreto, until it moved beyond the south end of Isla del Carmen. During its migration, the turtle moved directly across the mouth of the Gulf of California to the mainland shelf (< 100 fathoms) and continued southward (Figure 7). The turtle seems to have deviated from its coastal movements in the vicinity of Mazatlán, then regained its coastal route to the south. The turtle continued along the coast of Sinaloa, past San Blas. There are no quality location data from just north of Bahía Banderas, Nayarit, to the vicinity of nesting beaches in Michoacan, a period of five days. We assume that the turtle crossed the mouth of the bay and continued south along the mainland coast. Data suggest that the turtle spent approximately a week along the northern Michoacan coast prior to moving approximately 5 km SE of Colola, Michoacan, near a beach known a Careysillos, a known area of green turtle copulation (Alvarado et al. 1992). Here the signal was lost, possibly due to antenna damage or transmitter loss during copulation. The turtle, identified by its flipper tags, was reported nesting in Colola, Michoacan on 21 October 1997 (Jesus Diaz Flores, pers. comm.). The straight-line distance between endpoints of the homing movement was 1,180 km with an average heading of 134.0º (SE). The straightness index of the entire track was 0.82. During the turtle's movement on the feeding grounds its straightness index was 0.04. Locations of turtle F while on feeding grounds in Bahía de Loreto are included in Figure 5.

Turtle G (03849) female, haplotype E. Turtle G utilized more than 35 km of coastline within the Bahía de Loreto National Marine Park during the month-long tracking period, ranging from just east of Isla Coronado in the north to south of Isla Danzante. This turtle was captured near Playa Notri and released just to the south, near Isla Mestiza. Following release, the turtle moved south into waters east of Isla Danzante, then north to waters east of Isla Coronado before signals were lost east of Isla Danzante. The straight-line distance between endpoints of the turtle's movement on feeding grounds was 9 km with an average heading of 157.3º (SSE). The straightness index was 0.05. Locations of turtle G while on feeding grounds in Bahía de Loreto are included in Figure 5.

Turtle H (PTT 01084) a female, with haplotype E, migrated to Michoacan. This turtle had been captive since June 1986 at the CRIP-ECITM. Released in Bahía de los Angeles, Baja California, in January 1997, turtle H arrived near known green turtle rookeries in April 1997, and moved along the Michoacan coast in the vicinity of the reproductive area (Figure 8). Due to the high number of quality locations, the track of turtle H provides the most detailed track of homing migration, reflecting the data that may be lost when too few locations are obtained. Furthermore, additional locations will generally increase the total distance thereby raising the overall average swimming speed. The straight-line distance between endpoints of the homing migration was 1,631 km with an average heading of 135.6º (SE). The track's overall straightness index was 0.54.

Turtle I (PTT 03850) was a female, with haplotype N. This turtle was released in Bahía de los Angeles, in November 1998, and migrated to Michoacan (Figure 10) after having been captive, at the CRIP-ECITM in Bahía de los Angeles, since July 1996. In January 1999, the turtle arrived near the green turtle reproductive area. The track of turtle I followed a coastal route, except when crossing the Gulf of California. The straight-line distance between endpoints of the homing migration was 1,595 km with an average heading of 136.9º (SE). The straightness index of the track was 0.86.

There was no significant difference between the average swimming speeds for track segments of the three homing turtles ($p > 0.3$).

DISCUSSION

Recent studies have extensively documented green turtle migrations between nesting beaches and feeding grounds using flipper tagging, molecular genetics and satellite telemetry. However, complete description of turtle migration has lacked information on the homing leg of this two-way shuttling movement.

Our findings represent the first complete tracks of homing green turtles and confirm the relationship between Baja California feeding grounds and Michoacan rookeries, some 1,500 km distant, previously indicated by tagging programs. Furthermore, these results support the natal homing hypothesis, given the *a priori* prediction based on molecular markers, that these turtles would return to Michoacan rookeries (Nichols et al. 2000, Chapter 6).

Swimming speeds during the homing phase are, on average, nearly three times and two times greater than those recorded during station keeping at foraging grounds and at nesting beaches, respectively. Such information can aid studies of energy budgets, growth rates, and ultimately lead to more accurate population models.

Homing migrations.

Homing green turtles followed direct, coastal, shallow-water routes from feeding areas in the Gulf of California to rookeries in Michoacan, Mexico—in predominantly a southeasterly direction. Tracked turtles remained primarily on the continental shelf, in waters shallower than 100m, except when crossing the Gulf of California or spanning large bays and inlets. Turtle F began its homing migration in Bahía de Loreto, thus crossing a wider portion of the lower Gulf of California. The primary green turtle reproductive area, where more than 80% of the green turtles in the region are thought to reproduce, is located in Michoacan, Mexico, between Faro de Bucerias (18º 19’N 103º 29’W) and the delta of Rio Nexpa (18º 08’N 102º 58’W). The three turtles that departed the Gulf of California moved to this area of the Michoacan coast.

Given our prior knowledge—based on mtDNA markers—of the turtles’ putative origins (Michoacan, Mexico), these three tracks provide direct evidence for natal homing. The overall mean swimming speed for the three homing turtles was 45 km/d. Given this figure, we can estimate the time needed for turtles to swim from major feeding areas in the northwest Pacific to rookeries in Michoacan (Table 3). Green turtles must depart Baja California feeding grounds during late August through September in order to arrive at Michoacan rookeries for the start of the nesting season, which peaks in late October and early November (Figueroa et al. 1992).

The immediate migrations of the two sea turtles that had been held in captivity (H and I) in November and January, respectively, suggests that the onset of the homing migration may be strongly related to physiology, and the physical state of the turtles, in addition to environmental cues. A similar post-captivity homing migration was recorded after the release of a captive-raised loggerhead turtle (Nichols et al., in press).

Turtle F, a wild caught turtle, remained on Loreto area feeding grounds for more than three weeks prior to its early September departure for its Michoacan nesting beach. This turtle’s track represents our best estimate of wild green turtle homing from Baja California feeding grounds.

Once turtles crossed the Gulf of California, the tracks of Bahía de los Angeles turtles coincided very closely. Navigation during coastal portions of the track may be explained by landmark-based orientation. Turtles may have established southeastern bearing and then used the coast as a guide. However, a portion of all of the tracks occurs over deep water and during these segments none of the turtles appeared to deviate from their straight course. Notably, none of the turtles followed the coast of the Baja California peninsula during their migration.

The strength and complexity of tidal currents in the Gulf of California (Griffiths 1965) would seem to preclude the use of a chemical gradient as a cue and necessitate a compass mechanism that could overcome disadvantageous deflections. The observation that all three turtles followed similar paths during varying times of the year would appear counter to the hypothesis that turtles cued on physical gradients such as temperature. Northern Gulf of California waters reach peak temperatures in late summer and early fall. During winter months the longitudinal gradient would reverse. Turtle H was released in late January and followed the same migratory path as the other turtles, at a slightly slower pace. Navigation in green turtles is likely based on several cues.

Station-keeping movements.

Turtles released in Bahía de Loreto moved generally to the north and south in shallow coastal waters near the peninsula. All recorded movements on feeding areas in this region were within the limits of the Marine Park (Figure 5). These results suggest that adult turtles may exhibit low site fidelity to specific microhabitats in this region, at least during the summer months. For example, during the 20-day tracking period, turtle E moved from the capture location at Playa Notri, south along more than 20 km of coastline.

Similarly, the three turtles (A, B and D) tracked on Bahía de los Angeles feeding grounds remained within the shallow waters of the bay. Turtle C, however, left the vicinity moving generally northward (Figure 4). This turtle may have been equipped with a transmitter in Bahía de los Angeles while *en route* to its foraging area in the northern Gulf of California. This seems likely as fishermen throughout the northern Gulf of California to the Colorado River delta region often report green turtles, and green turtles were once abundant in the San Felípe, Baja California, area.

These data suggest that the use of satellite telemetry technology for studies of green turtle movement and habitat use on feeding and developmental areas should be carefully considered as a research tool—particularly for adult turtles—depending on the scale of resolution necessary. The time and effort required to track these turtles along more than 30 km of coastline, or as they range far from the release location (turtle C), may preclude the use of radio and sonic telemetry for studies other than those of short duration, small sample sizes, in relatively enclosed areas. Using data obtained through satellite telemetry, we are able to estimate residence times on feeding areas, describe coarse movements within large bays and marine protected areas and estimate mean vagility. The movement of turtles on feeding grounds suggests that not all adult green turtles captured are residents. Of the six turtles tracked in the Bahía de los Angeles region, four moved outside the geographic boundaries of the bay during the tracking periods. Estimates of home range sizes and finer scale habitat-use analyses may be increasingly possible as these technologies develop and location frequency and accuracy increase (French 1994). The major limitations of telemetry studies on Baja California feeding grounds, at the moment, seem to be retention of transmitters and the duration of the tracking period—problems that may be overcome by methodological changes such as altering antenna design and attachment techniques.

Swimming speeds.

Published swimming speeds, calculated from tagging studies and satellite telemetry efforts utilizing few locations, should be examined carefully. Generally, swimming speeds will be underestimated by both methods. Swimming speeds calculated from 43 green turtle tag recoveries, reported by Alvarado and Figueroa (1992) and Figueroa et al. (1992), range from 0.5 km/d to 42.7 km/d, with a mean of 3.6 km/d. Mean swimming speeds may change drastically as shorter time-to-capture intervals are considered and long-interval tag recoveries may vastly underestimate swimming speeds (Table 4). Resulting minimum travel rates, especially when long-interval tag recoveries are considered, may have no biological relevance. Rather, they may reflect a mixture of relatively high-speed migration swimming and long residence times at feeding or inter-nesting areas. Generally, swimming speeds based on tag recoveries alone are inadequate, except when release and capture closely bound a movement phase. Selecting those tag recovery data that represent long distance movements over the shortest time intervals often approximates this. When long distance tag returns with time intervals of less than three months are considered, mean swimming speeds approximate those obtained through satellite telemetry. The highest minimum travel rate recorded by the recovery of a Michoacan tag was for a post-nesting green turtle that traveled 1,470 km in 34 days, an average of 42.7 km/d, a swim speed similar to that recorded by this study.

Satellite telemetry data must also be interpreted carefully when it is used to calculate swimming speeds. The distance a migrating turtle travels between two points may be as great as two times the straight-line distance. For example, we estimated turtle H to have traveled more than 3,800 km (34.3 km/d) during the tracking period, using the complete, edited data set (Figure 8). When only the highest quality locations ($LC \geq 1$) are used (Figure 9) the calculated distance traveled decreases to 2,027 km and the average swimming speed for the entire track to 17.8 km/d. Our method of including additional locations based on the threshold swimming speed criteria allows for a more accurate depiction of sea turtle movements and swimming speeds.

Mean swimming speeds for track segments were three times lower on feeding grounds than during homing migrations. Mean swimming speeds were also two times slower during station keeping at the nesting beach than they were during homing movements. There was no significant difference between swimming speeds during station keeping on the two different foraging areas, Bahía de los Angeles and Bahía de Loreto.

The recorded swimming speeds for homing Baja California green turtles are similar to swimming speeds obtained during migrations of green turtles in other regions. In their preliminary report on post-nesting movements of green turtles from Michoacan, Byles et al. (1990) report an average swimming speed of 33.1 km/d. The turtles they tracked moved to the north, south, and out to sea after departing the nesting region.

Using satellite telemetry, researchers have recorded similar swimming speeds for post-nesting migrating green turtles in other regions. Balazs (1994) tracked post-nesting green turtles ($n = 3$) with carapace lengths of 85 – 91 cm from French Frigate Shoals to foraging areas in the Hawaiian archipelago. Reported swimming speeds during migrations were 38.4 to 48.0 km/d. Luschi et al. (1998) reported swimming speeds of 44.6 to 66.3 km/d for post-nesting Ascension Island green turtles (n = 6) migrating to Brazilian foraging grounds. However, these turtles were 107 to 120 cm (curved carapace length). Swimming speeds during directed movement may be correlated with turtle size. However, conclusions based on published swimming speeds may be confounded by factors such as water temperature, surface currents, total distance traveled (fatigue), and overall health of the study animals. For example, the mean swimming speed for the three homing turtles decreased with water temperature. Studies on various sizes of migrating green turtles that take such factors into account are needed.

With regard to swimming speeds on feeding grounds, our findings using satellite telemetry are similar to those determined for resident green turtles (n = 8) tracked in Bahía de los Angeles using radio and sonic telemetry. Seminoff et al. (in press) reports a mean vagility of 9.5 $\pm$ 1.3 km/d (range = 5.1 - 15.3 km/d), which is similar to the station-keeping behavior of satellite monitored green turtles on feeding grounds (when turtle C is excluded).

Conservation implications.

Despite an efficient protection program on nesting beaches spanning more than 20 years, and strict laws prohibiting the harvest of sea turtles in Mexico, East Pacific green turtle stocks continue to decline (J. Alvarado, pers. comm.) due primarily to directed and incidental take on feeding grounds (see Chapter 5). Inadequate knowledge of their activities away from the nesting rookeries is a major impediment to adequate green turtle recovery efforts. Knowledge of movement on feeding grounds, along migratory routes and in front of nesting beaches is fundamental to protection of the remaining adult green turtles in this population.

The green turtles tracked in the Bahía de Loreto region utilized nearly the entire coastline of the National Marine Park during foraging movements and 100% of their recorded movements fell within the protected area. Furthermore, turtle F was tracked from the National Marine Park to its nesting beach in Michoacan where it was confirmed nesting—the first documented foraging area to nesting beach migration for an East Pacific green turtle. The establishment of the Bahía de Loreto National Marine Park provides an opportunity to more fully protect critical green turtle life history stages and foraging habitat.

Three of the turtles tracked remained within the Bahía de los Angeles region. In addition, two turtles migrated from this feeding area to the vicinity of Colola, Michoacan. These data combined with previous mark-recapture and radio telemetry data suggest that the Bahía de los Angeles region should be considered a high priority as a sea turtle refuge. It, like Bahía de Loreto, is an important area for both developing immature and mature green turtles (Chapter 1).

Homing green turtles follow coastal migratory pathways, pass through areas of intense fishing activity, and depart Baja California feeding areas at specific times of the year. Homing migrations are most likely to occur from August through October, as green turtles arrive on Michoacan rookeries in October and November. Return migrations, to Baja California feeding grounds, are likely from December through February, at the end of the nesting season. This knowledge should be used to mitigate losses of sea turtles to fishing activities.

The importance of protecting foraging areas for green turtles cannot be overstated. Eastern Pacific stocks will be extirpated shortly unless critical feeding and developmental areas are given full protection and areas used for migration, both homing and post-nesting, become habitable. The establishment of a network of green turtle refugia along the coast of the Californias, with a focus on the protection of mature turtles, should be considered an immediate management priority.

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Table 1. Summary of movement data for nine green turtles tracked with satellite telemetry from Baja California, Mexico, foraging grounds.

Turtle	PTT #	SCL (cm)	Capture location	Release date	Final location	Final date[a]	Tracking Duration[b] (d)	Approx. distance traveled (km)[c]	Total number of fixes	Overall Avg. swimming speed (km/d)[d]
A	03795	91.9	BLA, BC	19 Aug 1996	BLA, BC	7 Nov 1996	80	198	13	2.40
B	05522	89.2	BLA, BC	23 Jul 1997	BLA, BC	19 Aug 1997	27	99	19	3.60
C	03847	77.3	BLA, BC	4 Aug 1997	Northern Gulf	19 Aug 1997	15	318	13	21.20
D	03848	88.7	BLA, BC	4 Aug 1997	BLA, BC	19 Aug 1997	14	90	13	7.92
E	05520	85.9	BLNMP, BCS	11 Aug 1997	BLNMP, BCS	31 Aug 1997	20	59	19	2.88
F	05523	89.9	BLNMP, BCS	11 Aug 1997	Michoacan	10 Oct 1997	60	1,563	40	26.05
G	03849	80.0	BLNMP, BCS	11 Aug 1997	BLNMP, BCS	9 Sept 1997	29	173	25	6.00
H	01084	75.6	BLA, BC	25 Jan 1997	Michoacan	16 May 1997	111	3,811	212	34.33
I	03850	74.3	BLA, BC	23 Nov 1998	Michoacan	19 Jan 1999	56	1,847	69	32.98

[a]Final date a valid location was received.
[b]Days from release until final valid location. Note: low quality positions and data were received past this date.
[c]Based on locations with LC $\geq$ 1 plus edited locations (see text for criteria).
[d]Distance traveled / tracking duration.
BLA = Bahía de los Angeles, BLNMP = Bahía de Loreto National Marine Park

Table 2. Swimming speeds for green turtles during station keeping and homing movements, along the Pacific coast of Mexico, obtained through satellite telemetry.

	Swimming Speeds for track segments (km/d) (mean ± SE, range)[b]			
Turtle (n feeding, n homing, n nesting)	Overall mean for tracking duration (km/d)[a]	Station keeping on feeding grounds	Homing migration	Station keeping at nesting beach
A (11, 0, 0)	2.40	4.57 ± 1.18, 0.65 – 12.47	NA	NA
B (18, 0, 0)	3.60	16.63 ± 3.72, 0.50 – 49.48	NA	NA
C (12, 0, 0) [C]	21.20	37.94 ± 8.30, 6.37 – 92.99	NA	NA
D (12, 0, 0)	7.92	15.72 ± 3.63, 0.88 – 47.44	NA	NA
E (18, 0, 0)	10.08	9.01 ± 1.68, 0.51 – 23.91	NA	NA
F (9, 27, 3)	26.05	10.94 ± 4.59, 0.76 – 45.09	47.57 ± 4.62, 5.93 – 94.37	8.23 ± 4.05, 2.99 – 16.19
G (X, 0, 0)	6.72	15.98 ± 3.36, 0.95 – 51.81	NA	NA
H (3, 148, 60)	34.33	16.94 ± 4.60, 8.68 – 24.60	43.97 ± 1.89, 4.76 – 94.62	37.29 ± 3.26, 0.22 – 95.30
I (0, 58, 10)	32.98	NA	45.41 ± 2.89, 1.98 - 95.24, 58	21.44 ± 6.41, 1.52 – 52.66,10
Overall (105, 233, 73)		15.78 ± 1.69, 0.50 – 92.99	44.75 ± 1.49, 1.98 – 95.24	33.91 ± 2.95, 0.22 – 95.3

[a]Calculated by dividing total distance traveled by total tracking duration.
[b]Mean of the average swimming speeds for each track segment.
[C]Turtle C (Figure 4) moved substantially northward from the release site.

Table 3. Approximate distances and swimming times required for green turtles migrating from major Mexican feeding grounds to regional rookeries, based on a mean swimming speed of 45 km/d. SD, CA = San Diego, California; LOL = Laguna Ojo de Liebre, BCS; BMA = Bahía Magdalena, BCS; BLA = Bahía de los Angeles, BC; BLNMP = Bahía de Loreto National Marine Park, BCS.

	Baja California Feeding Areas				
Rookery	Pacific Coast			Gulf of California	
	SD, CA	LOL	BMA	BLA	BLNMP
Islas Revillagigedos	1,648 km 37 days	1,043 km 23 days	672 km 15 days	1,210 km 27 days	805 km 18 days
Colola, Michoacan	2,108 km 47 days	1,518 km 34 days	1,150 km 26 days	1,584 km 35 days	1,173 km 26 days

Table 4. Examples of variation in swimming speeds with decreasing time-to-capture intervals calculated from long distance recovery data of green turtles tagged in Michoacan, Mexico (1981-1991). Source: Alvarado and Figueroa 1992, Figueroa et al. 1992.

	Time interval (days) between tagging and recapture			
	< 365 d	< 180 d	< 90 d	< 60 d
Number of tag returns	35	20	9	5
Mean displacement (km)	1,324	1,209	960	958
Mean swimming speed (km/d)	6.83	11.79	15.73	23.14
Swimming speed (km/h)	0.28	0.49	0.66	0.96

Figure 1. Release of East Pacific green turtle, *Chelonia mydas*, with satellite transmitter. Bahía de los Angeles, Baja California, Mexico, August 1997.

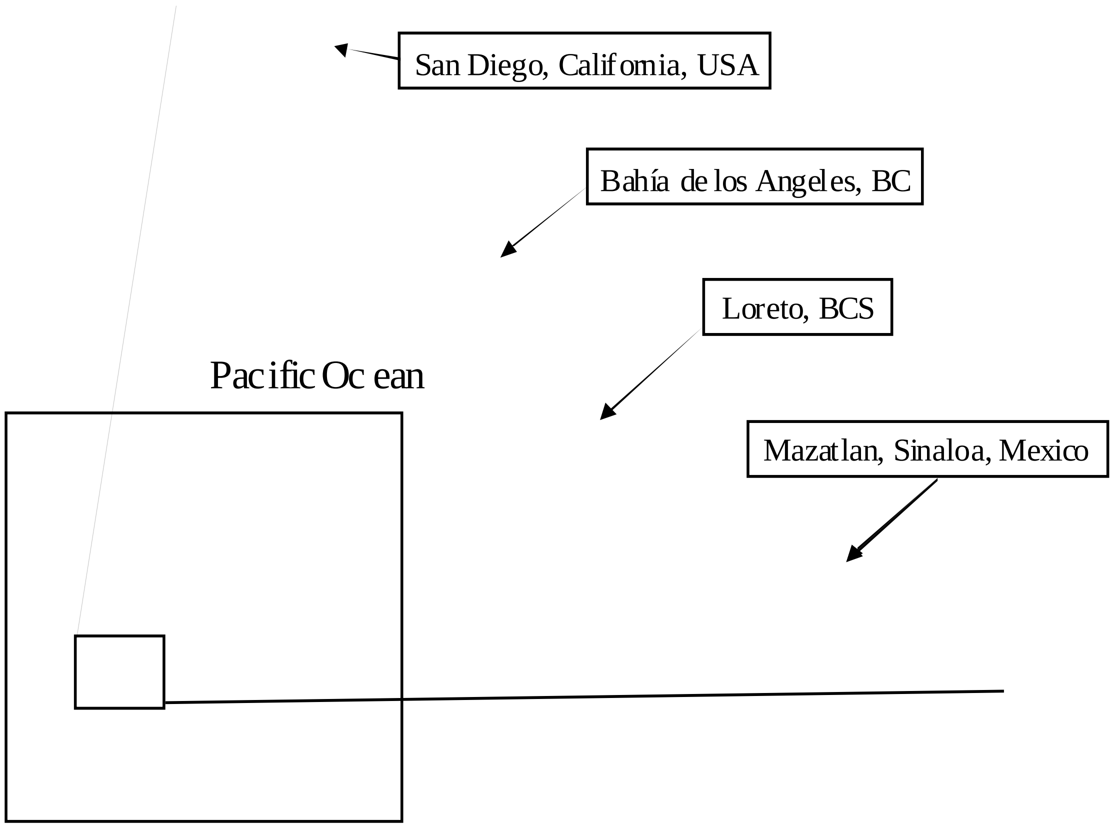

Figure 2. Map of satellite telemetry study areas in Baja California (BC) and Baja California Sur (BCS), Mexico.

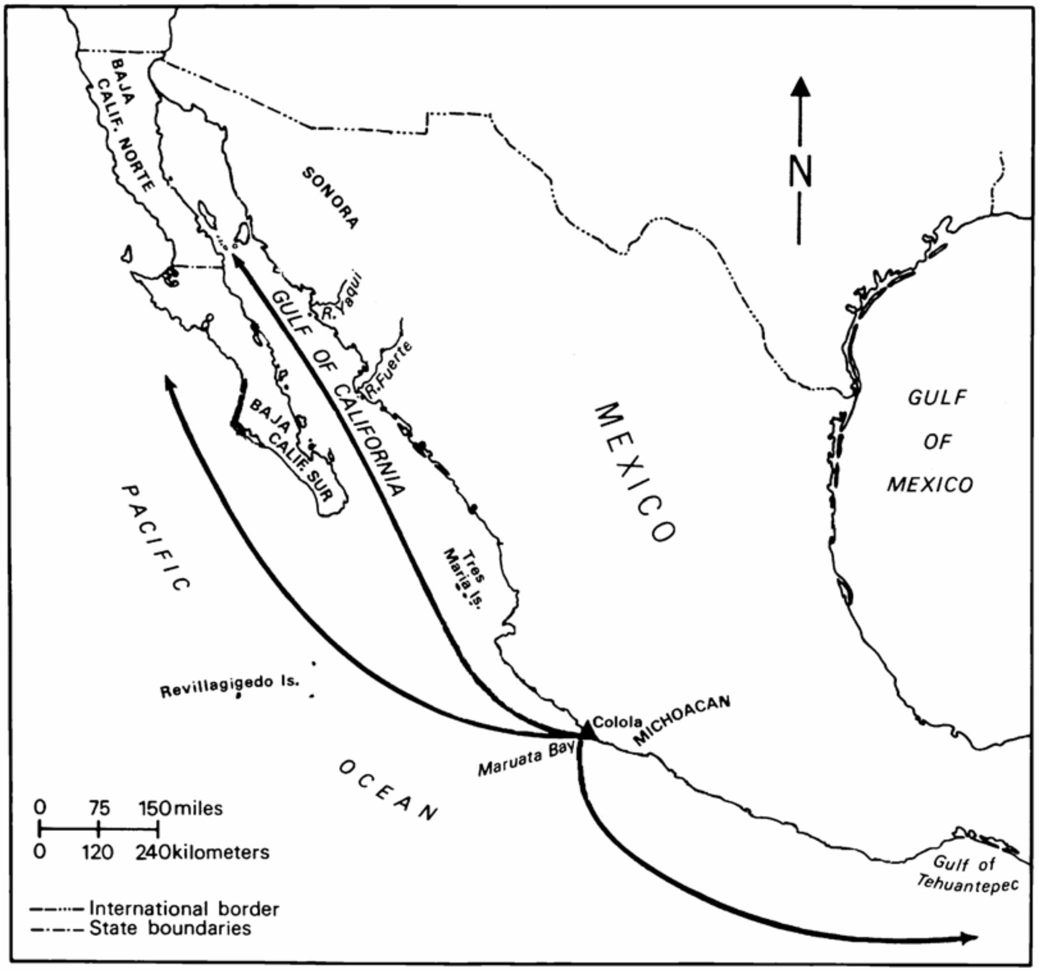

Figure 3. Generalized movements of green turtles (*Chelonia mydas*) from rookeries in Michoacan, Mexico, determined through flipper tag returns (adapted from Cliffton et al. 1982).

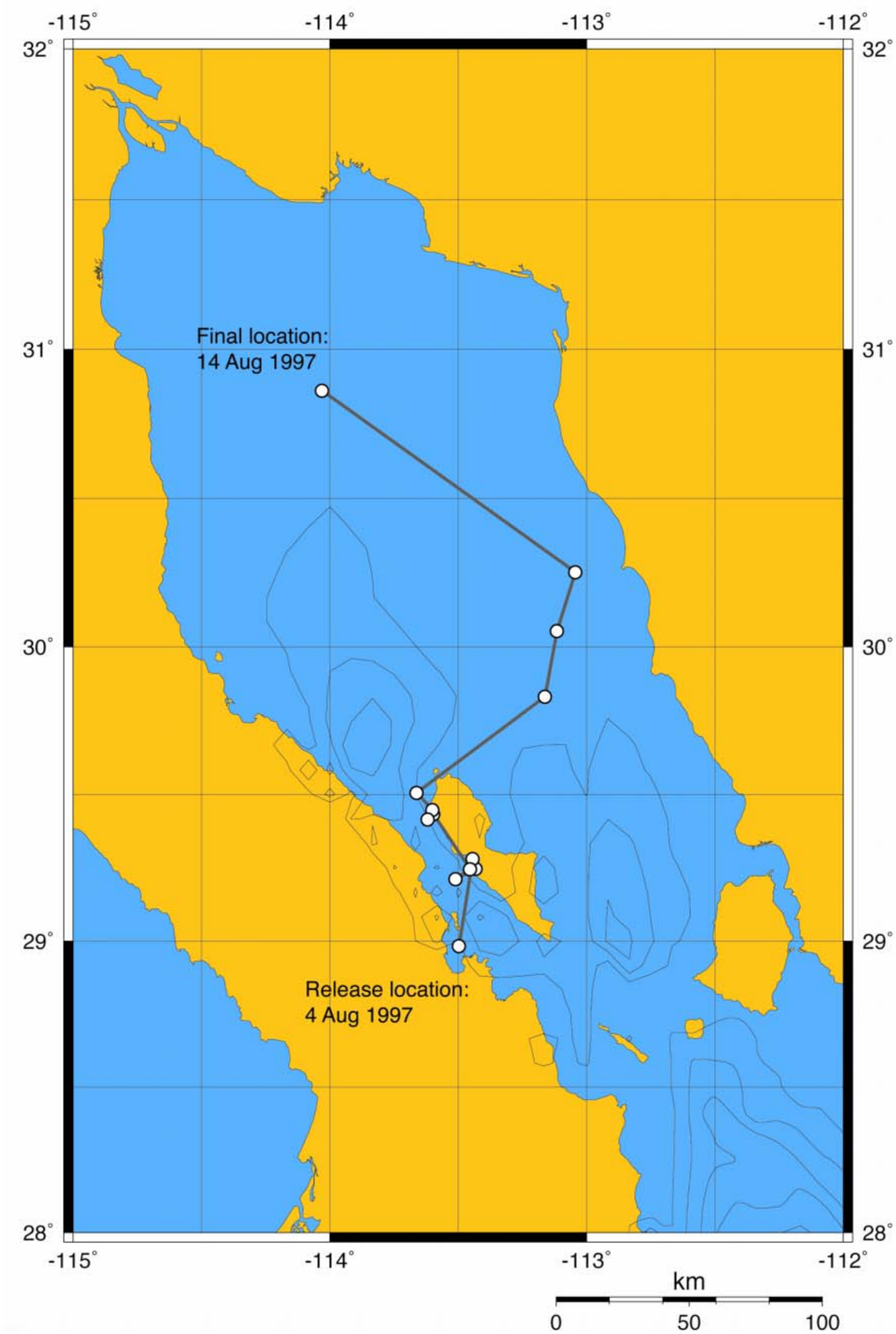

Figure 4. Movement of green turtle C from Bahía de los Angeles, Baja California, to the northern Gulf of California, using all valid locations (see text for editing details).

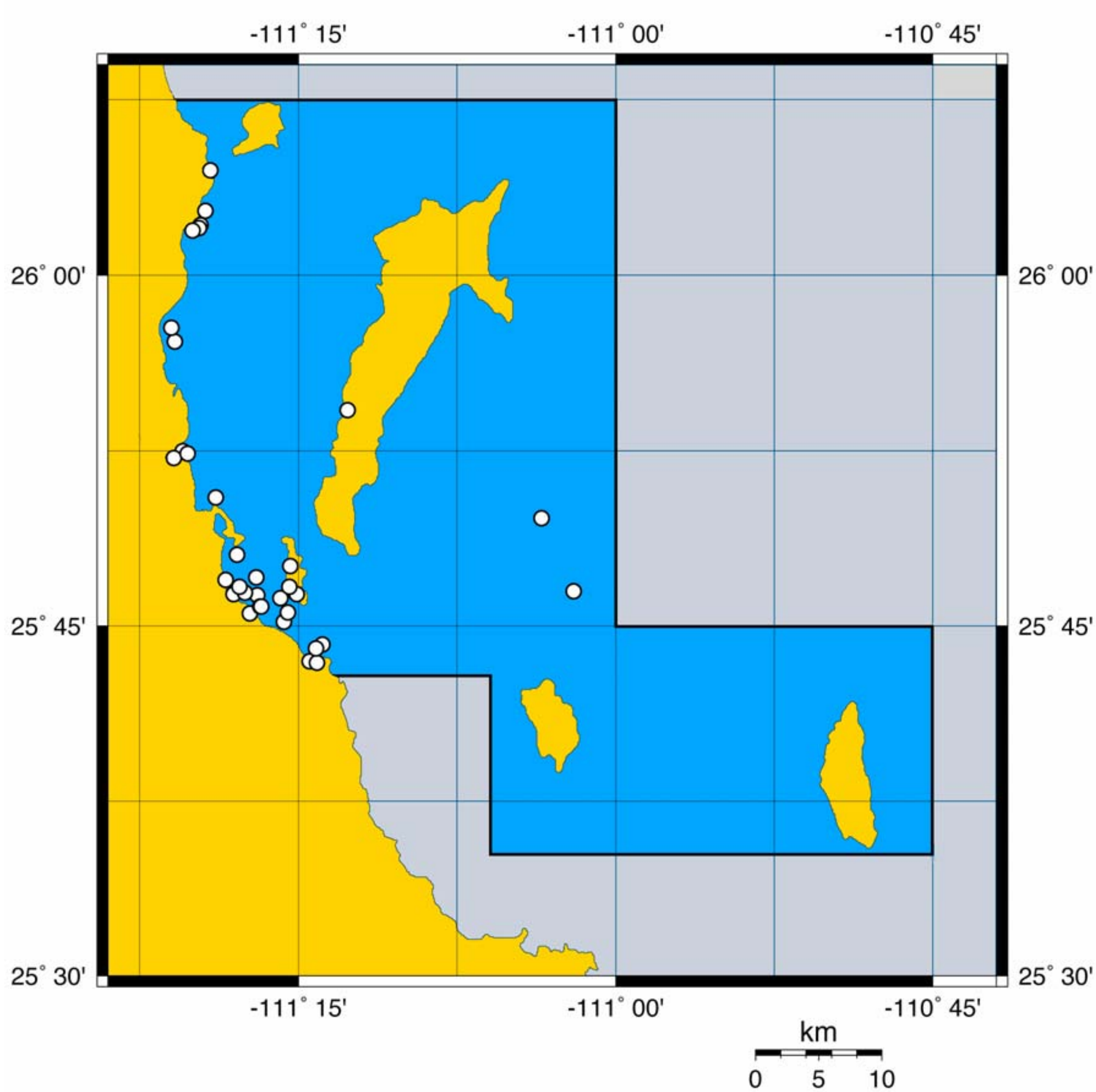

Figure 5. Combined locations (n = 35) from three green turtles tracked using satellite telemetry while on feeding grounds near Loreto, Baja California Sur. All of the fixes fall within the Bahía de Loreto National Marine Park boundaries, outlined in black. Only fixes considered valid are plotted in the figure.

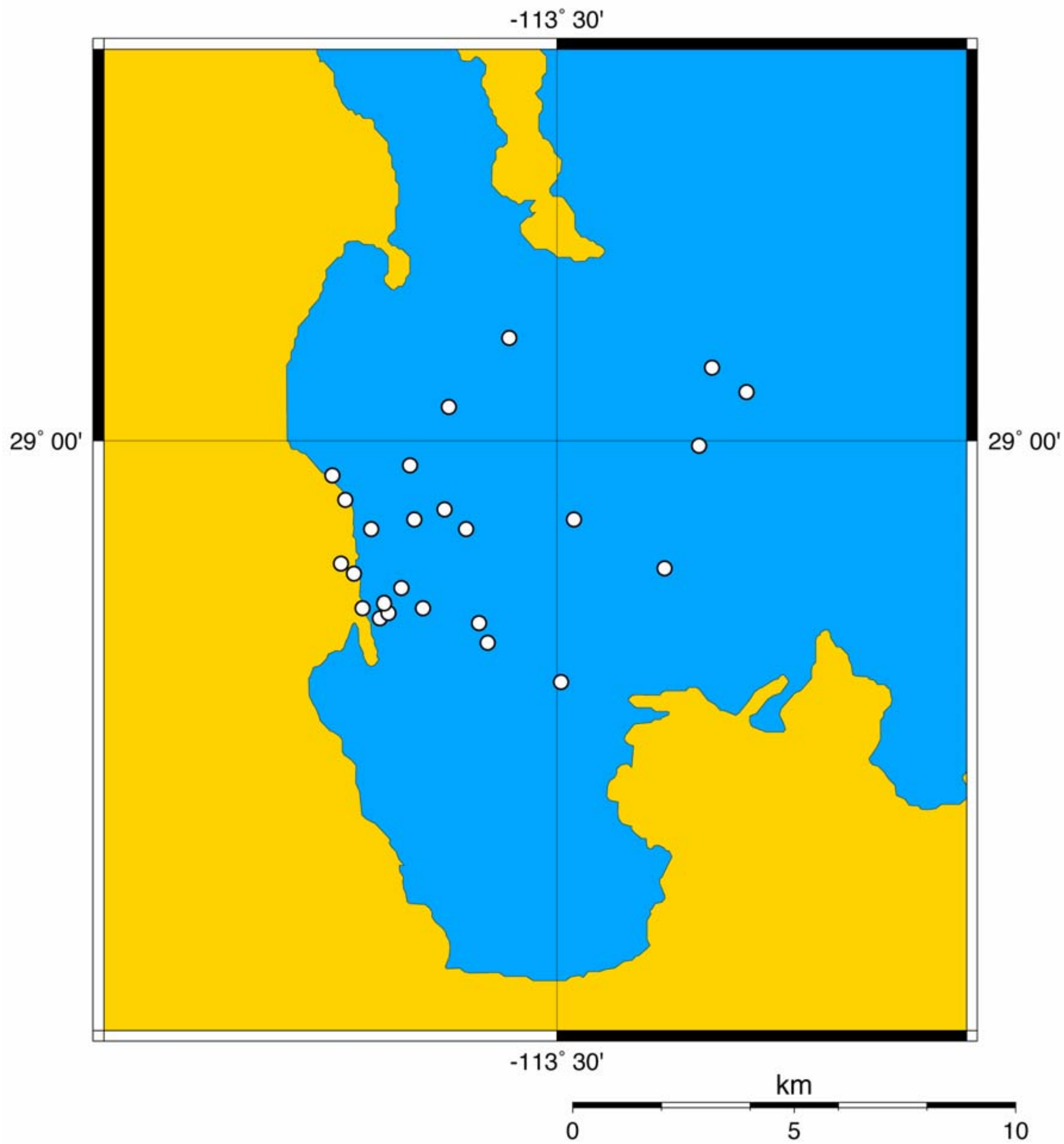

Figure 6. Combined locations (n = 25) of three green turtles tracked using satellite telemetry for 14 – 80 days while at feeding areas near Bahía de los Angeles, Baja California. Only fixes considered valid are plotted in the figure.

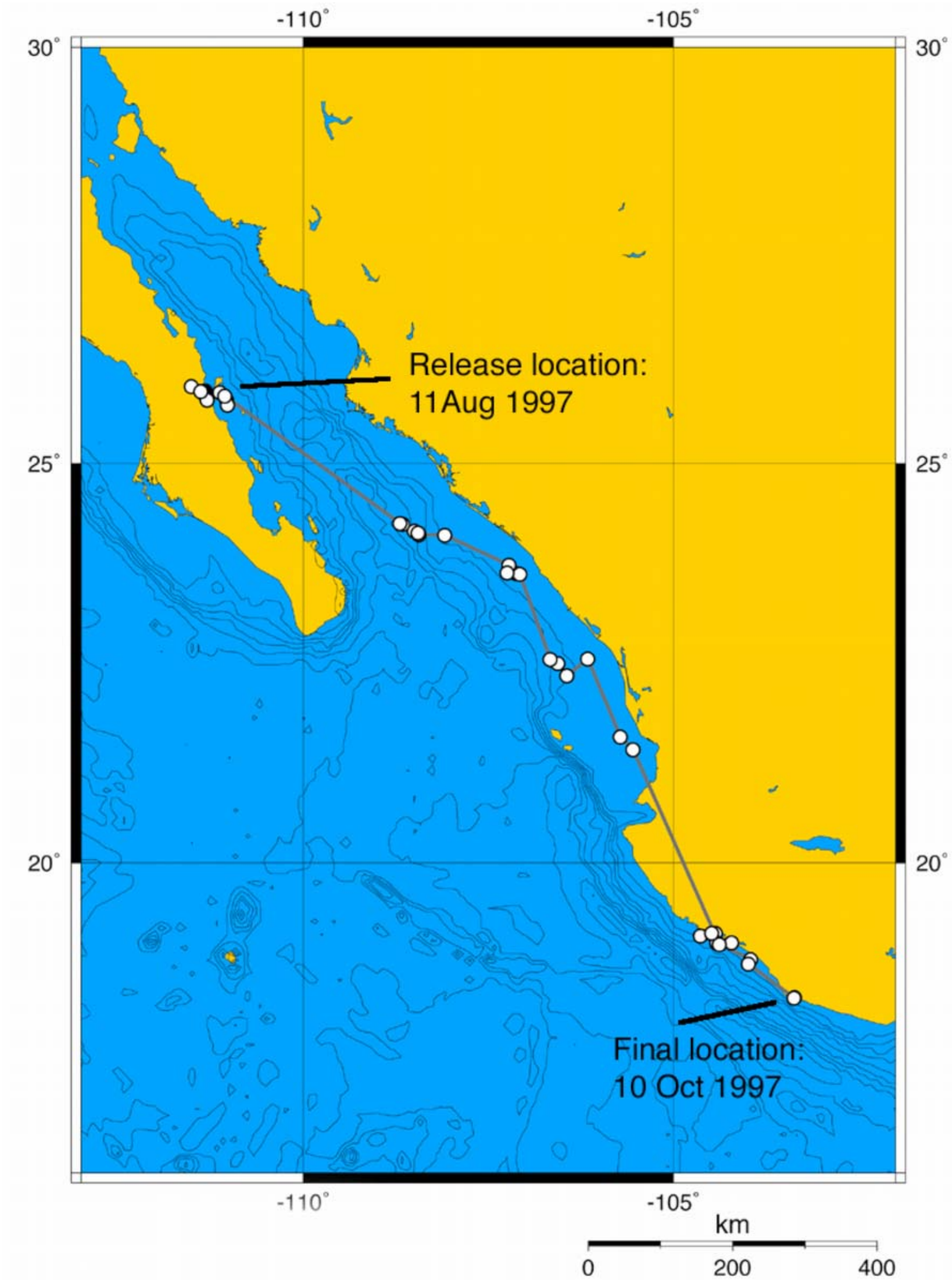

Figure 7. Homing migration of turtle F from Bahía de Loreto, Baja California Sur, to Michoacan, using all valid locations, August 1997 to October 1997.

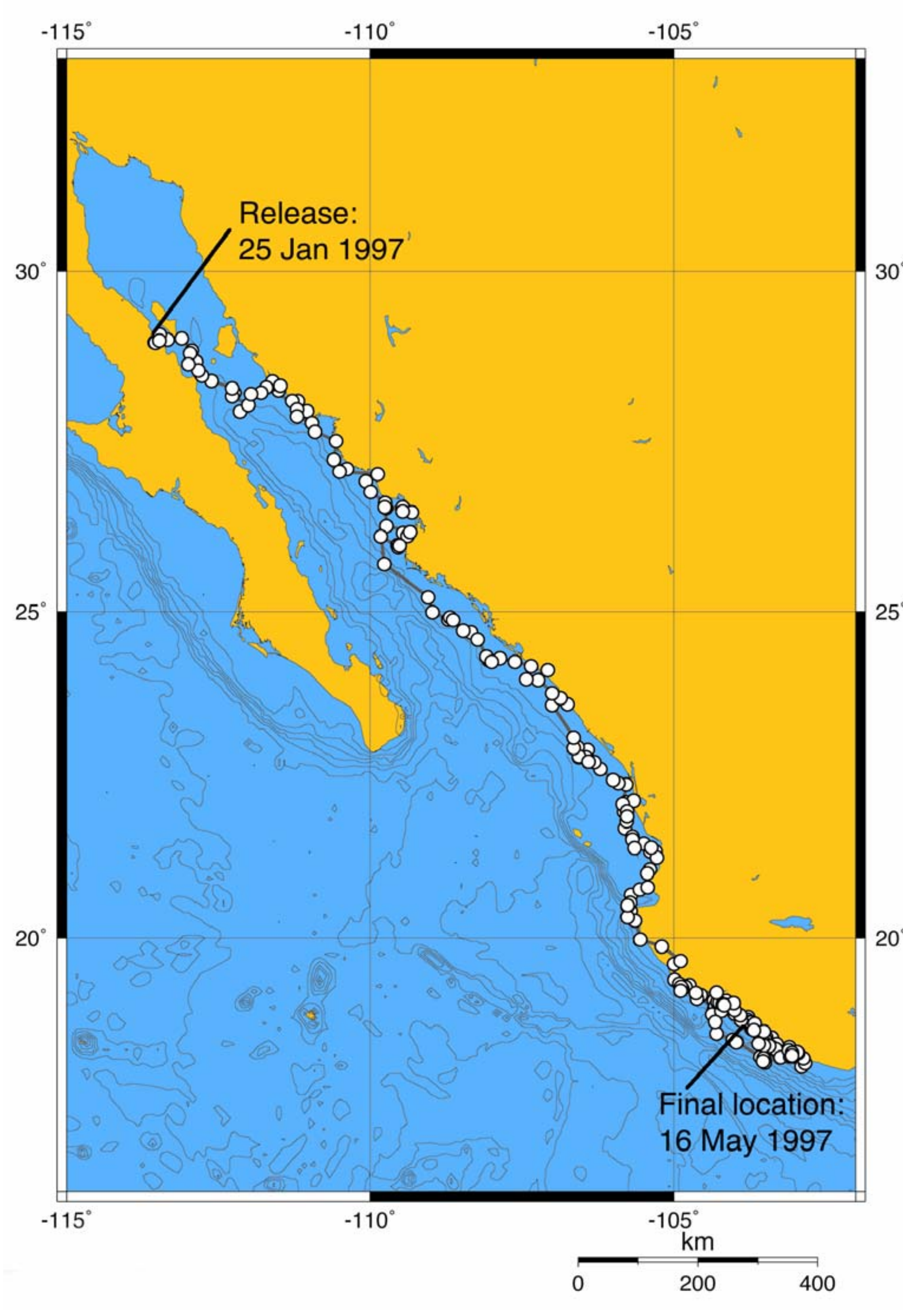

Figure 8. Homing migration of turtle H from Bahía de los Angeles, Baja California Sur, to Michoacan, using all valid locations January 1997 to May 1997.

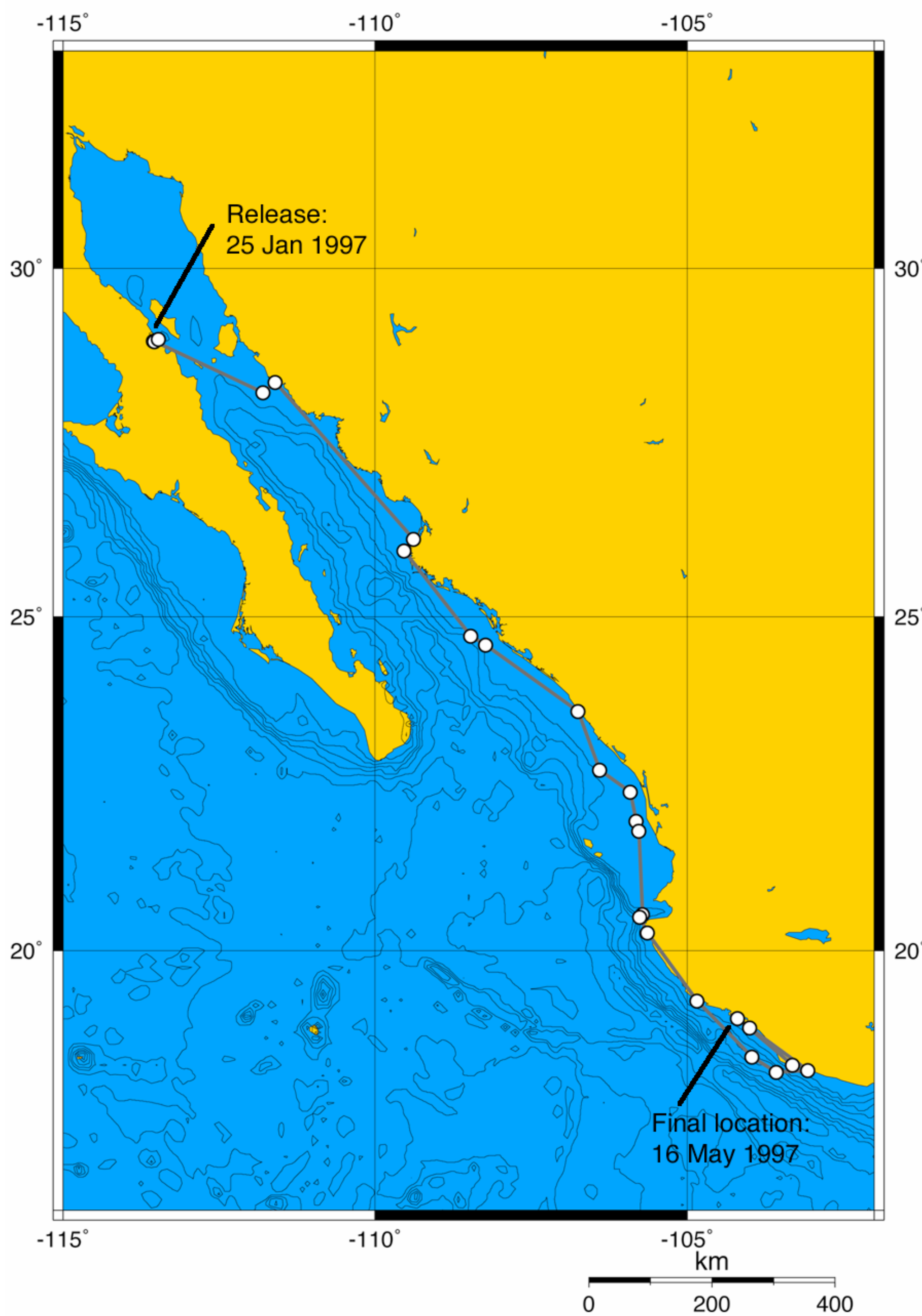

Figure 9. Homing migration of turtle H from Bahía de los Angeles, Baja California, to Michoacan (using only LC ≥ 1), January 1997 to May 1997.

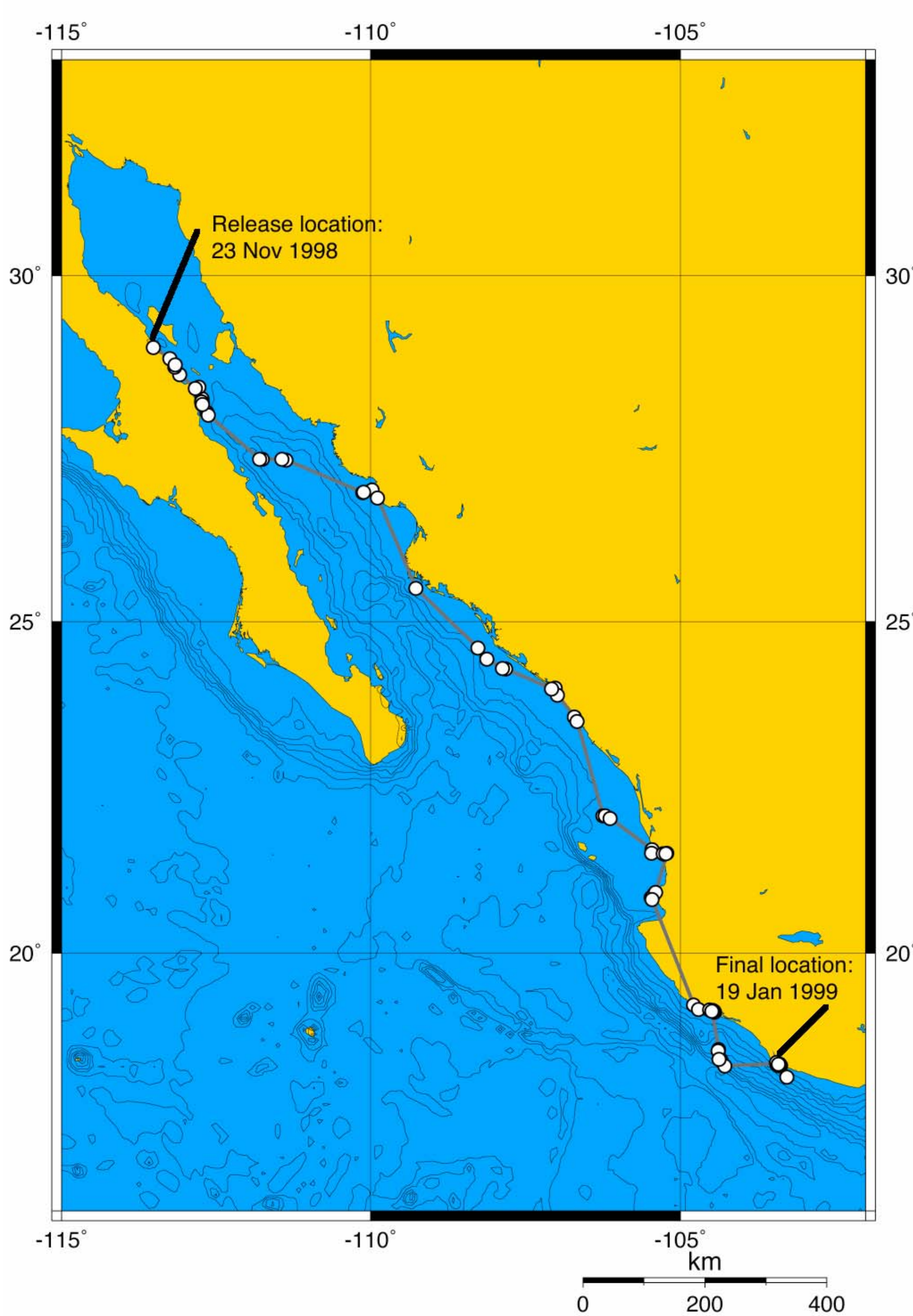

Figure 10. Homing migration of turtle I from Bahía de los Angeles, Baja California, to Michoacan, using all valid locations, November 1998 to January 1999.

CHAPTER 6

ORIGINS OF GREEN TURTLES, CHELONIA MYDAS, FORAGING IN WATERS OF THE BAJA CALIFORNIA PENINSULA, MEXICO

ABSTRACT

New methodologies have allowed for major breakthroughs in our knowledge of green turtle natal origins, migrations, and feeding ground composition, making many of the mysteries of sea turtle migration tractable. I used mitochondrial DNA control region sequences to assess the relative contribution of the two main North Pacific *Chelonia* rookeries to green sea turtle feeding grounds along the coast of the Baja California peninsula, Mexico. Control region segments of 385 base pairs were sequenced using mtDNA from 116 turtles (straight carapace length 40 to 100 cm) captured or stranded on Baja California feeding grounds between 1995 and 1998. Haplotypes were compared to those from the nearest major *Chelonia* rookeries in Mexico and Hawaii, USA. Eight mtDNA haplotypes were found among the Baja California turtles, representing those found primarily in the Michoacan and, to a lesser extent, Hawaiian rookeries. Four haplotypes comprised 97% of the samples. One haplotype, comprising 21% of the samples, has not been identified in the rookeries surveyed to date. It is hypothesized that these turtles may be part of the Islas Revillagigedos, Mexico, rookery due to its isolation, size, and close proximity to Baja California feeding grounds. A minimum of two, and possibly three, distinct stocks utilize feeding grounds in Baja California. The Michoacan and putative Islas Revillagigedos management units comprise approximately 95% of the contribution to feeding ground aggregations. The remaining 5% are hypothesized to

consist of turtles from the Hawaiian rookeries. Comparisons between Gulf of California and Pacific lagoon foraging areas indicate that a higher percentage of the putative Islas Revillagigedos haplotype occur along the Pacific coast. These findings are consistent with results from simultaneous studies utilizing traditional flipper tags and satellite telemetry and are consistent with predicted stock contributions based on population size and distance to feeding grounds. Green turtles are still regularly harvested in large numbers in Baja California and bycatch in a variety of fishing tackles is thought to be high. Mortality of both juvenile and adult turtles on their feeding and developmental areas will have severe impacts on rookeries in both Mexico and the U.S.A.

INTRODUCTION

Puzzling over the long distance movements and origins of migratory marine species is rapidly becoming a quandary of the past. The use of intrinsic markers such as DNA polymorphisms (Dingle 1991), naturally occurring stable isotopes in animal tissues (Hobson 1999), biotelemetry (Davis et al. 1996, Papi and Luschi 1996, Weihs and Levin 1997), oceanographic modeling (Olson et al. 1994), and traditional mark-recapture techniques (Squire 1987) have produced new, valuable information on the dispersal of juvenile marine organisms as well as the reproductive migrations of adults. While each of these techniques has produced compelling results on its own, used together the most elucidating views of marine animal life history emerge.

Like studies of pelagic fishes, marine birds, and mammals, knowledge of sea turtle biology has advanced substantially from the use of these modern methods (Utter and Ryman 1993, Baker et al. 1994, Norman et al. 1994, Polovina et al. 2000, Nichols et al. *in press*). The green turtle (*Chelonia mydas*) has proven to be a model organism for such studies. Use of genetic markers or "tags", electronic transmitters, and physical tags have produced information on green turtle migrations and local movements, feeding ground composition, fisheries interactions, and have provided useful information for conservationists and resource managers (Allard et al. 1994, Balazs and Ellis 1996, Luschi et al. 1996, Lahanas et al. 1998).

East Pacific green turtles, *Chelonia mydas*, (also commonly referred to as the black turtle or *tortuga prieta*) are the most frequently encountered species of sea turtle in coastal waters of the Baja California peninsula, Mexico (Chapter 1). The area is considered one of the most important feeding and developmental grounds for the five species of marine turtle in the eastern Pacific. The vast, protected, subtropical coastline of the Baja California peninsula and abundant, diverse forage once sustained extremely large aggregations of juvenile and adult green turtles (Townsend 1916, Caldwell and Caldwell 1962). For thousands of years indigenous groups in this region have utilized green turtles as a source of food and during the past century a large-scale fishery developed to exploit this abundant species (O'Donnell 1974, Felger et al. 1976). By the early 1980's green turtle populations had been "virtually extirpated" (Cliffton et al. 1982) and were considered economically extinct. Despite a complete ban on turtle products in 1990, local harvest, consumption, and incidental catch continue and are a substantial cause of annual mortality.

The green turtle is considered Endangered under both the U.S. Endangered Species Act of 1973 and the International Union for Conservation of Nature and Natural Resources (IUCN) Red Data Book (2000). On the main nesting beaches of the northeast Pacific, in Michoacan, Mexico, about 90% of the known nesting of green turtles in the region occurs (Alvarado, pers. comm,). However, numbers of nesting turtles have declined precipitously over the past 40 years, and continue to do so (Alvarado 1989). Annual mortality is estimated at between 7,800 and 30,000 sea turtles annually in the Baja California region (Chapter 3).

In regions such as the Caribbean (Carr et al. 1978, Lahanas et al. 1998), the Hawaiian Islands (Balazs 1980, Balazs and Ellis 1996), Ascension Island (Luschi et al. 1998, Hays et al. *in press*), and eastern Australia (Fitzsimmons 1996, Whiting and Miller 1998) the relationship between green turtle nesting and foraging grounds has been well established. While nearly 20 years of research and conservation efforts have focussed on green turtle nesting beaches in Michoacan, Mexico, little is known of the feeding biology, population structure, or the precise locations of their feeding and developmental grounds. Basic information such as natal origin, feeding habits, migratory routes and mortality rates is lacking. This dearth of knowledge has been considered one of the main impediments to green turtle recovery in the eastern Pacific (NMFS 1998). Assessments of the status of East Pacific green turtle stocks should include both long-term nesting beach census data as well as feeding area surveys (Limpus 1996). Because green turtle mortality is high in Baja California waters it is important to assess the contribution of each of the regional nesting rookeries to feeding grounds along the peninsula in order to best utilize limited conservation resources and assess the impact of mortality on feeding grounds on specific regional rookeries.

Movement of East Pacific green turtles away from nesting beaches has been previously investigated using mark and recapture methods and satellite telemetry. Alvarado and Figueroa (1992) reported that of 47 recaptured turtles that were tagged on Michoacan nesting beaches, 8 were recovered in Baja California waters. This suggests that in addition to using Baja California waters as juvenile developmental habitat, post-nesting adult turtles also return to the region to forage. Four of the five turtles that were reported by Alvarado and Figueroa to have been captured intentionally were reported from the Gulf of California.

Results of satellite telemetry of five post-nesting turtles from Colola, Michoacan, indicated movement away from the nesting beaches through pelagic waters but were inconclusive at determining feeding ground preferences (Byles et al. 1995). Tagging and telemetry data are incomplete and offer only preliminary information about East Pacific green turtle movements away from nesting beaches.

Recent studies suggest that the Hawaiian *Chelonia* population is genetically isolated from other populations in the Pacific. This was initially based primarily on tag returns between nesting and feeding areas within the Hawaiian archipelago (Balazs 1980). Hawaiian flipper tags have not been reported from Baja California waters.

Slight morphological differences have been described among *Chelonia* nesting in Michoacan (Figueroa 1989) and Hawaii (Balazs 1980), offering further evidence of their reproductive isolation. Differences in coloration, carapace shape and mean size of nesters are most notable (Caldwell 1962, Pritchard 1999). Molecular analyses have shown these two populations to be genetically distinct at the population level (Dutton et al. 1996).

Mark and recapture and satellite telemetry studies have been used in the past to resolve relationships between nesting and feeding populations and to study remigration and post-nesting behavior. Alone the results generated by these techniques are inadequate for contemporary management needs. The synergistic use of methods such as molecular genetics, biotelemetry, and morphometrics can add substantial depth to the study of foraging aggregations and migration (Nichols et al. 2000). Used together, these tools allow us to confirm hypotheses in ways impossible with any of the techniques alone.

In sea turtles, mitochondrial DNA has proven effective for describing population structure on nesting beaches (Bowen 1997). Due to its ability to resolve genomic differences between populations, the control region is considered the segment of choice for describing natal beaches. Genetic differences between nesting beaches, such as those documented for the Mexican and Hawaiian rookeries, have made it possible to utilize mtDNA sequences as "natural tags" to help determine the natal origin of sea turtles on feeding grounds (Bowen 1995, Broderick and Moritz 1996, Norrgard 1996, Lahanas et al. 1998). Such studies require the characterization of common haplotypes on each potential source rookery as a minimum prerequisite. Once identified, such information can be used to protect the genetic integrity of wild stocks when management schemes are necessary.

Fortunately, the two main potential source populations—the Mexican and Hawaiian nesting colonies—for sea turtles foraging along the Baja California peninsula have been described and are well differentiated (Chassin, In Prep, Dutton and Balazs, unpublished data) as when they are not, the analysis can be misleading. Logistical difficulties did not permit collections of samples from the Islas Revillagigedos rookery at the time of this study. When all source populations are not surveyed or surveyed inadequately, mixed feeding ground aggregations may contain genotypes or haplotypes that are not found in the source populations (Chapman 1996). A reasonably accurate contribution estimate can be achieved with sample sizes between 50 and 100 individuals, but the situation becomes distorted as mixed aggregation samples sizes increase (Chapman 1996) and as the number of candidate source populations increases.

We began this study with the following hypotheses, formulated on the basis of flipper tagging data and field observations:

- Baja California green turtle feeding aggregations are composed primarily of turtles from Mexican stocks.

- Baja California green turtle feeding aggregations are composed of turtles from other Pacific rookeries in proportion to their relative abundance.

9. If only Michoacan rookeries contribute to foraging areas, the composition of Gulf of California and Pacific coast foraging areas are not significantly different.
10. Haplotype frequencies of stranded and harvested turtles will not be significantly different from those for wild populations.
11. Haplotype frequencies for juvenile and adult size classes are not significantly different.
12. A simple model is used to predict expected contributions of nesting populations, based on the relative size of each nesting population and its distance from foraging grounds such that the total frequency of aggregated haplotypes of the representative rookery (f), is equal to the relative size of the rookery (N) times the inverse of the distance (d) between the nesting and feeding areas.

METHODS

In order to identify the contribution of the main regional *Chelonia* rookeries in Mexico and Hawaii to coastal foraging grounds along the Baja California peninsula we determined mtDNA haplotypes using tissue samples obtained from wild and incidentally captured turtles. Haplotypes were compared to those found on Mexican and Hawaiian rookeries. Results were compared to data from simultaneous mark and recapture and satellite telemetry studies (Nichols et al. 2000).

Tissue samples were taken from 116 turtles, with straight carapace lengths from 40 to 100 cm, captured in 1996-1998 on foraging grounds in Baja California, Mexico (Table 1). Turtles were captured in entanglement nets monitored continuously. Stranded turtles were located during routine beach and fishing camp surveys. Tissue sampling was chosen over blood sampling due to the simplicity and relative speed of the method, the remote field circumstances, ease of sampling on small, crowded, fishing boats at sea, and the option of requesting samples from fishers and other field workers who regularly encounter stranded turtles. A small tissue sample was taken from the dorsal surface of the flipper or neck of each turtle with a scalpel (Figure 2) or 4mm disposable biopsy punch (Acuderm, Inc. Fort Lauderdale, Florida 33309, USA) using sampling methods described by Dutton (1996). Prior to sampling the area was swabbed with disinfectant and the wound was later cauterized using silver nitrate swabs. When possible, in cases of recently stranded or harvested turtles, muscle samples were obtained. Tissue samples were preserved in 20% DMSO (dimethyl sulfoxide) in water saturated with salt (NaCl, without EDTA). Occasionally tissue samples were temporarily stored in dry NaCl until the solution became available. Tissues preserved in solution were refrigerated in labeled screw-cap tubes.

Live turtles were marked on the flipper with inconel tags for identification and to avoid subsequent resampling.

Total genomic DNA was isolated from tissue using a modification of the methods of Blin and Stafford (1976). About 50-200 mg of tissue was manually chopped and ground, and then vortexed. Homogenate was subjected to successive extractions with pure phenol, phenol-chloroform-isoamyl alcohol (24:1). Two-tenths volumes of 95% ethanol at –20ºC were added to the resulting mixture and stored at –20ºC overnight. Following an ethanol precipitation, pellets were resuspended in 20µl 1X TE.

PCR methodology was used to amplify approximately 385 bp of the control region of green turtle mtDNA (L strand) using oligonucleotide primers (LTCM-1 and HDCM-1) as described by Allard et al. (1994). The sequences of these primers were:

LTCM-1: 5' CCCCAAAACCGGAATCCTAT 3'

HDCM-1: 5' AGTGAAATGACATAGGACATA 3'

Reaction conditions for amplification were: 6 minutes at 94ºC, followed by 40 cycles of 2 minutes at 94ºC, 2 minutes at 50ºC, and 4 minutes at 72ºC. This was completed with a final 14-minute extension at 72ºC, and then storage at 4ºC. Each group of amplified samples contained a negative control in order to detect contamination. Control region fragments—initiating approximately 114bp from the start of the control region—were sequenced using an automatic sequencer at the National Marine Fisheries Service, Southwest Fisheries Science Center, La Jolla, CA Genetics Laboratory. Novel haplotypes were assigned arbitrary labels (Dutton, in prep). Results were compared to haplotypes from previously sampled green turtle rookeries (Chassin In prep, Dutton and Balazs, unpublished data).

Because of the complete resolution (lack of shared haplotypes) of the sampled rookeries (Mexico and Hawaii) and the lack of samples from the Islas Revillagigedos at the time of this analysis, maximum likelihood analyses were not used. To test for regional and temporal variation chi-squared test of independence of haplotype frequencies was conducted (Sokal and Rohlf 1981). Estimations of the contribution of each stock was calculated using approximate relative population sizes and the distance between nesting beaches and feeding grounds. Predicted relative contributions of major green turtle, *Chelonia mydas*, rookeries, were based on estimates of mean numbers of reproductive females for the past ten years divided by a factor based on approximate distances to Baja California feeding grounds.

RESULTS AND DISCUSSION

Analysis of the amplified mtDNA d-loop region of 116 green turtle samples (Table 1) from Baja California feeding grounds revealed 8 haplotypes (Table 2). The samples from the Pacific coast populations (N = 45) were comprised of 4 haplotypes (D, E, G and O), while 7 haplotypes were found in the 71 Gulf of California feeding ground samples (B, D, E, F, G, N and P) (Table 3). Due to the previously resolved regional structure of Pacific green turtle rookeries (Chassin In prep, Dutton and Balazs, unpublished data) five of the feeding ground haplotypes were assigned to either Hawaiian or Mexican rookeries. Three of these haplotypes had been described from Michoacan (E, F, and N) and two from Hawaiian rookeries (B and D). Haplotype G had been previously described only from San Diego Bay, California, USA, feeding grounds (Dutton, pers. comm). However, this haplotype had not yet been found on nesting beaches. Haplotypes D, E, F, and G comprised approximately 96% of the samples. Two novel, rare, haplotypes were found on the feeding grounds (O, and P)

Haplotypes E and F comprised 59% and 11% of the feeding ground samples, respectively. Chassin (In prep) found these haplotypes in 56% and 33% of Michoacan nesting beach samples (N = 39). Three rare haplotypes represented 11% of Chassin's Michoacan samples. Haplotype G comprised 21% of the feeding ground samples and has not been sampled from any rookeries to date. Dutton (pers. comm.) hypothesized that haplotype G may be from the Islas Revillagigedos rookery. Green turtles have been studied on feeding grounds in San Diego Bay, CA, USA (Dutton and MacDonald 1990, Dutton and McDonald 1992). Preliminary genetic data from San Diego Bay indicate that the novel haplotype (G) occurs at a frequency of (36%) (N=11) (Dutton, in prep).

Based on the assumption that the Islas Revillagigedos stock is comprised of solely the G haplotype, the observed management unit contributions of foraging turtles were not significantly different from the expected values (p = 0.3796), calculated using estimated relative rookery sizes (Table 4). Green turtles from Michoacan (71%) utilize Baja California waters in greater numbers than turtles from the Islas Revillagigedos (21%) and Hawaiian (6%) archipelagos. When an average distance factor (nesting beach to feeding ground) is added to the analysis, the expected frequencies more closely resemble those observed. However, if the Islas Revillagigedos rookery contains a mix of haplotypes, the situation becomes more complex and maximum likelihood analyses necessary. Furthermore, regional surface currents, particularly the California Current System (CCS), likely play an important role in the dispersal of hatchlings and the recruitment of juvenile green turtles in the eastern Pacific. The results of the genetic analysis are consistent with flipper tagging reports (Alvarado and Figueroa 1992) and satellite telemetry studies (Chapter 5).

While the genetic composition of the main rookeries has been described, the present analysis may be weakened by the fact that all putative source populations have not yet been included (i.e. small rookeries in Central America (Cornelius 1976), Islas Revillagigedos, Mexico (Brattstrom 1982), and possibly sporadic nesting in Baja California Sur, Mexico). The determination of natal origin of the turtles foraging in Baja California waters was made under the assumption that there are only two potential sources: Michoacan rookeries and Hawaiian rookeries. However, one or more of the unrepresented rookeries may be the source of the G haplotype. Future inclusion of these additional rookeries, as well as additional feeding ground sampling, may greatly affect the conclusions of this study.

These results suggest that turtles may disperse from Hawaiian rookeries to East Pacific feeding grounds (Nichols et al., *in press*). Bolton et al. (1996) report the occurrence of green turtles in the Hawaiian longline fishery north of the Hawaiian Islands and Balazs (pers. comm.) reports occasional East Pacific green turtles on Hawaiian feeding grounds. Kamezaki (pers. comm.) also reports occasional immature East Pacific green turtles from Japanese waters. Pitman (1990) has reported pelagic stage green turtles in the eastern Pacific. During the summer 1999 field season I sighted five immature green turtles basking on kelp mats (*Macrocystis* sp.) approximately 30 km offshore the Pacific coast of Baja California. The Baja California coast also serves as pelagic developmental habitat for loggerheads as they move from Japan to the coast of Baja California (Nichols et al. 2000). Thus, it is reasonable that some waif green turtles from the Hawaiian population find their way to eastern Pacific, and Baja California, waters—and vice versa.

Turtles from the Islas Revillagigedos, Mexico, are likely to contribute substantially to populations on feeding grounds in Baja California and California, USA. Based on early accounts, nesting on Isla Socorro and Isla Clarion may amount to as many as several hundred nests per year (Brattstrom 1982). Turtles dispersing from the nesting beaches on the Islas Revillagigedos may be more likely to recruit to Pacific coast feeding habitat than to the central Gulf of California, as is reflected by higher frequencies of the G haplotype on Pacific feeding grounds in this study. Furthermore, oceanographic patterns of the CCS may result in dispersion of the Islas Revillagigedo stock preferentially to California and Baja California waters.

The relative frequencies of haplotypes in Baja California waters was evaluated over several years, and although between year variation was noted, significant differences were not found ($p > 0.2$), and samples were lumped together for further analyses. Due to smaller sample sizes for the Pacific coast feeding grounds, the power of analysis to detect regional year to year and site specific differences was reduced. Larger sample sizes over a longer time period will be required to adequately address temporal and small-scale spatial variation.

Sex was recorded for 44 turtles (30F, 14M). No significant difference was found between haplotype frequencies for each sex (p . 0.2). Again, with such small sample sizes for each haplotype, this was not surprising.

Frequencies differed significantly ($p < 0.0005$) between Gulf of California feeding and Pacific feeding grounds. Notably, the F haplotype was absent from Pacific feeding ground samples and the G haplotype was more frequent among Pacific coast samples. These differences suggest that Baja California feeding grounds do not constitute a homogenous foraging population and that turtles do not recruit uniformly to the region from all source rookeries.

No significant difference was found in haplotype frequencies for size classes when immature-sized (SCL < 77cm) and mature-sized (SCL $\geq$ 77 cm) green turtles were compared ($p > 0.1$).

This study suggests that the Michoacan green turtle rookeries, which have declined in recent years, are the main source of green turtle recruits and remigrants to the

Baja California feeding grounds. Recovery efforts over the past 20 years on the nesting beach, such as protection of nesting females and eggs, should result in an increase in small size classes on the foraging grounds. The reverse is also true. Protection efforts on the feeding areas will reap benefits on the Michoacan nesting beaches. Unfortunately, incidental catch and poaching of juvenile and adult green turtles remains high in Baja California waters and proportionately impacts the Michoacan rookeries, preempting or slowing recovery of the population. What is important to emphasize is that mortality in Baja California waters—particularly of reproductive female turtles—will severely impact declining Michoacan rookeries and to a lesser degree Hawaiian rookeries. It may also have a disproportionate impact on smaller declining rookeries such as those of the Islas Revillagigedos (Figure 3).

Simultaneous mark and recapture studies and investigation of green turtle homing migration are consistent with these conclusions. With regard to green turtles only flipper tags from the Michoacan rookeries have been recovered on Baja California feeding grounds in recent years (Nichols, unpublished data, Seminoff and Resendiz, pers comm). Results of satellite telemetry experiments using three green turtles captured on feeding grounds in Baja California confirmed homing migrations to Michoacan, Mexico (Chapter 5). Based on results presented here, all three tracked turtles were confirmed to be of the putative Michoacan, Mexico haplotypes.

These results, despite several broad assumptions, emphasize two critical points. First, green turtles foraging in Baja California waters are primarily (> 90%) from the Mexican rookeries (Michoacan and possibly Islas Revillagigedos). Second, the absence of recovery signs on these rookeries, despite intensive government and university protection efforts, and evidence of recovery for other species nesting in Mexico after similar measures, may be largely due to the persistence of high levels of mortality on green turtle feeding grounds in Baja California. Efforts to reduce mortality on feeding grounds, currently underway (Chapter 8) should produce concomitant gains on eastern Pacific rookeries.

In conjunction with previous tagging studies and on-going satellite telemetry and morphometric research, the results obtained through molecular genetics can provide a base for further research and conservation efforts. Comparisons of these results to the composition of other feeding grounds, particularly those in southern Mexico and Central America, may provide further insights into migration and behavior of green turtles in the eastern Pacific.

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Table 1. Geographical locations of tissue samples, collected by year, at major green turtle feeding areas in Baja California, Mexico.

	Gulf of California (N = 71)		Pacific (N = 45)		
Year (sample size)	Bahía de los Angeles	Bahía de Loreto	Laguna Ojo de Liebre	Laguna San Ignacio	Bahía Magdalena
1995 (N = 19)	19	0	0	0	0
1996 (N = 36)	25	3	0	8	0
1997 (N = 38)	9	13	8	1	7
1998 (N = 23)	0	2	14	0	7
Totals (N = 116)	53	18	22	9	14

Table 2. *Chelonia mydas* sequence polymorphisms for a 385 bp of the control region of mtDNA. The 5 most common mtDNA control region haplotypes, and their temporary nomenclature, found on Baja California, Mexico, feeding grounds are shown (Dutton, unpublished data).

Haplotype	Base Position				
	60	99	185	257	318
B*	T	A	T	T	T
D	C	A	T	T	T
E	C	A	T	T	C
F	C	G	C	C	T
G	C	A	T	G	T

*Norman et al. (1994) designated this haplotype as "HAW".

Table 3. Number of individuals of each haplotype collected on Baja California feeding grounds.

Region (sample size)	Haplotypes B	D	E	F	G	N	O	P
Bahía de los Angeles (N = 53)	1 (2%)	3 (6%)	31 (58%)	11 (21%)	6 (11%)	1 (2%)	0 (0%)	0 (0%)
Bahía de Loreto (N = 18)	0 (0%)	1 (5%)	12 (63%)	2 (11%)	2 (11%)	0 (0%)	0 (0%)	1 (5%)
Laguna Ojo de Liebre (N = 22)	0 (0%)	0 (0%)	12 (52%)	0 (0%)	9 (39%)	0 (0%)	1 (4%)	0 (0%)
Laguna San Ignacio (N = 9)	0 (0%)	2 (22%)	5 (56%)	0 (0%)	2 (22%)	0 (0%)	0 (0%)	0 (0%)
Bahía Magdalena (N = 14)	0 (0%)	0 (0%)	8 (57%)	0 (0%)	6 (43%)	0 (0%)	0 (0%)	0 (0%)
Gulf of California Total (N = 71)	1 (>1%)	4 (6%)	43 (61%)	13 (18%)	8 (11%)	1 (>1%)	0 (0%)	1 (>1%)
Pacific Total (N = 45)	0 (0%)	2 (4%)	25 (56%)	0 (0%)	17 (38%)	0 (0%)	1 (2%)	0 (0%)
Overall Totals (N = 116)	1 (1%)	6 (5%)	68 (59%)	13 (11%)	25 (21%)	1 (1%)	1 (1%)	1 (1%)

Table 4. Number of individuals of each green turtle haplotype collected each year on Baja California feeding grounds.

	Haplotypes							
Year (sample size)	B	D	E	F	G	N	O	P
1995 (N = 19)	0 (0%)	2 (10%)	11 (58%)	3 (16%)	2 (10%)	1 (5%)	0 (0%)	0 (0%)
1996 (N = 36)	0 (0%)	3 (8%)	24 (67%)	6 (16%)	3 (8%)	0 (0%)	0 (0%)	0 (0%)
1997 (N = 38)	1 (3%)	1 (3%)	21 (54%)	4 (10%)	11 (28%)	0 (0%)	0 (0%)	1 (3%)
1998 (N = 23)	0 (0%)	0 (0%)	12 (52%)	0 (0%)	9 (39%)	0 (0%)	1 (4%)	0 (0%)
Totals (N = 116)	1 (1%)	6 (5%)	68 (59%)	13 (11%)	25 (21%)	1 (1%)	1 (1%)	1 (1%)

Table 5. Predicted and actual relative contributions of major green turtle, *Chelonia mydas*, rookeries, based on estimates of mean numbers of reproductive females for the past ten years and approximate distances to Baja California feeding grounds (BCFGs).

Rookery	Approx. number of mature females in rookery	Approx. distance to BCFG (km)[1]	Expected contribution to BCFGs[4]	Actual contributions to BCFGs
Michoacan, Mexico	1,000	1,000	80%/78%	71%
Islas Revillagigedos, Mexico	100	500	16%/14%	21%[2]
Hawaii, USA	250/500[3]	5,000	4%/8%	6%

[1]Measured to Cabo San Lucas, Baja California Sur, Mexico.
[2]Based on the hypothesis that haplotype G is represented at 100% on the Islas Revillagigedos rookery.
[3]Estimated at 250 and 500 reproductive females.
[4]Both scenarios, relative to changes in the size of the Hawaiian rookery, are presented.

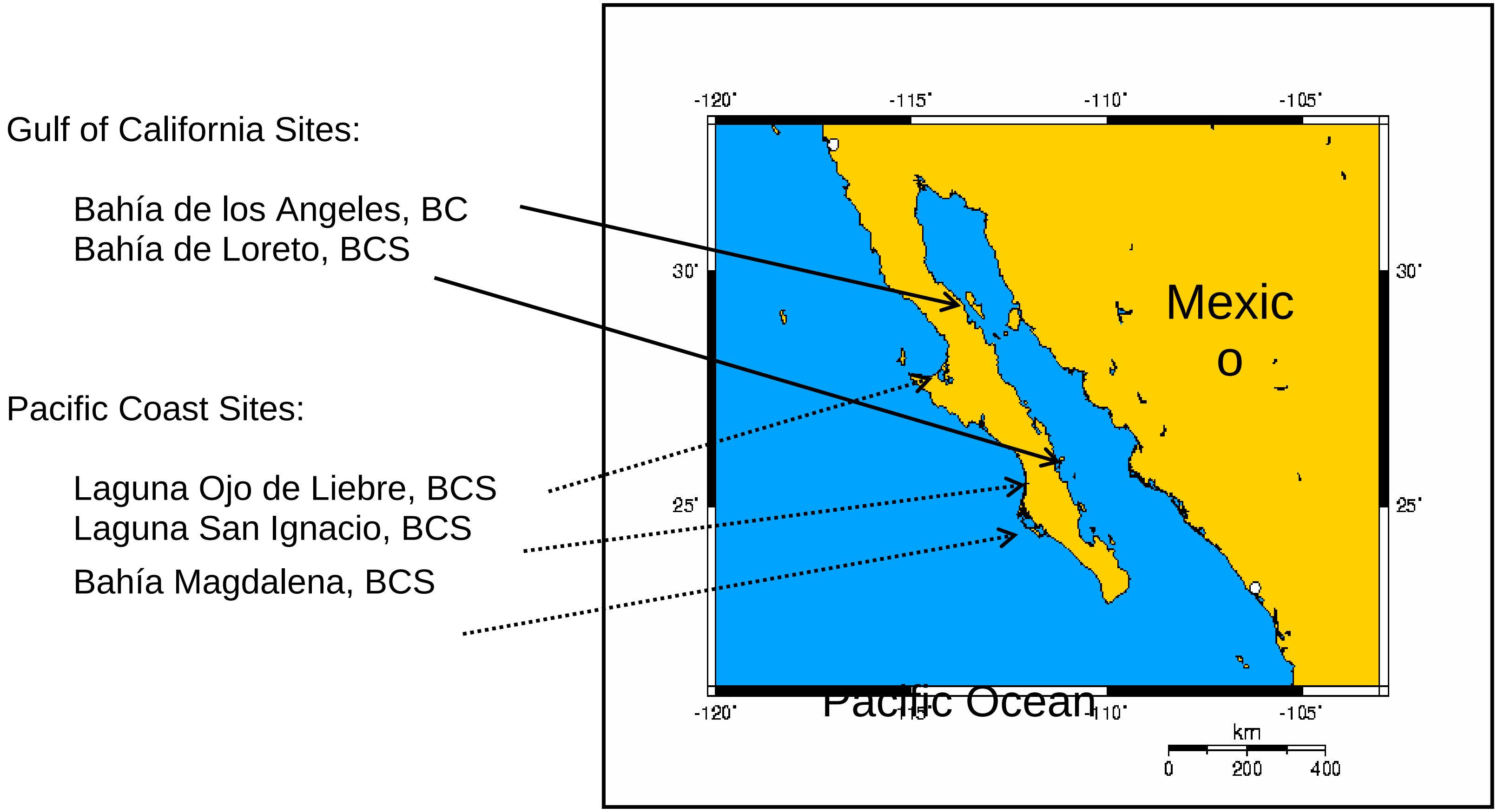
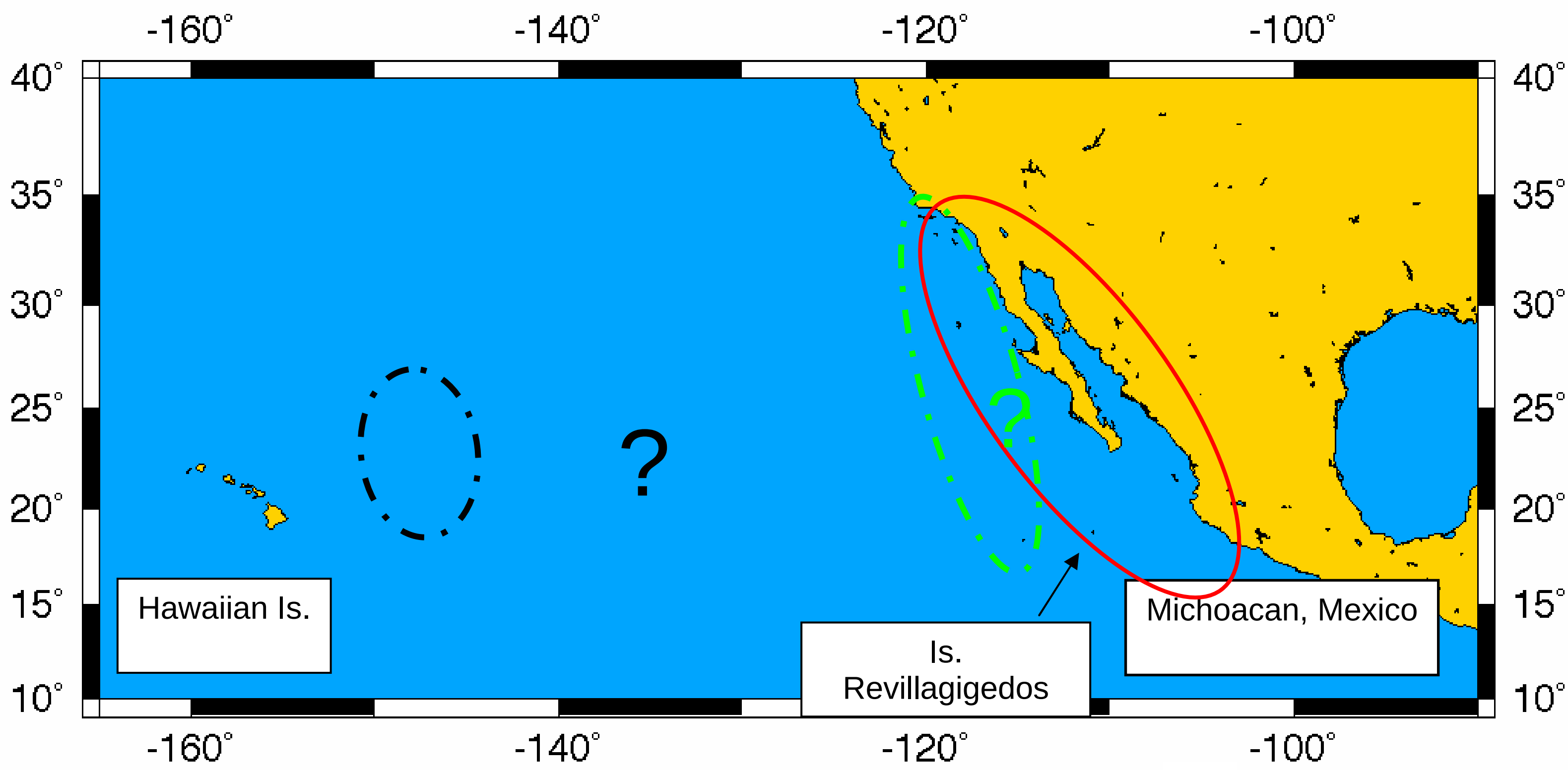


Figure 1. Study areas and sampling sites along the Gulf of California and Pacific coasts of the Baja California peninsula, Mexico.

Figure 2. Tissue sampling methodology. A small skin sample was taken from the neck or fore flipper of green turtles captured on their foraging grounds along the Baja California peninsula. Tissues were preserved in a 10% DMSO solution saturated with NaCl.



Solid line represents established relationship, dotted lines represent hypothesized relationships based on genetic data alone.

Figure 3. Origins of green turtles, *Chelonia mydas*, on Baja California feeding grounds based on analysis of mtDNA haplotypes. Satellite telemetry and flipper tagging data support the Michoacan-Baja California relationship.

Figure 4. Haplotype frequencies of green turtles at major feeding areas on the Baja California peninsula, Mexico. Haplotypes B and D are known from the Hawaiian Islands (Dutton, unpublished data). Haplotypes E, F, and N are known from rookeries in Michoacan, Mexico. Haplotype G is the putative "Islas Revillagigedos" haplotype.

CHAPTER 7
WHAT IS A BLACK TURTLE?
THE EAST PACIFIC GREEN TURTLE PROBLEM

ABSTRACT

Recent debates over the taxonomic status of the East Pacific green turtle (*Chelonia mydas*), known locally as the black turtle, have distracted attention from the primary concerns regarding sea turtle conservation in the eastern Pacific. Arguments asserting that specific status for the East Pacific green turtle (*Chelonia agassizii*) have been bolstered by geopolitical concerns and as a dishonest conservation tool have filled journal pages with a war of words that seem irrelevant to current conservation needs and biological reality. Based on the examination of 82 East Pacific green turtles from the Mexican genetic stock, sampled on feeding grounds in Baja California, Mexico, I demonstrate that color, size and to a lesser extent, carapace shape are widely variable and unreliable indicators of stock affinities. Such morphological characters provide weak evidence for isolation. Green turtles on Baja California feeding grounds reach sizes far greater than the minimum and mean size of nesters (60 cm and 77.3 cm, respectively, SCL) and approximate the sizes of mature Hawaiian green turtles (> 90 cm). Carapaces and plastrons of East Pacific green turtles are generally dark in color, predominantly brown with black and gray, respectively. However, some turtles of the Mexican stock exhibit lighter coloration in their carapaces and plastrons, particularly turtles in small size classes. East Pacific green turtles of all sizes tend to be slightly more vaulted than their Hawaiian counterparts, and caudal indentations over the hind flippers vary from

extremely pronounced to subtlety apparent. Findings support the conclusion that the East Pacific green turtle may be a geminate evolutionary unit. Each green turtle stock should be managed for recovery and their importance to eastern Pacific marine ecosystems and human cultures emphasized, rather than the advocated species concepts of researchers. The main threats to East Pacific green turtle stocks have little to do with taxonomy, and are primarily political and social in nature. Conservation efforts will produce the greatest gains when they focus on issues related to poaching and fisheries-related mortality.

INTRODUCTION

"...the fairest thing on the dark earth: I say it is whatever one loves...

Helen, far surpassing the beauty of mortals,

leaving behind the best man of all, sailed away to Troy..."

-Sappho

There has been considerable confusion and debate over the taxonomic rank of the East Pacific green turtle, *Chelonia mydas*, also known commonly as the black turtle, *tortuga negra*, or *tortuga prieta*. Some, based on phenetic analysis and morphological differences, consider the East Pacific green turtle a full species (*Chelonia agassizii*) (Pritchard 1999). Others regard it as a geminate evolutionary unit (GEU), within the global green turtle (*Chelonia mydas*) complex (Karl and Bowen 1999). Some authors have claimed that pro-*agassizii* motives were based on untruths and political, rather than scientific, purposes related to conservation agendas—using the analogy of war to describe the exchange of ideas (Bowen and Karl 1999). Karl and Bowen (1999) proposed the "geopolitical species concept" to describe the criteria that drive, in their opinion, the debate on this group's status. Others retort that pro-*mydas* views were lacking robustness, particularly with regard to species concepts, morphology, and behavior (Pritchard 1999).

A number of the discussions and debates have focused on advocacy of particular views of evolutionary theory rather than the physical realities of the turtles themselves. For example, during my first meeting with Brian Bowen in 1993, he asked me if I was going to "shoot down *Chelonia agassizii*." Several years later, during an invigorating discussion of the status of the black turtle at the 20th Symposium on Sea Turtle Biology and Conservation, Peter Pritchard incorrectly described the size distribution and coloration patterns of the East Pacific green turtle, in a way favorable to his point of view—that *Chelonia agassizii* is a small, dark, unusually-shaped congener of *Chelonia mydas*. Consider the following quote from Pritchard (1999): "…their interpretation that genetic data provide evidence that the East Pacific green turtle is *at best only* a subspecies of *Chelonia mydas*" (my emphasis). The implication of the hierarchical *at best* and the diminutive *only* is that subspecific status, even if warranted, is somehow *less desirable* than specific status.

While closure of the *mydas-agassizii* debate nears, resolution of this dilemma has not proven easy—however, for a lack of information and differing species concepts rather than politics. Issues related to the nomenclature, morphology, evolutionary history, and specific status have been discussed sporadically in the literature, but not resolved based on a thorough examination of green turtles from the various regional stocks in question (Parham and Zug 1996, Karl and Bowen 1999, Pritchard 1999).

Missing from this discussion have been the perspectives of researchers with extensive experience with East Pacific green turtles on both nesting beaches and feeding areas, familiarity with adult and immature size class morphologies, and an impartiality towards resolution of taxonomy in a manner independent of conservation imperatives. Furthermore, modern genetic tools used in conjunction with morphological descriptions may offer some new insights.

Here I offer an assortment of observations and insights to the debate. My intention is not complete resolution of the status of the East Pacific green turtle within the global *Chelonia* complex, as that shall be left to a much larger study by professional taxonomists, morphometrists, and geneticists to work out. Regardless of the evolutionary and morphological affinities of the East Pacific green turtle, I hope to at least insist that the dire straits of these taxonomically challenged *Chelonia* stocks be recognized and that conservation efforts focus on their ecological role, cultural significance, and commercial value. This perspective should not be overshadowed by the drive to win the *war*, capture Troy, and take *Helen* home.

NOMENCLATURE AND TAXONOMY

The nomenclature used to describe the East Pacific green turtle has been confusing. Subtle morphological, behavioral, and physiological differences likely exist between many green turtle populations (Hirth 1997). If they are found to be associated with reproductive isolation, and represent an important component of the species' evolutionary history, several of the proposed subspecific designations may apply.

The valid name for the green turtle is *Chelonia mydas* (Linnaeus) 1768. *Chelonia mydas agassizii* (Bocourt) has been described in the eastern Pacific, from the coasts of the Americas and the Galapagos Islands. Caldwell (1962) described a new subspecies of green turtle, *Chelonia mydas carrinegra,* in the Gulf of California, based on characters previously described for East Pacific green turtles—primarily dark coloration. *Chelonia agassizii* has been used intermittently by several researchers (Pritchard and Trebbau 1984, Márquez 1990, Figueroa and Alvarado 1991).

Common names for these green turtles include, in English, "East Pacific green turtle" and "black turtle"—in Spanish, *tortuga prieta*, *tortuga negra,* and *tortuga blanca*. In the Galapagos Islands a particularly light-colored morph is known as the "yellow turtle".

The Seri Indians of Sonora, Mexico, distinguished eight kinds of *Chelonia* (Table 1). Some of the names refer to size and condition of the turtles rather than morphology. However, three morphotypes within Seri taxonomy roughly coincide with the contemporary variations I have seen in Baja California. Mexican fishermen refer to several color patterns of Chelonia as well, including the dark *negra* (black) and the brown *frijolillo* (the color of beans).

Carr (1952), in *The Handbook of Turtles*, writes:

> "It seems most unlikely that only one recognizable form exists in the Indo-Pacific area; if this should prove to be the case, then all the green turtles there will have to be called *japonica*, since that is an older name than *agassizii*. In the present account it has seemed to me that the most convenient course is to follow earlier writers in regarding the green turtle of the eastern Pacific as different from that of the western Pacific…I have…seen enough of *C.m. agassizii* on the Pacific coast of Central America to feel little hesitation in saying that it is different from *mydas* on the other side and that, moreover, these differences are merely average ones which show considerable overlapping; and for this reason it seems best to use trinomials for the two forms."

Parham and Zug (1996) provide some advice on nomenclature based on the available names for this *Chelonia* population. They conclude that if the eastern Pacific population is distinct from the rest of the world, the valid name is *Chelonia formosa*. If Pacific populations as a whole are distinct from those of the rest of the world, the valid name is *Chelonia japonica*, and *Chelonia mydas* remains for the rest of the world. They advise that *Chelonia mydas* should be used presently for green turtle populations throughout the world, using common names in association to distinguish eastern Pacific populations (e.g. East Pacific green turtle).

It is important that conservation needs and advocates do not dictate taxonomy (Bowen and Karl 1999). And it goes without saying that taxonomy, but not taxonomy alone, should influence conservation. As conservation biologists we work to protect those groups and forms considered valuable—whether that value is based on a desire to preserve diversity, ecosystem processes, economic potential, or some aspect of our innate affinity for the natural world (Kellert and Wilson 1993).

GENETICS

Recent advances in molecular genetics have offered particular insights into sea turtle phylogeography (Bowen and Karl 1996). Resolution of evolutionary affinities within the global *Chelonia* complex has provided elegant new hypotheses regarding sea turtle life history and behavior (Bowen et al. 1995). Genetic markers have been useful for identification of stocks and management units (MUs), particularly with regard to feeding grounds (Lahanas et al. 1998, Chapter 6).

With regard to the East Pacific green turtle, recent genetic data do not support its uniqueness as a phylogenetic unit (Bowen and Avise 1995, Karl and Bowen 1999). The major phylogenetic structure lies consistently along ocean basins, resolving the Atlantic-Mediterranean and Indian-Pacific groups (Bowen et al. 1992, Karl and Bowen 1999).

The East Pacific green turtle likely represents a geminate species, or geminate evolutionary unit (GEU), and we are currently measuring early stages of genetic divergence and relatively recent isolation. As Bowen (1998) states: “a lack of genetic distinctiveness at neutral loci, in the face of morphological, behavioral, or biogeographic differentiation, may denote an important finding.”

The future evolutionary potential of this unit (East Pacific green turtle) qualifies it under the evolutionarily significant unit (ESU) criteria (Waples 1991). It is worth considering that the majority of these findings are based on analyses of remnant green turtle stocks, at perhaps less than 1% of their pre-exploitation levels (Chapter 2). As such, genetic diversity within regions is likely artificially low and regional differences may be overestimated or strongly influenced by anthropogentic patterns.

Haplotype frequencies for the Mexican East Pacific green turtle rookeries have been identified and used to help determine natal origins of green turtles foraging in Baja California waters (Chapters 5 and 6). Based on these results I have hypothesized that Baja California green turtles are predominantly from the Michoacan, Mexico, stock and to a lesser extent from the Islas Revillagigedo and Hawaiian stocks. Conservation attention within the region should be focused on the protection and recovery of the most vulnerable stocks. The East Pacific green turtle should tentatively be considered a GEU. Within the region, rookeries should be managed for recovery and on feeding grounds genetic diversity monitored. Actions should focus on preserving the diversity (both genetic and, as we will see, morphological) within the East Pacific green turtle. This variety is the source of future *Chelonian* diversity.

MORPHOLOGY

Subtle morphological differences between groups of animals are commonly used to distinguish sympatric morphotypes, populations, subspecies, congeners, and to describe hybrids (Nishiwaka and Tobayama 1982, Schnell et al. 1982, Brownell et al. 1987, Rosel et al.1994). Several authors have investigated the morphometrics of sea turtles (Cornelius 1976, Le Toquin et al. 1980, Balazs et al. 1998, VanDam and Diez 1998, Coles 1999). However, wide variation within groups and overlap between populations may preclude the use of such characters as evidence for evolutionary history and reproductive isolation.

Descriptions of sea turtle morphology will benefit from stock-specific morphological studies, especially on feeding grounds where all size classes may be available to the researcher. We have determined that sea turtles from at least three disparate rookeries may forage together in Baja California waters, including green turtles from Michoacan, Islas Revillagigedo, and Hawaiian stocks (Chapter 6). Basing morphological studies of variation within genera—or the description of a new species and subspecies (Caldwell 1962a)—on an unfiltered “grab-bag” of *Chelonia* from the feeding grounds may result in erroneous conclusions. Turtles from each of these stocks may have varying, wide ranging color patterns, shapes, length to weight ratios, and maturity characteristics. For example, in the Hawaiian Islands, green turtles exhibit predominantly *mydas*-like characteristics, although *agassizii*-like features have been reported (Balazs 1990). Carr (1972) observed the *agassizii*-morph in regions other than the eastern Pacific: “To my eye…the black turtle stock occurs elsewhere…among the mid-Pacific Islands, and in parts of the Indian Ocean.” It is possible these may have been turtles from the East Pacific green turtle stocks on wide-ranging developmental and/or foraging forays, or that the *agassizii*-like characters occur in stocks throughout the Pacific basin.

By determining the natal origins of these turtles prior to assessing their morphologies, we can provide information that is useful for specific conservation units and avoid erroneous speculation on the relevance of morphology to resolving stock structure.

Caldwell (1962a), after carefully studying a large number of green turtles harvested near Bahía de los Angles, Baja California, described them as morphologically distinct—based primarily on color—from other Pacific green turtles, naming them *Chelonia mydas carrinegra*. However, he based this primarily on turtles harvested on feeding grounds and without knowledge of the location of their natal rookeries. Several other authors have highlighted the morphological distinctiveness of the East Pacific green turtle (Carr 1961, Figueroa and Alvarado 1990, Balazs 1990, Kamezaki and Matsui 1995, Pritchard and Mortimer 1999, Pritchard 1999, Ugalde-Caballero 1999). Five main features consistently stand out in these discussions:

1) The relatively small size of East Pacific green turtles relative to *Chelonia* in other regions.
2) Heavy black pigmentation or marked melanism of the carapace, head, flippers, and neck of East Pacific green turtles.
3) Suffusion of gray pigmentation in the otherwise light colored plastron.
4) Indentations or constrictions of the carapace margins over the hind flippers (cordiform shape of the carapace).

5) Slight dorso-ventral expansion: the carapace is "higher and narrower", vaulted, or arched.

Between 1995 and 1998 I collected data on 82 green turtles from Baja California feeding grounds determined to be part of the Mexican stock (predominantly haplotypes E and F, see Chapter 6). I investigated their morphology, relative to the five characteristics described above. For some of the turtles, full morphological examinations were not possible due to the circumstances of data collection, so sample sizes will vary for each character.

1) Size.

Body size has been used to distinguish the East Pacific green turtle from other green turtle populations (Figueroa et al. 1992). Pritchard (1999) suggests that the relatively diminutive East Pacific green turtle could not mate with the massive green turtles found at the Ascension Island rookery. However, these populations represent the extremes of the size range found in *Chelonia*. The difference between the mean sizes of East Pacific green turtles, of the Mexican stock, and the adjacent Hawaiian stock is not nearly as drastic as the Atlantic/Pacific differential (Balazs 1980, Figueroa et al. 1992).

Body weights for 60 green turtles from feeding areas, known to be part of the Mexican stock, ranged from 12 to 130 kg. Mean weight for pooled size and sex classes was 52.5 kg, (SD = 3.02). There was no difference in weights for recognizably male and unsexed turtles ($p > 0.2$), as suggested by Caldwell (1962). Weight can be predicted from SCL using the equation:

$$\log(W) = 0.318 + 0.019\,(L) \quad (R^2 = 0.963)$$

Where W is body weight and L is straight carapace length measured from the notch to tip.

Straight carapace lengths for 68 turtles of the Mexican stock captured on feeding grounds ranged from 40 to 100 cm (mean = 69.6 cm, SD = 1.54). Seminoff et al. (in prep.) report a mean SCL of 83.9 cm (range 77.3 to 89.2 cm) for 16 mature male (based on tail length) East Pacific green turtles from Bahía de los Angeles, Baja California. The size range for 152 turtles, of all represented stocks, randomly captured in Bahía de los Angeles was 46.0 to 96.6 cm (mean = 75.1 cm), and was not significantly different from those used in this analysis.

Balazs (1990) reported that the sizes of 379 green turtles nesting at French Frigate Shoals between 1973 and 1979 were between 80.8 to 106.2 cm, with a mean SCL of 92.2 cm. Green turtles nesting in Michoacan had mean carapace lengths of 82 cm (~77.3 cm SCL, n = 718, range 60.0 – 102 cm) (Alvarado and Figueroa 1990), and Cornelius (1976) reported mean SCLs of 82.9 cm for *Chelonia* at Playa Naranjo, Costa Rica (range 73.0 – 97.0, n = 73).

It is difficult to make conclusions based only on comparisons of size ranges of turtles on feeding grounds to those on nesting beaches. However, we have regularly found turtles in Baja California waters, of the Mexican stock, that exceed the mean size of nesters in the Hawaiian stock (92.2 cm), and turtles larger than the minimum size at nesting in Hawaii are extremely common in Baja California (Chapter 1). In Bahía de los Angeles, Baja California, Caldwell (1962) reported East Pacific green turtles larger than 95 cm (120 kg). Fishermen also report that captures of East Pacific green turtles in excess of 100 cm (SCL) and 200 kg were once common on feeding grounds near San Juanico, Baja California Sur, along the Pacific coast of the peninsula. Furthermore, we are currently satellite tracking a 102.7 cm (SCL), 140 kg, green turtle captured in Bahía Magdalena, Baja California Sur. East Pacific green turtles may be slightly smaller than their Hawaiian counterparts, on average, but to characterize them as a diminutive race of green turtle is erroneous. Reproductive barriers between eastern Pacific and Hawaiian stocks based on size, is not likely.

Nutrient limitation in the eastern Pacific Ocean, diet (algae vs. sea grass), cool, temperate waters (< 15°C in winter) encompassing the main feeding grounds, and slow growth rates (<2 cm/y average for all size classes) (Seminoff et al., in prep.), may partly explain the trend to smaller East Pacific green turtle adult size.

Considering the nearly complete extirpation of the East Pacific green turtle on their Baja California feeding grounds during the past two decades, current harvest of adult turtles on feeding grounds, high levels of contemporary fisheries-related mortality (Chapter 3), and poaching of adult turtles from Michoacan nesting beaches until 1990 (Figueroa et al. 1992), it is possible that the apparent size differential is an artifact of overexploitation, and recovering stocks. As recovery of the East Pacific green turtle stock continues, it will be informative to monitor the mean size of nesting females relative to those of Hawaiian green turtles, which have not been exported since 1900 and have been protected by the U.S. Endangered Species Act since 1978 (Balazs 1980).

2) Body proportions.

The East Pacific green turtle has been described as having a narrow, vaulted carapace. To investigate this character, the ratio of the curved to straight carapace width

(CCW/SCW) was used to provide a simple index of "vaultedness". Widths were measured at the widest point of the carapace.

Adult-sized turtles (SCL > 77.3 cm) showed no evidence of variation ($p = 0.98$), relative to sex, in the ratio of curved to straight carapace width, and were pooled for further analyses. The mean ratio for 50 immature-sized turtles (SCL < 77.3 cm) was 1.26 $\pm$ 0.03 with a range of 1.17 to 1.35. Nineteen adult-sized turtles had a mean curved to straight carapace width ratio of 1.26 $\pm$ 0.04 with a range of 1.21 to 1.36. No significant difference was found between adult and immature sized turtles with regard to the "vaultedness" index. However, it is apparent that the ratio becomes greater as the carapace length increases (Figure 1). In fact, the mean CCW/SCW ratio for 157 nesting East Pacific green turtles in Colola, Michoacan, measured between 1995-1996, was 1.35 $\pm$ 0.05 (range 1.22 to 1.54). Nesting turtles ($n = 157$) were significantly more vaulted than adults from the same stock on feeding grounds ($n = 19$) ($p < 0.01$) as well as adult green turtles nesting on French Frigate Shoals ($p < 0.01$).

Balazs (1987) described a similar trend among green turtles on Hawaiian feeding grounds (Figure 2). Among 122 immature green turtles, the mean ratio of curved to straight carapace widths was 1.20 $\pm$ 0.04, with a range of 1.11 to 1.19. Also, the adult female Hawaiian green turtles are reported to have a highly arched appearance (Balazs 1980). Among 93 adult female green turtles nesting on French Frigate Shoals this ratio was found to be 1.28 $\pm$ 0.05, with a range of 1.17 to 1.44.

The ratio of body depth to SCL was compared in nesting green turtles from Colola, Michoacan, and adult-sized turtles from Baja California feeding grounds. Means for both populations were 0.37 $\pm$ 0.02, and no evidence for difference was found (p =

0.47). No difference was detected between differentiated males on feeding grounds and nesting females ($p = 0.49$). Pooling data from both feeding grounds and nesting beaches Figure 3 shows how the ratio BD/SCL remains relatively constant as turtles grow.

Despite slight overlap in the ratios of immature (SCL < 77.3 cm) Baja California and Hawaiian *Chelonia*, there was strong evidence that they differed in carapace vaultedness ($t = 9.77$, $P < 0.0001$, 166 *d.f.*). When only size classes smaller than 60 cm (SCL) are considered, differences are still highly significant ($p < 0.0001$).

3) Shape-caudal indentations.

Nearly all green turtles encountered in Baja California waters exhibited caudal indentations over the hind flippers (94%, n = 82), although to varying degrees, with the exception of several of the smallest immature turtles (Figure 4). In some turtles the caudal indentations are extremely pronounced, giving the carapace a marked heart-like shape. In other cases, carapaces are more rounded and "*mydas*-like". This character has proven difficult to quantify.

As East Pacific green turtles grow, the caudal portion of the carapace has a tendency to become more elongated relative to SCL through an elongation or widening of the pair of pygal or post-central scutes (the marginal scutes directly over the tail).

Caudal indentation is common in East Pacific green turtles, but sufficiently variable so not to be a reliable stock-identifying character. Furthermore, it has been described, to some degree, at other Pacific locations.

4) Shape-roundness.

The East Pacific green turtle carapace has been described as being elongated and narrower than other green turtle populations, which are more round in shape. In green turtles there is a general trend towards a loss of roundness and a more narrow, elongated form as carapace length increases. In both Mexican and Hawaiian (Balazs 1980 and 1987) stocks, immature turtles have higher roundness indexes (SCW/SCL) than mature turtles ($p < 0.001$). Roundness indices in immature Mexican and Hawaiian green turtles (SCL < 70 cm) were not significantly different ($p = 0.10$).

However, roundness index differences were detected between adult females on Michoacan, Mexico (1995-1996) (mean = 0.74 ± 0.03, 0.67 – 0.84, n = 157), and Hawaiian rookeries (mean = 0.77, 0.74 - 0.81, n = 379) (Balazs 1980). Figueroa (1989) also calculated roundness indices for adult female turtles nesting in Michoacan (1985-1987) (mean = 0.73 ± 0.04, 0.70 – 0.82, n = 100). Roundness indices for Hawaiian turtles are similar to those reported for Ascension Island (mean = 0.77 ± 0.06, 0.61 – 1.00, n = 200) and Tortuguero (mean = 0.77 ± 0.03, 0.64 – 0.97).

On average, roundness, or the SCW/SCL ratio, may be a useful character for describing stock differences. However, considerable overlap doesn’t allow roundness as a diagnostic character for taxonomic separations.

4) Color-carapace and plastron.

Green turtle carapace and plastron patterns are difficult to describe and highly variable. Hirth (1997) summarized color patterns described for several regions. Generally, green turtle carapaces have variable black, brown and yellow streaks that become suffused with olive-green spots. Plastrons are generally white, becoming light yellow in adults.

I assessed the coloration and pigmentation of the carapaces and plastrons of 69 turtles. The Pantone™ color matching system was used to standardize descriptions of

pigmentation. A majority of the turtles, 64% (n = 44) were described as having dark, nearly completely black (7C), or black with gray (3U), carapaces (Figure 5). Approximately 22% (n = 15) were categorized as having moderately dark carapaces that contained black, gray, and dark brown (477U), with some light brown (478C) (Figure 6). Only 14% (n = 10) of the carapaces were considered light colored, containing excess brown (469/478C), brownish-red, and light gray (3U) pigmentation (Figure 7).
There was no evidence of variation in mean SCL for color classes (ANOVA $F_{2,58} = 1.49$, $p = 0.23$).

Plastron patterns are generally more straightforward to assess, due to the relative uniformity of color. East Pacific green turtle plastrons are typically cream or yellow in color with suffusing gray pigmentation on the sides and mid-line (Figures 5 and 6) and occasionally covering the majority of the plastron. Some fishermen in Baja California call turtles with white or cream colored plastrons, *tortuga gallina*, and say that only small turtles lack gray plastron pigmentation (Figure 8). Four turtles were encountered without any gray plastron pigmentation. The mean SCL for these turtles was 52.4 cm (range 45 to 65 cm). Turtles with amelanistic plastrons were significantly smaller than those with gray plastron pigmentation ($t = 3.46$, $p < 0.05$, 4 d.f.).

Generally, carapace coloration among all size classes of green turtles from the Mexican stock is extremely variable, ranging from nearly entirely black with mottled gray spots to lighter brown with “starburst” patterns—a pattern more typical of that described in central and western Pacific—and even Atlantic—green turtles. Occasionally turtles have starburst patterns of radiating lighter brown and light gray. Carapace color does not appear to be a consistent, reliable indicator of stock affiliation, or natal origin.

Plastrons tend to be yellow, cream, or white in color with gray pigmentation along the edges and down the medial line, often suffusing the entire plastron. Turtles without gray pigmentation in the plastron are occasionally encountered, but tend to be small in size. It is thought that pigmentation may change with size, with turtles becoming more melanistic as they grow (Figures 6 and 14). All adult-sized turtles had partially to completely gray plastrons. Plastron color varies from white/light yellow in immature turtles (< 65 cm, SCL) to nearly solid gray in larger turtles (Figure 9).

The carapace of the adult Hawaiian green turtle has similarly been described as predominantly black (80% or more) with infusions of yellowish gold and olive (Balazs 1990). The head and flipper are also predominantly dark in color with light outlines of the scales. A small number of turtles have a predominantly brown carapace with yellow, gold and reddish brown patterns. Plastron color ranges from orange to yellowish orange in Hawaiian green turtles, and the gray pigmentation described for the East Pacific green turtle has only been found in a few Hawaiian *Chelonia* (Balazs 1990). However, the turtles pass through a pronounced color phase where plastrons become diffused with gray and black pigment (8 cm carapace length), disappearing by 20 cm carapace lengths. Juvenile Hawaiian green turtles are described as having highly variable color patterns. Recently a turtle with distinctively *agassizii*-like characters was encountered. Genetic analyses indicate that the turtle came from the Mexican stock (Balazs, pers. comm.).

The Seri Indians, of Sonora, Mexico, recognized distinct “chromotypes” (Table 1) within the *Chelonia* populations of the Gulf of California (Felger and Moser 1985). These are broadly described as a light or “red” turtle, a large and strong dark, “blue” turtle, and the gray and brown common turtle of the ancestors. These categories roughly coincide with the general color patterns found presently in *Chelonia* from Baja California waters.

- "Blue" chromotype (Figure 5). Carapaces have highly melanistic carapaces and plastron. Carapace may have mottled gray appearance. Plastron can appear dark gray-blue. These turtles can be very large in size, over 100cm (SCL) and up to 200 kg. Caudal indentation is most pronounced over the rear flippers and carapace is highly vaulted. This is likely the morphotype described by Caldwell (1962) as *C.m. carrinegra*. It is the most common color pattern found in Baja California and Michoacan, Mexico.
- "Brown" chromotype (Figure 6). This turtle appears to be neither as large, nor as heavily melanistic as the "blue" chromotype. Carapace is gray with medium brown spots and streaks. The plastron is light yellow with light gray infusion. Caudal indentations are not as pronounced as in the "blue" type. The brown color pattern is moderately common on Baja California feeding grounds.
- "Red" chromotype (Figure 7). These turtles have carapaces with a higher percentage of light brown, reddish brown, and yellow pigmentation, often with radiating "starburst" patterns. Plastrons tend to be more yellow in color, but with slight infusions of gray in larger turtles. This color type is the least common in Baja California and Michoacan.

My survey of these four characters that have been used to promote the East Pacific green turtle as a distinct taxonomic unit, indicates that considerable variation occurs within the Mexican stock. The range of variation overlaps considerably with that of the adjacent Hawaiian stock. To my eye, the variation of shape and color in the Mexican stock includes a range of turtles formerly described as *mydas*-like, with a majority of the animals exhibiting “classic” agassizii-like traits.

Size, shape and color variation should be investigated for additional *Chelonia* stocks, on nesting beaches as well as feeding grounds, in order to include all size classes.

WAR GAMES: TOWARDS AN APOLITICAL SEA TURTLE

The conservation problems facing the East Pacific green turtle have little to do with the political concerns and "lies" related to taxonomy raised by Bowen, Karl and Pritchard (Conservation Biology, vol 13. No. 5, 1999). Furthermore, the morphological analyses of the previous sections, while elucidating the patterns previously derived using molecular genetics, hold little directly relevant information for dealing with the main threats to eastern Pacific *Chelonia* stocks.

Strong biases in scientific matters is ideally an avoidable—but more likely, inherent—evil, and using conservation imperatives to manipulate taxonomy is certainly intolerable, "bad" science. However, in the interest of advancing conservation biology, several other issues take precedence regarding the status of the East Pacific green turtle. In following two sections I will describe the actual conservation context of the East Pacific green turtle, particularly the Mexican stock, in the Baja California and wider eastern Pacific regions, and point out how if scientific results regarding the taxonomic status of the East Pacific green turtle have been "spun" by advocacy organizations, they have surely been spun in the wrong direction.

Despite nearly twenty years of protection on the main rookeries in Michoacan, Mexico, the number of nesting East Pacific green turtles continues to decline (Figueroa et al. 1992). More than 7,800 East Pacific green turtles are harvested annually in Baja California alone (Chapter 3), bycatch levels are unknown, and an active black market for turtle products exists (Resendiz and Hernandez 1993). This rate of mortality has not been adequately addressed by resource managers and may be hidden in order to protect lucrative but politically volatile fisheries such as those for shrimp and finfish, as well as personal interests in access to turtle meat. A recent example illustrates the practical difficulties facing East Pacific green turtle conservation in Baja California.

In late 1997 and early 1998, the death of 94 green turtles in the Guerero Negro, Baja California Sur region was reported by fishermen and subsequently attributed to the large salt producing corporation, Exportadora de Sal, S.A. (ESSA) by Procuraduria Federal de Proteccion al Ambiente (PROFEPA), a Mexican Federal Environmental Enforcement Agency, as well as several environmental organizations such as Greenpeace-Mexico, Grupo de los Cien, Natural Resources Defense Council, World Wildlife Fund, and International Fund for Animal Welfare (Cousteau 1998). The environmental groups quickly seized the opportunity to link the turtle deaths to the salt project, decrying that they may “be the key to protecting their brethren in San Ignacio from a similar fate.” The official report on the turtle mortality concluded that the turtles died of osmotic shock related to the release of bitterns from the salt production process (PROFEPA 1999).

This salt exportation company had already been the focus of much negative attention due to their controversial proposal to construct a second, larger processing facility near the neighboring San Ignacio Lagoon in the Vizcaino Biosphere Reserve. The proposed expansion to include this lagoon, an area that is classified as a whale sanctuary, Biosphere Reserve and considered ecologically sensitive, has been strongly protested by the international environmental community for the past several years and has been the focus of a vigorous campaign (Dedina 2000). The successful movement to resist the proposed development had drawn attention from the international media as well as the support of American actors and politicians. The death of the marine turtles and subsequent PROFEPA report therefore provided further reasoning for the environmental activist community to protest the new plant. However, the development of political agendas around this issue may have delayed the scientific facts (Knudson 1999) and obscured the truth about the source of the turtle mortality, ultimately misguiding conservation efforts directed at the recovery of the green turtle. Several aspects of the PROFEPA report are inconsistent with our knowledge of sea turtle biology, distribution and abundance.

There are five distinct areas of concern with regard to the conclusions of the PROFEPA report:

1) *Analysis of toxicology data*.

The PROFEPA report proposed that a toxicological cause of the turtle mortality could have been due to one of three scenarios. The first is that contamination from the salt brine settlement ponds and/or discarded batteries were sufficiently high to induce acute lethal toxicity. The second is that the saline conditions resulting from salt brine effluent induced lethal osmoregulatory stress. The third is a combination of both of the above factors in which the osmoregulatory stress created by hypersaline conditions made the turtles more susceptible to lethal effects of other contaminants.

The report concludes that it was the third explanation, a combination of both hypersaline conditions and exposure to contaminants that resulted in lethal effects to the turtles. However, there is insufficient information to support this conclusion. The lack of toxicological data pertaining to the influence of osmoregulatory stress and the toxicity of contaminants in aquatic organisms (especially for turtles) makes interpretation of this explanation very difficult. However, it is the lack of replication of the samples from this study that is the most severe limitation in defending or refuting any of the proposed hypotheses. The total number of dead and healthy turtle tissues examined for toxic residues was not adequate to conduct a conclusive evaluation. In some cases, there were tissue concentrations from only 2 inflicted animals, making it impossible to conduct a quantitative comparison between the contaminant levels in healthy versus stranded turtles. Preliminary data from a study of heavy metal concentrations in the scutes of wild, apparently healthy, sea turtles in Baja California waters suggest that the presence of low mercury levels may be worth monitoring (Presti 1999). Inadequate sample replication was a major limitation in the interpretation of toxicology data. (This shortcoming in baseline data is currently being addressed through a collaborative project with CIBNOR, La Paz, Baja California Sur)

These animals died within a rather short period of time. Therefore, if the causes of mortality were of toxicological origin, the turtles would have been exposed to a very high concentration of some agent. No such levels of any of the toxicants analyzed were detected in the water or tissue samples. Exposure to low concentrations of toxicants over long periods of time would result in subtle physiological or biochemical effects that initiate the beginning of a disease state. Mercury in small levels over time may cause neurotoxicity and immunosuppression. This could substantially affect turtle survival. However, it would not be typically characterized by an acute mass die-off (Presti 1999).

2) *Lack of other species mortality*.

Anecdotal evidence was presented in the PROFEPA report that suggests that there may have been fish and phytoplankton mortality in the Laguna Ojo de Liebre. However, the report states that initially no death of any additional aquatic species was reported. Data on biological diversity of the aquatic community was presented, but without the use of standardized scientific methodologies (such as indices of biological diversity). These quantitative analyses need to be conducted in order to provide an accurate description of the ecological health within different areas of the lagoon and through time.

It seems logical that a spill large enough to kill nearly 100 sea turtles in such a short period of time would have also resulted in massive mortality of fish and invertebrates that would have been overwhelmingly obvious to everybody in the area.

Furthermore, ESSA's salt production, like all other saltworks, has produced large amounts of bitterns since they began operations. Until 1996, when they began storing them, these bitterns were dumped in the lagoon and were never reported to have produced any of the reported sea turtle mortality effects.

3*) Lack of comparisons of stranded animals to the population at large.*

According to the PROFEPA report (1999), of the 94 turtles found stranded, 93 were described as mature and immature females. The report states that the stranded turtles represent a "normal" grouping, and that males are solitary and are only found during mating. This is not consistent with our data from sea turtle research in the region over the past three years in which mature male turtles are frequently encountered together in Baja California waters (Seminoff et al. in prep). However, if selective size mortality was occurring due to toxicological stress, it is generally the smaller age classes that are most sensitive and not the largest individuals. The size of the spill is not discussed, but would have to be quite large in order to impact an area large enough to support 94 green turtles. In four years of intensive summertime research and netting efforts on both the

Gulf of California and Pacific coasts of the Baja California peninsula we have never captured 94 turtles in a single three-month field season, despite summer months being considered by fishermen as "high-season" for turtle harvest. Furthermore, gut content analyses are not presented in the report. Such information would be useful to compare to published accounts of sea turtle diet components (Seminoff et al. 1998) and would help determine the foraging locations of the turtles immediately prior to death.

Interviews with fishermen indicate that female turtles are preferred over males. Turtles harvested for sale are more likely to be female. In other parts of the world the preference for females is also apparent. In the report "State of the Marine Environment Report for Australia" authors (Marsh et al. 19VV) state that commercial and traditional hunters target females for human consumption: "Vitelogenic females (those preparing to breed) are favoured because they are fattest."

4) *Reports of shrimp trawlers in the region prior to the stranding.*

In the first report of the stranding that I was aware of, fishermen implicated shrimp trawlers. Trawlers along the Pacific coast commonly encounter sea turtles in their nets, especially when turtle excluder devices are illegally tied closed or used incorrectly. Because sea turtles are still consumed in the region fishers often retain these turtles. A storm forcing the trawlers to enter the lagoon during that time period may have been followed by the jettison of sea turtles from the holds of more than a dozen boats. This scenario is presented in the PROFEPA report and should be further investigated.

It should be noted that Mexican Ministry of Fisheries data indicate that the shrimp fishery in Baja California increased three-fold from 1997 to 1998 and that the Pacific shrimp fishers caught 71 % of the total shrimp landed in 1998 in Mexican waters (see

Introduction). Shrimp fishers, interviewed in Mazatlán, Sinaloa, indicated that many boats were fishing off of Baja California's Pacific coast during the 1997-8 season.

The purpose of this discussion is not to place blame, philosophize on the nature of scientific truth or to condemn the actions of a particular group. Nor is it a cynical reaction to the taxonomic debate, as Bowen and Karl (1999) suggest. Rather, I hope to initiate a public discussion of the actual factors that have led to the decline in East Pacific green turtles and restore the focus of conservation, research, and recovery efforts on addressing and alleviating the main threats to Pacific sea turtles.

The illegal kill—and subsequent misdirected investigation—of so many endangered turtles in and around Laguna Ojo de Liebre is appalling. A credible and sound scientific investigation leading to an honest and accurate resolution of the source of this mortality is needed. It is critical to avoid scapegoating and to properly place the responsibility.

The Ojo de Liebre situation provides a more relevant example of how geopolitical factors, such as embargoes, international trade agreements, and corporate interests, influence conservation of Pacific sea turtles. The real problems facing East Pacific green turtles are less a matter of unresolved discussions of taxonomy, evolutionary theory, and species concepts and more an issue related to the political, social, and cultural factors that directly influence sea turtles survival on both nesting and feeding areas.

THE *REAL* EAST PACIFIC GREEN TURTLE PROBLEM

In the article, “Leatherbacks face extinction in the Pacific”, Spotila et al. (2000) describe the alarming decline in Pacific leatherback turtle (*Dermochelys coriacea*) populations. Unfortunately, they have only scratched the surface of what appears to be a general negative trend among sea turtles as a group, and particularly the East Pacific green turtle, in the Pacific Ocean. Such discussions should be initiated for all turtle species in the eastern Pacific.

At the recent Symposium on Sea Turtle Biology and Conservation (March 2000, Orlando, FL, USA), Carlos Delgado and Javier Alvarado of the University of Michoacan, Mexico, presented data demonstrating a 90% decline in number of nesting female green turtles (*Chelonia mydas*) at Colola, Michoacan, their main East Pacific rookery—*since* the 1989-1990 nesting season. During the 1999-2000 season, fewer than 200 females were encountered. At the same symposium our research group presented estimates of mortality on primary green turtle feeding grounds in Baja California, Mexico. Based on market surveys and stranding records, green turtle mortality is conservatively estimated at upwards of 7,800 turtles annually. Approximately 13% of these are adult-sized animals (Chapter 3).

The reasons to protect the East Pacific green turtle include, but extend far beyond, its distinct morphology, evolutionary lineage, or taxonomic rank. Sea turtles are an important part of the eastern Pacific coastal ecosystem and were once extremely abundant (Townsend 1916, Cliffton et al. 1982). Turtles foraging in Baja California waters originate on nesting beaches as far away as Japan (*Caretta caretta*), southern Mexico, and Hawaii (*Chelonia* sp.). Efforts to protect them on their foraging and developmental habitats will have Pacific-wide ramifications (Alvarado and Figueroa 1992, Nichols et al. 1998). They are historically and contemporarily an important source of economic and household prosperity for hundreds of coastal communities (Caldwell 1963). In northwestern Mexico East Pacific green turtles are at the core of a rich array of natural resource-based cultures, maritime stories, creation myths, songs, culinary traditions, folk remedies, and social events (Chapter 2). Among the Seri Indians, these animals were once the nutritive and spiritual mainstay of a subsistence lifestyle in an arid coastal desert. Regardless of the result of the arguments over taxonomic status of the eastern Pacific populations, the morphological diversity as well as the benefits, goods and cultural assets provided by these animals are being lost.

Kamezaki describes a 50% decrease of the Japanese loggerhead turtle (*Caretta caretta*) population over the past decade (Kamezaki 1997), the primary source for East Pacific loggerheads (Bowen et al. 1995). He estimates the number of nesting females in one nesting season at approximately 1,000 individuals—the annual number of nests on Japanese beaches is between 2,000 and 3,000. In Baja California, our surveys indicate that loggerhead mortality exceeds 2,000 juvenile animals annually. Hawaiian long-line fisheries and Japanese squid driftnet fisheries also take pelagic loggerheads (Gjernes et al. 1990, National Marine Fisheries Service 1995).

The decline of the East Pacific hawksbill (*Eretmochelys imbricata*) population is poorly documented. However, a stock that once supported a lucrative fishery in Baja California, Mexico (Cliffton et al. 1995), is now on the verge of extirpation—of the many nesting sites along the in the eastern Pacific coast, only one or two hawksbill rookeries remain, each with fewer than 10 nests per year (A. Abreu, *pers. comm.*).

The lone bright spot is the recovery of the olive ridley (*Lepidochelys olivacea*) populations in the region (R. Marquez, pers. comm.). Apparently their life history, feeding habits and physiology have helped them evade the ravages of slow growth, fishing tackle, and the local gastronomic proclivities once the markets for their skin and eggs were legally closed (Aridjis 1990)

Concurrent with sea turtle declines have been notable increases in landings of billfishes and crustaceans, intensified fishing efforts, and insufficient monitoring both on the high seas and inshore waters. Northwestern Mexico harbors some of the richest fisheries anywhere in the Pacific basin. The same factors that create such productive waters—upwelling, extensive coastal lagoon systems, and high primary productivity—once supported vast numbers of developing and foraging juvenile and adult sea turtles.

Basic life history research on sea turtles in the eastern Pacific has lagged far behind other regions of the Americas despite the presence of some of the Pacific's largest rookeries, critical foraging grounds, and the presence of five of the world's seven sea turtle species. Bycatch and directed, clandestine, harvest still threaten these populations during juvenile pelagic stages, benthic developmental stages, as foraging adults, and during long distance migrations, which span the Pacific Ocean. The paucity of knowledge of these populations, particularly for the pelagic stages and at feeding sites, is one of the most serious barriers to their recovery.

The preservation of what is left of eastern Pacific sea turtle populations is dependent on quick, decisive management actions. While an ideal strategy would include robust mathematical models capable of predicting the impact and providing fine adjustments of various management schemes, there certainly exists a vast literature from which to draw a plan adequate for the immediate future. Publications such as that of Spotila et al. and the subsequent popular press reports help to create a political space in which conservation efforts for endangered species may spawn and thrive.

However, advances beyond science are necessary and scientists may need to extend themselves to the advocate role—without dubious propagandizing. Saving these majestic, ancient creatures will take political will—such as the recent challenges to WTO decisions on environmentally detrimental trade policies—as well as changes in social attitudes and traditions. Creative economic incentives that reduce the overcapitalization of fisheries, encourage local stewardship, create subsidies for alternatives to fishing, shift the burden of proof to the resource users, and control the open-access nature of fisheries are among the solutions (Larkin 1988, Botsford et al. 1997, Dayton 1998). The most effective sea turtle recovery efforts will be multifaceted, involve several disciplines, and involve many local people—a "conservation mosaic" approach (Chapter 8). Such measures will benefit all sea turtle populations as well as the ecosystems they depend on. Without such changes we'll be left with elegant accounts of the extinction process, a collection of stunning memorabilia, detailed cladograms, and a freezer full of DNA.

Recognizing that funds for conservation are limited, it is important that we prioritize those taxa in most urgent need of attention. The East Pacific green turtle, regardless of the depth of its genetic or morphological affiliations to other *Chelonia* populations is in danger of being extirpated due to a lack of basic knowledge, and a variety of social and political factors—and not for lack of fully coveted specific status that Bowen and Karl (1999) suggest conservationists and scientists are at war over. While the loss to the earth's total genetic diversity may be minimal relative to other groups, as Bowen and Karl point out, the shearing of this bud of the evolutionary tree will take with it far more than we could ever calculate in dollars, pesos, or amino acids.

In their article, “In war, truth is the first casualty” (Conservation Biology vol. 13 no. 5, 1999), Brian Bowen and Steve Karl—referring to the black turtle debate—developed the analogy of conservation as war. The “war” described is one unfortunately often fought within the ranks, between the scientist and the advocate—and at times a personal battle fought within one’s own mind. The analogy is reasonable, although the casualties of this war are not only truth. They also include the species, subspecies, populations, ecosystems and biological processes we seek to preserve and protect—the *Helen of Troy* of the war. The realities of sea turtle conservation in northwestern Mexico suggest that the casualties include the animals and the communities and traditions related to them. Perhaps one solution is to trade war for truth, cooperation, and collaboration.

There are many problems and barriers facing sea turtle conservation (Pritchard 1980). A disagreement that amounts to the distinction between a bud and a branch should not be one of them.

In the end, Helen may have been more fortunate than the green turtles of the eastern Pacific. During the sack of Troy, Odysseus found her and took her to her husband, Menelaus. Menelaus returned with her to Sparta (it took them seven years to get home) where, it seems, they lived happily ever after. The future of the green turtle—and the war over it’s survival—however, is yet to be seen.

CONCLUSIONS

The East Pacific green turtle, in summary, can be described as follows:

13. Nesting in the North Pacific occurs primarily on rookeries in Michoacan, Mexico, and to a lesser extent the Islas Revillagigedo archipelago. Sporadic nesting also occurs from Baja California, Mexico to Central America. In the South Pacific, nesting occurs in the Galapagos Island and to a lesser extent along the coast of South America.
14. These rookeries represent genetically identifiable conservation units or stocks—some of which have been nearly extirpated.
15. Turtles may forage as far north as Alaska, USA, and south to Chile. East Pacific green turtles have been found feeding in the Hawaiian Islands and Japan. The coast of Baja California represents one of the most important feeding grounds for the East Pacific green turtle.
16. The East Pacific green turtle is probably no more genetically isolated than any other regional assortment of *Chelonia* rookeries.
17. Mature turtles may be as small as 60 cm (SCL), but regularly reach sizes in excess of 100 cm. Diminutive size is not a reliable indication of stock affinities, nor does it represent a reproductive barrier between eastern and central Pacific stocks.
18. Varying degrees of restriction of the carapace occur over the hind flipper occurs in East Pacific green turtles. However, this is not a reliable indicator of stock, as it is known from other Pacific stocks.
19. Carapaces of East Pacific green turtles tend to be more vaulted in both immature and mature animals, relative to Hawaiian stocks. However, considerable overlap in these ratios occurs between stocks.

20. Carapaces of adult East Pacific green turtles tend to be highly pigmented, often predominantly black and gray. Immature turtles may be lighter in color. However, color tends to change as turtles mature and is highly variable even in adults, ranging from black to light brown and gray. Carapace color patterns do not differentiate Mexican East Pacific green turtles from other Pacific stocks.
21. Head and flipper coloration typically coincides with carapace coloration.
22. Several chromotypes have been identified within the Mexican East Pacific green turtle stock (blue, brown, and red).
23. Plastron color in adults is typically cream to pale yellow often infused with varying areas of gray, sometimes completely dark gray. Immature turtles may have entirely white plastrons. Color is too variable to be an adequate indicator of stock affinity.
24. Adult turtles with lightly colored carapaces tend to have pale plastrons.
25. The East Pacific green turtle, or black turtle, should be referred to by the scientific name *Chelonia mydas* until questions of subspecific status are resolved on a global scale.
26. Protection of East Pacific green turtles, particularly on their foraging and developmental grounds, remains a high priority. Stocks continue to exhibit downward population trends.
27. The primary causes of East Pacific green turtle mortality are related to directed take on feeding grounds. The existing legal, ecological, and cultural imperatives for protection have little to do with the current debate over resolution of the taxonomic status of the populations in question.

28. Scientists and advocates alike must work together to use sound science, resource management, and education to address the *real* issues and most relevant threats facing sea turtle recovery.

The debate over the taxonomic status of the East Pacific green turtle provides for stimulating reading and ranging discussions, requires that we examine the basic assumptions about our concepts of species, and utilizes fresh results and insights from the expanding field of molecular genetics. The fruits of this debate will be a better understanding of the evolutionary history of the East Pacific green turtle and perhaps some clarification of the rules of taxonomy among sea turtle conservationists.

This, however, is not enough of the kind of conservation science needed to promote the recovery of the East Pacific green turtle. A pragmatic account of conservation needs and an interdisciplinary response is required. The Endangered Species Act and the Recovery Plan for U.S. Pacific Populations of the East Pacific Green Turtle do not require that the group receive full specific status (*Chelonia agassizii*) in order to attract the resources needed to promote its recovery (USFWS 1973, NMFS 1998). Bowen and Karl (1999a) also note that as a germinate species, the East Pacific green turtle qualifies for legal protection under the evolutionary significant unit (ESU) criterion of “future evolutionary potential”. The East Pacific green turtle is a scientifically recognized taxonomic entity legally deserved of protection. Thus, to suggest that those promoting full species status of the East Pacific green turtle are politically motivated and seek conservation resources is an unnecessary, inaccurate, and potentially damaging and divisive conclusion. To depict this debate as “war” within the ranks unnecessarily polarizes the conservation community at a time when unity, cooperation, progressive management, action, and honest science in the field are especially needed.

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Table 1. Seri nomenclature for *Chelonia mydas* (Felger and Moser 1986). *Moosni* is the general term used for sea turtles.

Seri names	Comments
moosniáa "real sea turtle"	Common green turtle in the region, probably the taxon referred to as *C.m.carrinegra* (Caldwell 1962). We refer to this chromotype as "blue".
moosnáapa "true sea turtle true"	The "true" *moosni* eaten by the ancestors. Not a large turtle, with a brownish-gray carapace. We refer to this chromotype as "brown".
moosníil "blue sea turtle"	Seen only by the ancestors, a huge, strong turtle that turned the harpoon and rope line blue. This may have been a large, adult "blue" chromotype, which by the mid 1970s had become very rare.
moosni ictoj "red sea turtle"	Felger et al. (1986) suggest that this may have been an albino form. More likely, it represents the chromotype we call "red", a light colored turtle, with a relatively pale plastron.
quiquíi	This was the term used to refer to thin, inactive moosni with little meat and much fat. These may have been post-overwintering turtles.
cooyam	Young green turtles entering the region from the south for the first time. Distinguished by its white plastron and dark carapace, often mottled with amber.
cooyam caacol "large cooyam"	An adolescent turtle growing up in the region. Likely turtles that had established their developmental home ranges in the area.
ipxom haquíma "the fattest one"	Mature *cooyam caacol*. Possibly pre-migratory adults.
moosni quimoja "quimoja sea turtle"	Refers to a giant moosni, > 100 kg. It was hunted and eatenby the Seri.

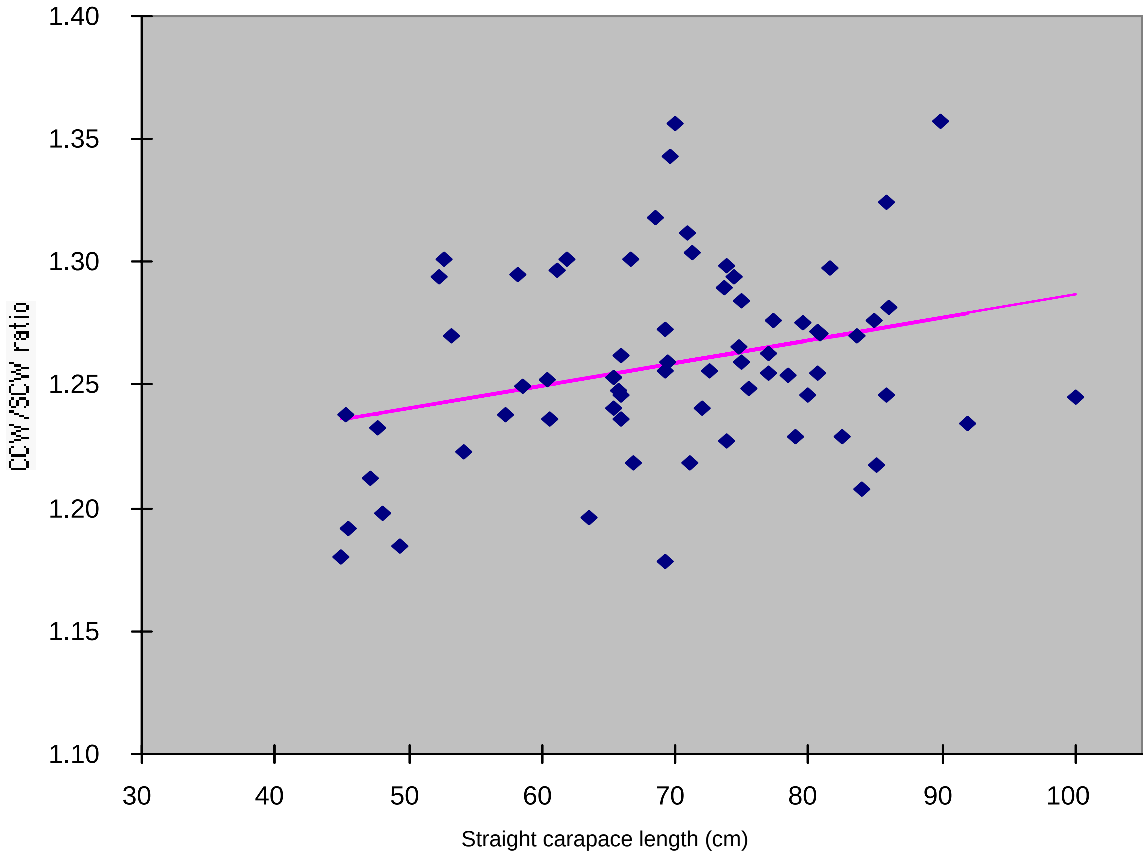

Figure 1. Regression of curved and straight carapace width ratio vs. SCL (R^2 = 0.08) of East Pacific green turtles captured on Baja California feeding grounds during 1995-1998. All turtles were determined to be from the mainland Mexico stock, based on mtDNA haplotypes (see Chapter 6).

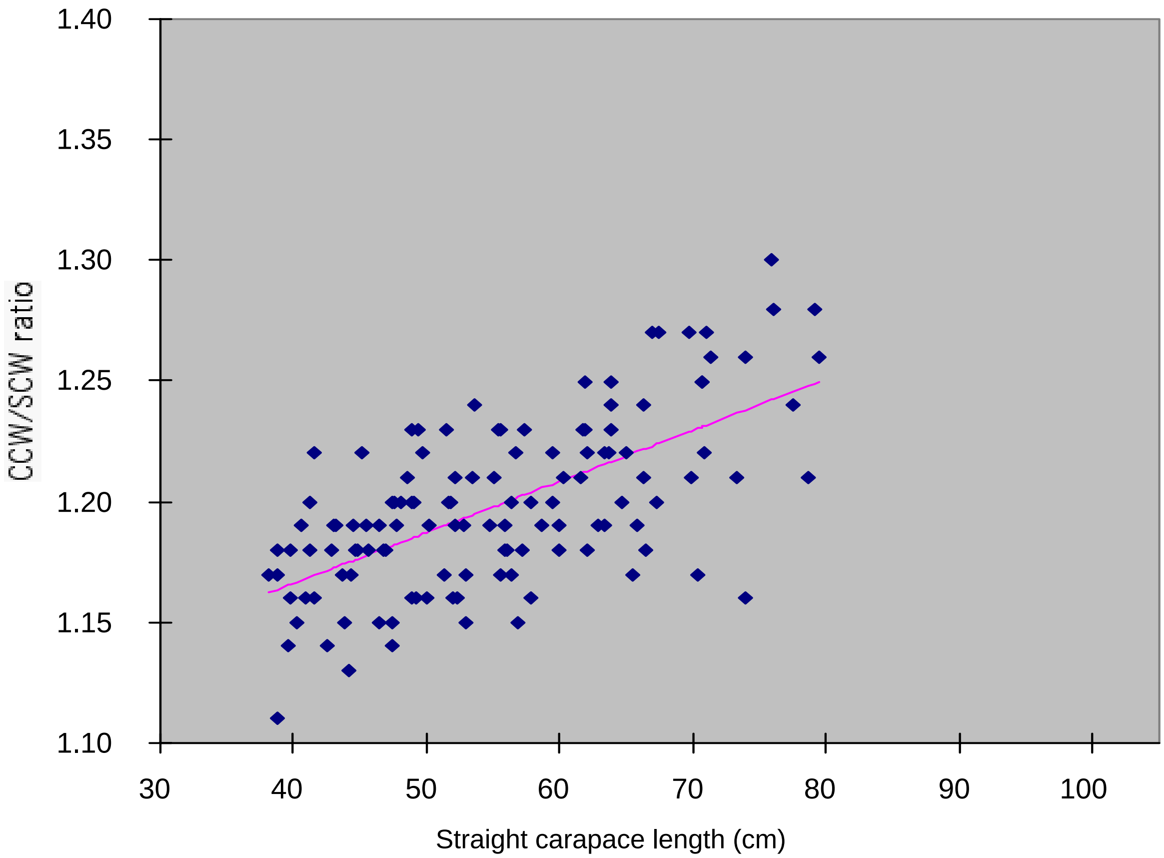

Figure 2. Regression of curved and straight carapace width ratio vs. SCL (R^2 = 0.411) of immature green turtles captured on Hawaiian feeding grounds (Balazs 1987).

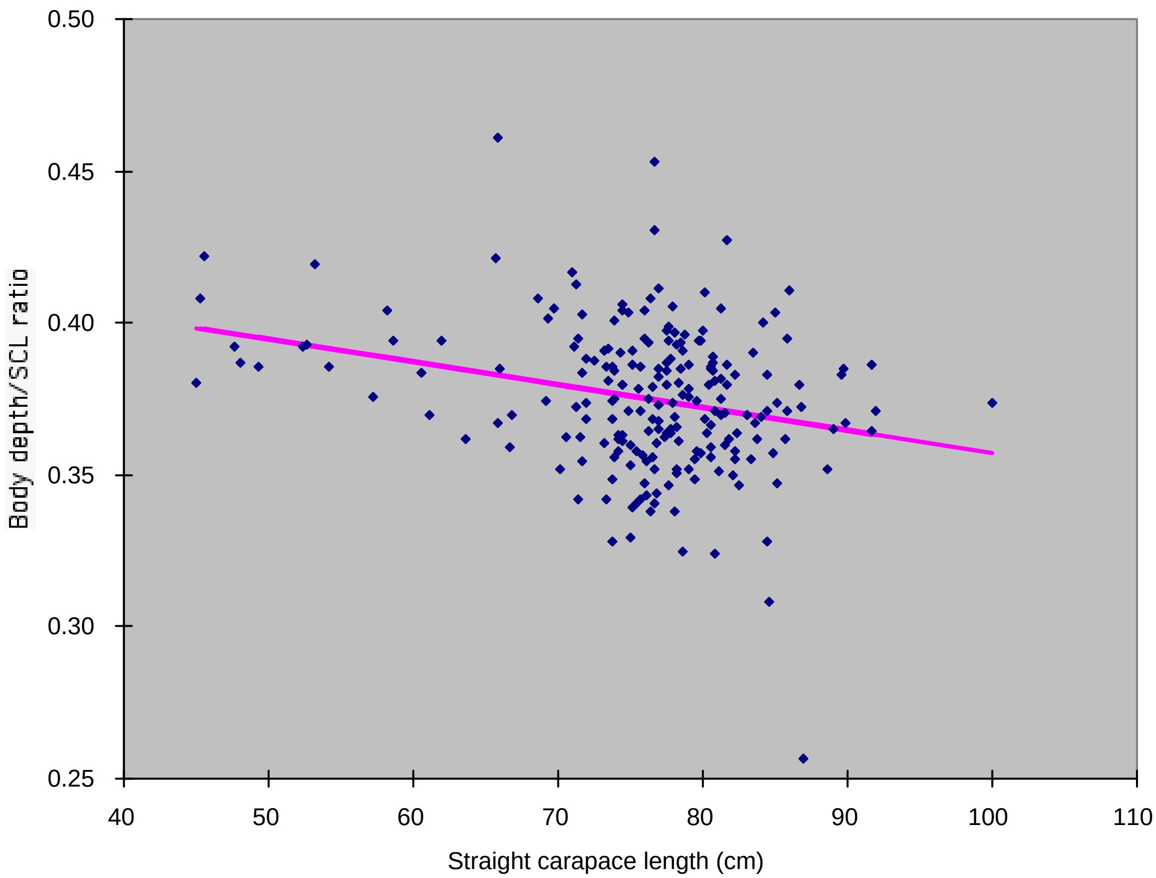

Figure 3. Regression of Body depth / straight carapace length ratio vs. SCL ($R^2 = 0.07$) of green turtles captured on Hawaiian feeding grounds (Balazs 1987).

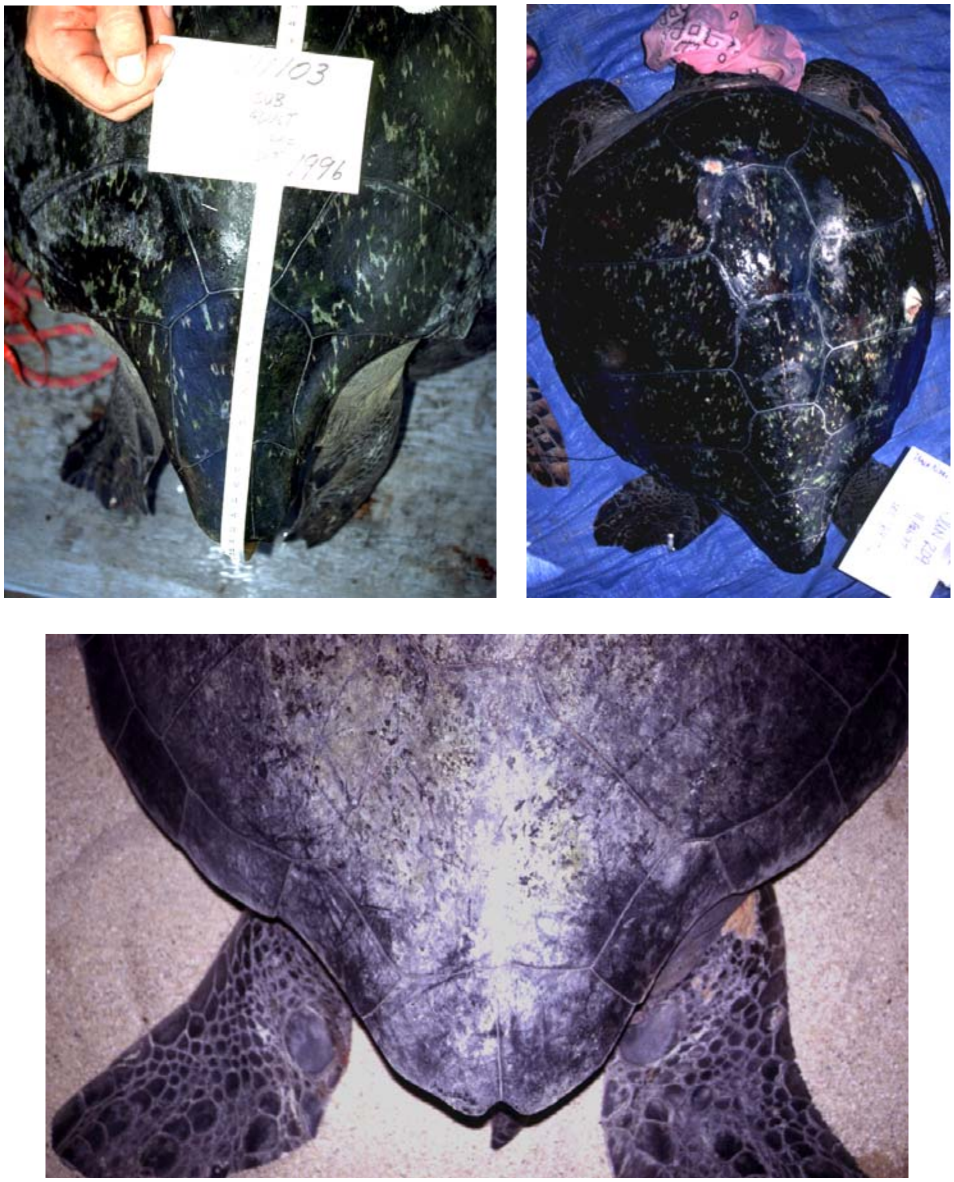

Figure 4. Examples of pronounced caudal indentation of the carapace over hind flippers in adult-size ($\geq$ 77.3 cm) East Pacific green turtles of the Mexican stock. Both of the top turtles were captured on feeding grounds in Bahía de Loreto, Baja California Sur, Mexico. The bottom turtle was nesting in Colola, Michoacan, Mexico.

Figure 5. The “blue”, or dark, chromotype in an adult-size (SCL = 77.3 cm) East Pacific green turtle of the Mexican stock from Bahía de los Angeles, Baja California, Mexico. The carapace is predominantly black, with mottled gray (top). The plastron is predominantly gray, with some yellow (bottom).

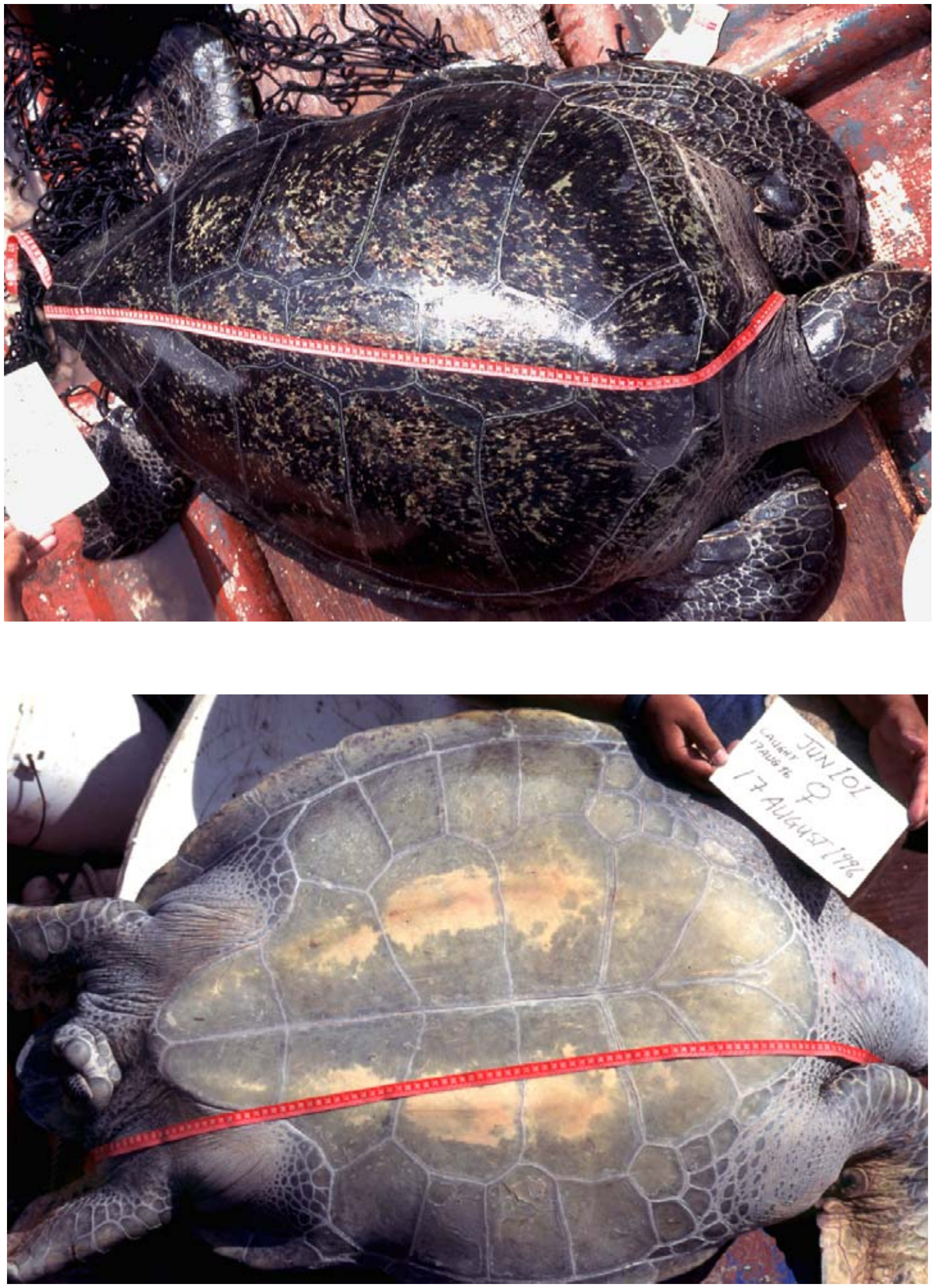

Figure 6. Example of the “brown” chromotype in an adult East Pacific green turtle of the Mexican stock from Bahía de Loreto, Baja California Sur, Mexico. Carapace is predominantly black and brown with light brown streaks (top). Plastron is predominantly gray with some yellow (bottom).

Figure 7. An example of the “red”, or light, chromotype in the East Pacific green turtle, Mexican stock. This turtle was photographed in Bahía de los Angeles, Baja California, Mexico, in June 1996. Note the caudal indentations of the carapace over the rear flippers. SCL = 67 cm. The plastron (not pictured) is predominantly yellow with gray.

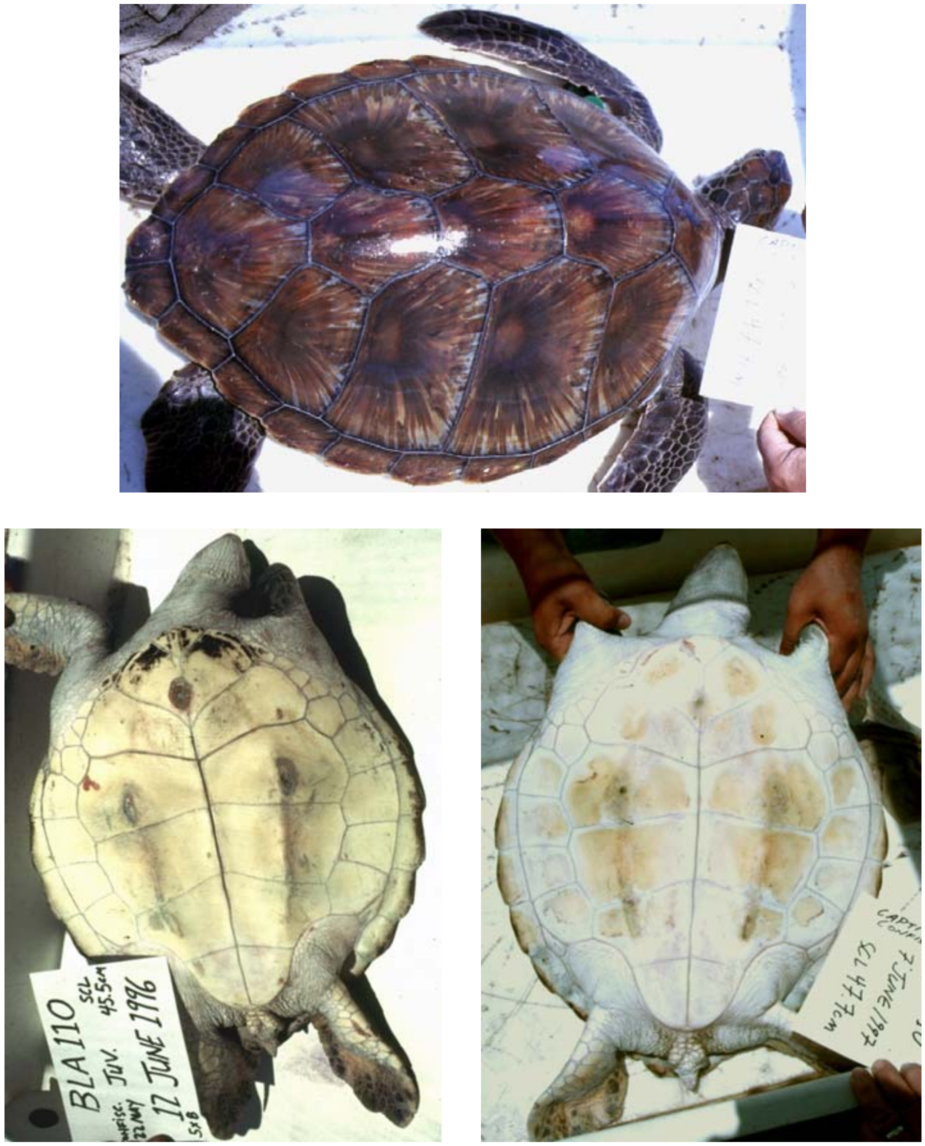

Figure 8. Immature East Pacific green turtle of the Mexican stock (SCL = 47.7 cm) photographed in Bahía de los Angeles, Baja California, Mexico, June 1996 (bottom L) and June1997 (bottom R). Radiating starburst pattern carapace, lack of caudal indentation over hind flippers (top), and lack of gray pigmentation in the plastron (bottom). Between years 1996 (L) to 1997 (R) a slight loss of yellow and infusion of gray pigment was noted in plastron. The turtle grew 2.2 cm in one year.

Figure 9. Comparison of East Pacific green turtle plastrons. Both turtles were determined to be part of the Mexican stock. These turtles were captured simultaneously on feeding grounds in Bahía de Loreto, Baja California Sur, Mexico during August 1997.

CHAPTER 8

TOWARDS A CONSERVATION MOSAIC: A CASE STUDY OF SEA TURTLE PROTECTION IN BAJA CALIFORNIA, MEXICO

ABSTRACT

Successful recovery of Baja California's sea turtle populations will necessarily involve thousands of fishermen, hundreds of communities, dozens of resource managers, and many scientists working throughout this vast region. However, surveys indicate that understanding of, and compliance with, the laws protecting sea turtles is extremely low, even among the professional sectors—a major barrier to conservation efforts. The complete moratorium on the use of sea turtles by the Mexican government—now more than ten years old—has failed to produce conservation gains in this region. Four of the five sea turtle species inhabiting Baja California waters have continued to decline in number on their index rookeries, largely due to unsustainable incidental and directed take. A rethinking of the state of regional sea turtle conservation efforts suggests that a new strategy, including a community-based structure and local participation, combined with a global perspective, and broad educational efforts may result in marked conservation gains and population recovery. This approach to studying sea turtle life history and protecting these endangered animals includes participatory research utilizing modern scientific methods, grassroots community meetings, and educational programs, which include Internet applications. Indications of success include local media attention on sea turtle conservation progress, growing international support for regional sea turtle

conservation efforts, public awareness of sea turtle life history, increased numbers of flipper tag reports by fishermen, the formation of a 300-member regional conservation network, citizen-based sea turtle population monitoring programs, and local, community-based, initiatives to create in-water sea turtle refugia at the most important feeding and developmental areas in Baja California. This successful “conservation mosaic” combines strengths of several disciplines and approaches to natural resource conservation and a model for endangered species recovery.

INTRODUCTION

> **mo·sa·ic** (mO-'zA-ik) *noun* 1) a surface decoration made by inlaying small pieces of variously colored material to form pictures or patterns; *also*: the process of making it, 2) a picture or design made in mosaic, 3) something resembling a mosaic <a *mosaic* of visions and daydreams and memories, Lawrence Shainberg>.

Vast amounts of biological and ecological information are collected annually and are used in the maintenance of biological diversity, protection of ecosystem functions, and conservation of natural resources. In the past, management schemes have typically focused on developing a scientific understanding of the species or resource in question and the pursuit of policy changes (Frazier 1999). Early conservationists (e.g., Pinchot and Leopold) argued that wildlife decisions should be based on science and that wildlife professionals should receive biological training. Missing among these ecological studies of natural resources has been consideration of the relationships between humans—the principal source of threats to species and ecosystems—and nature. The rich traditions of geography, anthropology and sociology must be included in conjunction with biological data. For example, geography has a rich history of human-sea turtle studies (Nietschmann 1973, 1980, 1995) from which to draw and many of the most important works on Baja California have been by geographers (Meigs 1939, Aschmann 1959, Henderson 1972, 1984). One result of this separation is conflict between conservation policies, researchers and environmentalists, and the desires of local communities (Dedina 2000, Hoare 2000). Campbell (1998) perspicaciously describes the dynamics within the IUCN Marine Turtle Specialist Group:

> "If equally qualified and respected scientists can reach different conclusions on the feasibility of using marine turtles, then there is something other than science at work. When defending positions on sustainable use, many individuals begin their justifications in terms of science, but eventually refer to wider views and beliefs about resource management, environmental ethics, risk, and local people. As the science surrounding marine turtles is used to support a variety of positions on use, it may be more useful to focus on these wider beliefs when considering conservation conflicts."

The growing literature on community-based and human dimensions of wildlife conservation suggests that the scope of environmental management is changing, moving beyond shibboleths, and that the field of conservation biology is embracing the complexity of the interactions between wildlife and human society.

Some management schemes have begun to integrate the rich literature of the social sciences (Decker and Goff 1987), consider local traditions, and are becoming adaptive and decentralized. These approaches are frequently referred to as "co-management" or "adaptive management" (Tables 1 and 2). Environmental protection in both developed and developing countries is increasingly regarded as a "people issue" (Cultural Survival Quarterly 1991). Bradshaw and Bekoff (2000) promote integration and interdisciplinary approaches to environmental issues and state that "an honest and open effort to reintegrate social and natural sciences has the potential to bring definition and meaning to achieving sustainable and ethical relationships with nature." By extending wildlife conservation to include quality human dimensions information, environmental managers are more likely to solve real problems and improve decisions that are made about wildlife (Manfredo et al. 1995).

Community-based conservation (CBC) has become increasingly popularized in the conservation literature, calling for increased participation, grassroots approaches to development, local empowerment, and community control of local natural resources (Parry and Campbell 1992, Heinen 1993, Western et al. 1994). At the core of these strategies are policies and management rights that enable communities to become partners in, and greater beneficiaries of, local resource management. However, community-based approaches do not always provide stand-alone solutions, and may be inadequate in some situations (Strum 1994). The translation from idealistic conservation theory to on-the-ground efforts is difficult to achieve. Studies in Mexico and Central America suggest that despite community-based conservation rhetoric, international environmental organizations, state and federal governments, and outside scientists tend to define agendas and dominate efforts (Dedina 2000 and Young 2000), perpetuating the "top-down" approach they sought to replace. Frazier (1999) describes lack of long-term commitment, lack of consensus, the need for evaluation, and unrealistic goals as potential pitfalls to CBC efforts. Thus, some conservationists are doubtful that community-based approaches can be applied widely. Although not a new concept, the implementation of community-based natural resource management has generally been limited in Baja California (but see Donlan and Keitt 1999), especially with regard to sea turtle conservation.

With these observations, critiques, and experiences in mind, I argue for a "mosaic" approach to conservation and resource management programs. This model expands and combines the strengths of co-management and community-based strategies, and incorporates modern research and communications technologies. The approach integrates human components with traditional resource management schemes and the realities of the current political and economic setting. I describe the model using as a case study the current efforts to recover endangered sea turtle populations in the eastern Pacific, specifically in the Bahía Magdalena, Baja California Sur, Mexico region. The "conservation mosaic" approach highlights the importance of community involvement, but acknowledges the role of the state to set policy agendas (Pomeroy and Berkes 1997). By including, but not being limited to, the principles of the co-management approach, it encourages participatory research but recognises the need for substantial financial resources, often available only from governments, private donors, or large international nongovernmental organizations, to conduct such projects. The mosaic approach attempts to balance local traditions with global responsibilities. This approach includes a human dimension, is based in a decentralised management structure, encourages enhanced communication, ongoing dialog between local community members, resource managers, and other stakeholders, involves a participatory approach to research, and emphasises education at all levels. The best available scientific knowledge, at the core of this model, should be used to inform all aspects of the project, from communication and education to reserve establishment and monitoring (Figure 2). Much like the multifaceted carapace of the turtle itself, the best and most successful conservation efforts will reflect the complexity of the natural world. Each facet will ideally inform progress in the others. This "mosaic" is a direct response to the real complexity and international scope—both biologically and socially—of most conservation problems.

THE SEA TURTLE CASE STUDY

Five species of sea turtle are known to inhabit the coastal waters of Pacific Mexico. The two most common species to frequent the waters within and adjacent to Bahía Magdalena, Baja California Sur—a large mangrove estuarine complex, spanning some 130 kilometers of coastline, on the Pacific side of the Baja California peninsula—are the East Pacific green turtle (*Chelonia mydas*) and the Pacific loggerhead turtle (*Caretta caretta*). Other species include the olive ridley (*Lepidochelys olivacea*), leatherback (*Dermochelys coriacea*) and hawksbill (*Eretmochelys imbricata*) turtles. Sea turtles are an important part of the cultural history of northwestern Mexico (Chapters 2 and 3). Overuse was largely responsible for their decline (Cliffton et al. 1982). However, unlike other regions where the cultural connections to these animals are mostly gone (Nietschmann 1995), in Baja California patterns of local use remain and will ultimately play a critical role in sea turtle recovery. As in many fishing communities in the region, the multitude of uses of sea turtles by families living near Bahía Magdalena, Baja California Sur, has been an important part of coastal living for many generations. Green and loggerhead turtles are the most commonly caught species by the fishers of Puerto San Carlos, Puerto Magdalena, and Lopez Mateos, the three largest communities on the shores of Bahía Magdalena (Gardner and Nichols 2001). Results of region-wide surveys suggest that attitudes towards sea turtle conservation, local history of exploitation, and the relative abundance of species in the Bahía Magdalena region is typical of those found in small coastal communities throughout the Baja California peninsula.

Turtle use originated as subsistence hunting by the region's indigenous inhabitants, but over time this use broadened into a lucrative fishery (Caldwell 1963). In addition to the food, medicinal uses, and products provided to an individual fisher's household, there were economic benefits associated with the sale of turtle meat to the international market (O'Donnell 1974, Dedina and Young 1995, Garcia-Martínez and Nichols 2000).

For many years, the taking of turtles was largely unregulated, and sea turtles seemed an inexhaustibly abundant resource (Caldwell and Caldwell 1962). As many as 375,000 turtles were hunted between 1966 and 1970 (Cliffton et al. 1982). As populations began to decline, the Mexican Ministry of Fisheries implemented size limits and closed seasons. However, by the mid-1970's and early 1980's it became increasingly obvious that such large-scale hunting was not sustainable and that management schemes were ineffective (O'Donnell 1974, Cliffton et al. 1982, Cantú and Sánchez 1999). Broad legal protection of sea turtles in Mexico came with an Executive Order issued in 1990 by the Ministry of Fisheries and the Ministry of Urban Development and Ecology (now SEMARNAP). The legislation states that the Mexican Federal Government strictly prohibits the pursuit, capture, and extraction of any species of sea turtle on any beach or in federal waters. Article Three specifically states that:

> "*The specimen of any species of sea turtle incidentally captured...shall be returned to the sea, independent of its physical state, dead or alive*." (DOF, 31 May 1990)

However, the taking of turtles in the Bahía Magdalena region continues presently despite the passing of these strict laws prohibiting their use (Gardner and Nichols 2002). Nearly 95% of the fishermen (n = 263) interviewed in Baja California had eaten sea turtle since the 1990 ban, often monthly or even weekly (see Chapter 5). Compliance is at a minimum within the communities primarily due to the weakness of enforcement measures and the strong traditional use of turtles during holidays and special events (Garcia-Martínez and Nichols 2000). Additionally, incidental captures of sea turtles continue to occur in gillnets of local fishers, both in and outside the bay (Chapter 3).

There has been much confusion over the legality of taking turtles for private household consumption. Many people that I had discussions with in the Bahía Magdalena area believed that it was legal to take turtles accidentally caught in nets, especially if freshly dead. Such people were not aware of the details of the legislation protecting sea turtles, and therefore did not consider that they were doing anything wrong by consuming turtles at home. The lack of awareness of the law and an absence of follow-up assessment of the 1990 policies reflects the low emphasis placed on human dimensions of sea turtle protection in the region.

There remains a need for enforcement of such legislation as well as a program to clearly explain the laws and their ecological purposes. As in many developing countries, there are socio-economic constraints to proper enforcement of laws involving endangered species (Gomez 1982). This is especially true in Baja California where communities are often separated by hundreds of miles, from urban centers such as La Paz, Ensenada, Tijuana, and Mexicali, where enforcement agents are based.

The goals of my research include the involvement of fishing communities in the development of conservation projects, the involvement of local students and fishers in the collection of data, and the public sharing of research results on a regular basis. Community meetings serve as an outlet to share information on the biology of sea turtles as well as their protected status. Participation in community-based research is one component of an adaptive management approach to resource conservation.

With sea turtle populations continuing to decline globally, it is imperative that conservation strategies are consistently evaluated. There have been great advancements in the knowledge of sea turtle biology and the science of conservation is continually developing new tools. However, the major causes of sea turtle decline in many parts of the world, including northwestern Mexico, stem from anthropogenic factors and the human dimension may be the area of research where most conservation gains are yet to be achieved. Scientists have documented the ways that fishers have negatively impacted sea turtle populations, but what is often overlooked is how these same individuals can contribute to conservation. As researchers become increasingly aware of the cultural motivations involved in sea turtle exploitation, it becomes critical to shift conservation efforts in the direction of the people at local levels.

THE COMMUNITY-BASED RESEARCH APPROACH

Conservation agendas and field research projects are generally designed and executed by national and international managers and scientists. Bradshaw and Bekoff (2000) remind us that as researchers we are accountable not only to funding agencies, but also to the recipients of the new knowledge. They state, simply, that “knowledge must be used responsibly in the service of life.” In community-based activities, fishermen are recognized as the primary participants, and along with their families play a central role in making decisions about planning, regulation, allocation, enforcement, and monitoring.

Recently, the linkages that have always existed between formal researchers and informal local researchers have been more widely recognized (Johannes 1993, Western et al. 1994). Active participation of local stakeholders, usually at the grass roots level, in the design, execution and evaluation of research with formal researchers may result in the achievement of both conservation goals and acquisition of knowledge.

Community-based management is a system in which fishers, processors and the communities, in which they live and work, all play a role in the management of the resource. Local community representatives share in management responsibilities through a community board representing stakeholders in the local fishery and in the coastal community at large (Coastal Communities Network 1996).

One of the fundamental assumptions of the community-based approach is that individuals will necessarily choose to care for the animals and resources in which they have a personal stake (Mast 1999). In community-based management, local organizations define and share specific management responsibilities and authority. Bromley (1994) states that "community-based conservation seeks to locate arenas of mutuality between those who want biological resources to be managed on a sustained basis and those who must rely on these same biological resources for the bulk of their livelihood" (p. 428). In most cases, this presents a difficult process of consensus building. However, in the case of the conservation of sea turtles in Bahía Magdalena, it appears that the two different values that Bromley described are distinctly related. My experience has been that local fishers have demonstrated an interest in conservation for ecological and aesthetic reasons, as well as to preserve a source of their traditional livelihood and an occasional source of food. This may be a lesson learned by fishers from their work with gray whale conservation and ecotourism. Young (2000) quotes a fisherman as observing that “when a whale gets caught in one of my nets, it isn’t good for me or the whale.” Another inhabitant noted that, “when you take care of the animal, you take care of yourself.” This attitude has recently been reiterated by those fishers with an interest in sea turtle conservation.

The main idea behind the participatory process is simple. When individuals work together to explore answers to management problems, they come to understand the issues. Conflicts are often resolved when all stakeholders discuss the results of the information gathering process, and form policies for future actions. By combining the knowledge gained through community-based, participatory research with the insights of the social sciences, recovery efforts stand a much better chance of succeeding.

Sea turtle conservation is multidimensional, as the threats and causes of declines are diverse. Therefore, it is the responsibility of sea turtle conservationists to advocate adaptive management techniques. Feldmann (1994) states that even if the authorities devise strategies to protect resources, "*such strategies may be ineffective if they are* *incompatible with customary or traditional rights recognised at the community level*" (p. 397). This dilemma is particularly true in the case of sea turtle conservation in Bahía Magdalena.

Community-based strategies are not new to sea turtle conservation. For the past decade, local involvement in turtle conservation efforts has been increasing as evidenced by the increasing numbers of symposium papers and reports on the topic, as well as inclusion of CBC in the Marine Turtle Specialists Group techniques manual (Frazier 1999). Such approaches take a variety of forms. These include community monitoring of lighting practices on nesting beaches, community-based stranding networks and beach patrols (Figueroa et al. 1992), self-enforcement by fishing communities, formal sharing of traditional knowledge (Nabhan et al. 1999), development of alternative activities for poachers (Ahmed et al. 1999 and the systematic consideration of interviews with fishers (Tambiah 1999). Additionally, sea turtle conservation has become a viable attraction in some ecotourism initiatives and other forms of sustainable development (Campbell 1998, Govan 1998, Vieitas et al. 1999).

COMBINING SCIENTIFIC AND LOCAL RESEARCH KNOWLEDGE

The success of this project is due in large part to the vast experiences of local stakeholders and their active participation, usually at the grass roots level, in the design, execution, and evaluation of research techniques. The combination of academic research with local knowledge and experience has proven fruitful.

Involvement of current and former turtle hunters in the day-to-day functioning of the research program has led to expected and unexpected outcomes, nearly all favorable. I know of only one case where a research assistant purposefully captured sea turtles during non-field seasons. More frequently, my experience has been that fishers take ownership of the project and continue collecting data, samples, and observations year round. Typically, assistants conduct their own informal educational efforts, attend local and regional meetings and occasionally become full time members of research projects.

The vast experience of lifelong fishermen is a tremendous asset to the research projects. Fishers have knowledge of former and current primary sea turtle feeding areas, access to data and samples otherwise unavailable to outsiders, provide a network of mechanical, technical, and emergency support, and offer some continuity to the project.

In 1997, when I initiated the research program in Bahía Magdalena, four brothers—Juan, Gabrielle, Melacio, and Octavio Sarrabias—began as my field staff. All four of the brothers are fishermen and expert boatmen. They immediately consulted the older fishermen in the community and found several who served as our initial guides to the most productive sea turtle feeding areas in the bay. In the non-field season, while fishing, the brothers record sea turtle bycatch, measure and tag turtles, and collect tissue samples opportunistically in the community. While fishing with their peers, they often share their experiences. On one occasion, after releasing a turtle that had been accidentally captured in a net, the other younger fisher commented that it was the first time in his life that he had ever released a live turtle. He stated that releasing the turtle and knowing that the he had done the right thing was worth more than the $40 he may have gained by illegally selling the animal. A year later, he was still talking about that day and the turtle release. Since 1997 the Bahía Magdalena project has employed more than thirty fishermen in various aspects of research, monitoring, and outreach.

Many environmental and resource issues are easy to identify and solving them is often just a matter of common sense (Mast 1999). In some cases people have been recognizing and solving resource management problems for hundreds, if not thousands, of years (Johannes 1993, King 1997). Involving fishers in sea turtle monitoring efforts is simple. Measuring a turtle, estimating how many are caught or what they are worth does not require much expertise. Documenting changes in populations can be done by anyone who has been asked to record their observations. It is extremely important that we begin to value information collected by non-professionals as well as anecdotal information consistently reported by community members.

Traditional knowledge of sea turtle ecology is rapidly disappearing or has already degraded (Nietschmann 1995). Participatory skills would enable researchers and fisheries agents to help gather this valuable information and distribute it throughout the region.

In helping fishermen to make the conservation process their own, as a researcher I have not provided answers or given instructions. Rather I have asked questions and observed. For example: “What do fishers stand to lose if sea turtles are lost through overexploitation? What will happen to the cultures and traditions related to the sustainable use of sea turtles?" By asking questions—rather than giving answers—and responding to the results, some of the most important advances in sea turtle conservation in Baja California to date have been made. I have found that most fishers know the answers to many questions about local abundance, demographics, distribution, movements, and common names of sea turtles—often better than the researchers or fishery agents. By asking questions and listening, everyone learned and fishers gained a feeling of ownership of the program and a new perspective on the issues related to sea turtle recovery.

EDUCATION, BROADLY DEFINED

Education is nearly always touted as one of the main solutions to environmental problems. Yet, in many cases it is not pursued in a locally relevant way. Environmental programs often focused on exceedingly general or irrelevant environmental themes to local communities. Typically, environmental programs and workshops are focused at school children and are conducted sporadically as grants for such work come and go.

My approach to education has been to interpret each stage of the project as an educational opportunity, from fundraising, project implementation, and data collecting through regional, national, and international dissemination of the results. I have incorporated education into the project, not as a discrete, stand alone, effort, rather as a necessary component of all project activities. The result has been increased transparency and accountability, participation in all aspects of the work by fishers and community members, and recognition by participants that the local ecosystem is of global relevance. Specifically, my educational goals were to increase awareness of sea turtle life history, major threats to their longevity, and the global relevance of Baja California sea turtle feeding grounds among the local communities. This was undertaken in order to change attitudes about the take of sea turtles, and more generally, the take of endangered species. Secondarily, I worked to share this knowledge with the international conservation community.

Attitudes are considered exceedingly difficult to change (Fishbein and Ajzen 1975). Advancements in attitude change theory have occurred in the last decade, including the importance of distinguishing between situations of persuasion with high elaboration and situations of persuasion with low elaboration. High elaboration persuasion occurs when the recipient of information attends to information, comprehends it, and integrates it into their existing thoughts. Low elaboration persuasion occurs when people don't attend to the persuasive message, but are influenced by something tangential to the message content (Manfredo et al. 1995). In order to achieve conservation goals, a combination of both high and low elaboration persuasion attempts (simple, easy to understand messages, attractive presentations, utilization of several types of media, and informal discussions) were used (Appendix D).

School children have been invited to participate in the project in a variety of ways. Several hand-on workshops have been held at the Centro para Estudios Costeros, in Puerto San Carlos, where local children have learned about sea turtle life history, learned to identify each species, practiced measuring turtle carapaces, and produced sea turtle artwork for distribution in the community. Following these workshops, children helped researchers by collecting discarded carapaces from vacant lots and arroyos throughout the community. The group discussed the impact of poaching on sea turtle populations. This represents the higher end of elaboration.

High elaboration persuasion reiterates the importance of recognizing the national and international origins of sea turtles feeding in Baja California waters and the responsibility associated with their conservation. If national fisheries agents continue to work with coastal inhabitants using participatory techniques they can share this global perspective and an understanding of the reasons for national laws protecting marine resources and endangered species.

Currently, fisheries training does not include sociology or psychology and fisheries officers are often not very good people managers. I have proposed workshops for enforcement agents—to be held at key regional location along the peninsula—that would address both the biological and deep-seated social issues related to sea turtle conservation in the region.

Beyond meetings and workshops, local, national, and international media outlets have proven extremely valuable tools. By sharing turtle tracking data via the Internet, students from all over the world have participated in the project and have interacted with students in Baja California. Persuasion delivered via media such as the Internet, children's magazines, newspapers, etc., are examples of low elaboration. Articles in local newspapers have highlighted collaborative research breakthroughs, described the threats to sea turtles and Baja California, and have generated editorials and debates that have spilled over to radio and television. Recognition by local, national and international media can serve to legitimize conservation efforts and if handled cautiously can serve as one of the most useful educational tools available. By highlighting the long-distance migrations of Baja California turtles, the project has brought attention to local conservation issues and their international relevance. Such exposure also serves to facilitate acquisition of funds for projects to expand and progress. These media outlets have enabled us to increase awareness of the status of Baja California's turtles among conservationists, biologists, tourists, and—most importantly—the general public.

Attractive sea turtle posters, guides to their identification and children's books will be distributed during 2000-2001. These will serve to reiterate—in a low elaboration manner—previous messages about turtle conservation.

SEA TURTLE RESERVES AND PROTECTED AREAS

Despite more than 20 years of integrated protection efforts by government and university researchers on nesting beaches in Michoacan (Figueroa et al. 1992), expenditures by the U.S. Fish and Wildlife Service of more than half a million dollars, participation by international conservation and eco-volunteer groups like WWF, and countless human hours of effort, the project has documented a precipitous decline in the reproductive population of green turtles. This has been attributed to high mortality levels on feeding grounds (Chapter 3). Similar patterns of decline have been reported on loggerhead nesting beaches in Japan (Kamezaki 1997). A more holistic approach to sea turtle conservation should include protection at critical life stages, particularly the large mature and immature female turtles.

Protection efforts for sea turtles in Baja California focus on their feeding and developmental grounds. Mexico has previously established reserves and sanctuaries for migratory birds and marine mammals in Baja California (Diario Oficial 1972, 1979) and should consider extending this process—using even existing protected areas—to sea turtles.

Literature on wildlife reserve design abounds. Several ideas should be considered in the development of sea turtle feeding ground reserves in Baja California:

- Local communities must accept the reserve.
- Reserves must be large enough to encompass station-keeping movements of foraging turtles. A minimum size of 4,000 ha is recommended (Seminoff et al. in press).

- Locations should be selected in areas where enforcement is feasible and likely. Reserves are worthless if they do not protect the target species, and may erode the reserve concept.
- Reserves are not stand-alone solutions and must be incorporated with other strategies in the conservation mosaic.

The approach will vary from site to site, but should be based on the concept of community-based and locally managed conservation areas. In some cases this is in the form of community initiated federal reserves (e.g. Bahía de Loreto National Marine Park) and, in others, informal agreements between fishing cooperatives or ejido members (e.g. Punta Abreojos and Bahía de los Angeles).

In Bahía Magdalena a committee has formed to address sea turtle conservation issues. In August 2000, eight fishing cooperatives with a total of more than 100 members joined together their concessions to initiate the first conservation area in Baja California expressly for sea turtles. The core of the zone is the Estero Banderitas, a branch of the main bay. This region has been demonstrated to hold relatively high densities of immature green turtles, a fact divulged by the activities of local poachers. During semana santa, or Easter week, in 2000, one fisherman reportedly captured 60 green turtles in Estero Banderitas alone, all for regional sale. The fishermen who have the concessions to fish and conduct aquaculture in its waters will effectively protect the entire estuary. While protecting their aquaculture beds, the fishers will limit the use of gillnets, prohibit turtle nets, and work to reduce poaching. As sea turtle populations return, the cooperative has plans to include them as part of the eco-tourism attractions currently limited to whale and bird watching. The stated mandate of several of the cooperatives includes ecotourism activities, in addition to fishing and aquaculture. One cooperative leader observed that “by catching and selling a turtle, one might gain $20—once. But by taking people to see turtles many times over the turtle’s lifetime, it’s possible to gain much more.” Furthermore, by establishing themselves as leaders in marine conservation, the fishers believe that their products will attract more attention and value through programs such as the Marine Stewardship Council’s sustainable fisheries program (Cooper and Sutton 1998). In the words of one fisherman, “for the same price, consumers would rather buy oysters from a cooperative that also cares about their waters and protects endangered species, like sea turtles.”

The Committee has involved local politicians from Puerto San Carlos and Ciudad Constitución, Baja California Sur, SEMARNAP officials, the Centro para Estudios Costeros, and the local branches of the armed forces in their plans, and each group has pledged their support for this progressive effort. Members of the committee have ambitious plans, hoping that the protection of sea turtles will spread from the Estero Banderitas to include the entire Bahía Magdalena region. “We want this bay to be known as well for its turtles as it is for its whales,” stated one cooperative member.

GLOBALLY RELEVANT LOCAL ACTION

Bahía Magdalena provides foraging grounds for sea turtle species originating on distant nesting beaches (Table 3). Loggerheads nest in Japan (Bowen 1995), and green turtles in Hawaii and southern Mexico (Nichols et al., 2000). Olive ridleys may nest as far away as Central America and Oaxaca, Mexico. The protection of sea turtles in this region during their critical developmental stages has wide ranging implications for Pacific sea turtle recovery. Recognition of these connections may increase interest in protecting these animals and help draw needed funding for community-based initiatives. The region is already visited by ecotourists from all over the world who come to view gray whales and sea birds. In addition, there is a moderate sport fishing industry, both within the bay and in oceanic waters. Furthermore, the bay provides a deep-water port to a variety of national and international fishing vessels and fish and shellfish from the bay are exported globally. Many of the inhabitants have recently moved to the region from other areas, including mainland Mexico, Japan, and the U.S.

The biological, social, and economic connections between the Bahía Magdalena communities and the rest of the world are well established. Despite these connections, the area has received relatively little attention from the international conservation community. A long history of resource extraction has led to a sharp decline of many commercially important species, such as shellfish, shark, and bottom fish—and the endangerment of others, such as sea turtles and gray whales. The real international connections between Bahía Magdalena and the world should be used to promote conservation projects with substantial local involvement and benefits. Successful management of the resources, especially migratory species such as sea turtles, by the local community will have globally relevant consequences.

ENFORCEMENT BY COMMITTEE

Effective enforcement of sea turtle protection laws has proven one of the main limitations to sea turtle recovery in developing countries (Gomez 1982). Patrols of vast, remote areas on a continual basis are costly, and generally impractical.

National and international laws and policies prohibit the use of and trade in sea turtle products and provide a context for protection of feeding and nesting habitat and reduction of bycatch during commercial fishing activities. However, fisheries agents are usually located in urban centers, such as La Paz and Ensenada, are poorly funded, and unable to regularly monitor nearshore fishing activities. The result is that patrols are infrequent and fishermen are often well aware of them in advance. Forming partnerships with village resource users is a realistic alternative to the status quo.

Enforcement by local inhabitants has been offered as one alternative to centralized patrols (Rawlinson et al. 1993). However, we have found that local fishers, on an individual basis, are not interested in being singled out as the “bad guy” for fear of retribution. A solution to this dilemma is the formation of rotating enforcement committees. Each member of the community or cooperative eventually participates in an enforcement capacity.

Non-compliance with regulations protecting sea turtles typically goes undetected and is often unpunished even when it is detected. Ideally, where community management plans exist, and the dangers to the turtle stocks are understood, fishers who violate laws will be identified quickly and subjected to strong social pressures to stop.

Fisheries agencies in Baja California have begun the process of community partnerships, and some examples of success are notable, particularly involving the Pacific lobster and abalone cooperatives where federal environmental officers (PROFEPA) deputize cooperative associates as local fisheries agents (I. Arce, pers. comm.). These successful examples serve as models for expanding efforts to include wider areas and sea turtle protection initiatives.

This approach has proven successful in communities such as Punta Abreojos, BAJA CALIFORNIA SUR. However, initiation of this type of enforcement regime has proven difficult. Isidro Arce, former Enforcement Officer for the Punta Abreojos Fishing Cooperative, indicated that during the first year of his tenure the committee strictly enforced the regulations. Anyone bringing a sea turtle to shore, formerly a common occurrence, was promptly punished—typically 30 days suspension from cooperative activities. Arce said that "everyone was mad at me, but when we started seeing positive results, they cooperated and thanked the enforcement committee." The community recognizes the beneficial results of increased vigilance, and has taken their environmental protection efforts to the next level, forming a local NGO dedicated to local ecological and endangered species issues. In 2000, Arce attended the international Sea Turtle Symposium held in Orlando, Florida in order to share his experiences with others working on CBC around the world. Back in Punta Abreojos he has shared his new knowledge and works to help other cooperatives achieve community-based resource management.

An important component of local enforcement is that benefits are accrued by the community in a timely manner. The realization of such benefits can garner increasing political support for the enforcement committees. Such benefits can be in the form of revenues from ecotourism, an increased demand for safe, sustainably produced products, or more psychological benefits such as pride, leadership, and regional recognition.

The local community often knows exactly who is working in the bay, including fishers who use illegal or destructive fishing techniques, exceed quotas, or fish out of season. In Bahía Magdalena, this is very much the case. If fishers can claim ownership of a coastal management or species recovery plan, they can apply social pressures against those who infringe on the plan. Community social obligations are often more important than money and transgressors of the social order are severely punished or ostracized. By contrast, federal laws and regulations are often ignored and sporadically enforced. Local communities and fishers monitor the state of the bay's resources daily. They know immediately by inspection if there are problems or opportunities with the resources. For example, many fishermen were able to provide an accurate estimate of monthly sea turtle mortality. These numbers were corroborated with my own surveys and observations. PROFEPA agents and INP biologists can both learn from local fishers and share their valuable understanding of biological processes in a participatory management scheme.

In July 2000 a group of more than 100 fishermen, representing eight fishing cooperatives, formed the "Comité para la Protección de las Tortugas Marinas, Bahía Magdalena". The purpose of the committee is to protect sea turtles within their concession areas, specifically Estero Banderitas and surrounding waters, and to develop sustainable sea turtle ecotourism activities that will build on the current seasonal gray whale-watching industry. The intent of the committee is to work towards the cessation of turtle hunting without the intervention of state or federal law enforcement or other heavy handed tactics. Their first planned activity is to form a vigilance committee of ten fishers and to visit the homes of several known local poachers to solicit cooperation and to explain their planned activities.

The efforts in Bahía Magdalena are modeled after the successes in Punta Abreojos. Members of the cooperatives met in Punta Abreojos in August 2000 to discuss enforcement strategies. The groups hope that their example will help initiate similar programs in other fishing communities.

MONITORING

The impending recovery of Baja California's sea turtles provides a unique opportunity to document conservation success. As immature turtles on feeding grounds reach maturity, it will prove extremely important to quantify conservation gains. These will be evident both through in-water surveys on feeding grounds and through interviews and questionnaires.

Researchers at UABCS (La Paz) have initiated a long-term study of attitudes towards and use of sea turtles. Surveys will be repeated at 8 sites in Baja California Sur every two years.

Fishermen in Bahía Magdalena are collaborating with the non-profit organization, WiLDCOAST, and the Centro para Estudios Costeros to conduct an in-water monitoring program in Estero Banderitas. This model program will be expanded to include a total of eight sites. These in-water monitoring sites will serve as indicators of sea turtle population trends.

Conservation "report cards" for each site are being developed by the Grupo Tortuguero in order to easily assess changes in several categories.

Surveys for stranded turtles should be continued and expanded to other areas. Currently, they are focused mainly in the Bahía Magdalena region, and opportunistically in other areas. Data on strandings and sightings should be reported to the Grupo Tortuguero website <www.baja-tortugas.org>.

Coordination of conservation efforts with sea turtle rookeries represented on Baja California feeding grounds, such as those in Michoacan, Mexico, and Yakushima Island, Japan, are extremely important. Recaptures of tagged turtles must be reported to the associated projects. A co-ordinated regional monitoring netowrk will facilitate collaboration and the exchange of information.

SIGNS OF SUCCESS

Indications of success are difficult to quantify. However, the formation of the Sea Turtle Conservation Network of the Californias (Grupo Tortuguero de las Californias) provides a clear indication of the potential for success of the conservation mosaic approach.

Through the course of this project, and the nearly a decade it has taken to initiate, it has become clear that communication between fishermen, conservation groups, environmental managers and researchers would be critical to any efforts to recover sea turtle populations in the region. Tagging, telemetry, and genetic studies have demonstrated that the Baja California coast is important to sea turtle stocks from many countries. A regional approach is critical to identifying the scope of threats and coordinating recovery efforts. Monitoring efforts, training, and research efforts will benefit greatly from a regional approach. This is neither a novel nor complex concept, however, putting it into practice can be (McNee 1999).

In Mexico, as other countries with rich marine resources, the separation between environmental managers, researchers and fishermen can be quite wide and the process of involving all three in a decision-making process complex if not culturally unacceptable. However, the success of conservation efforts does require cooperation and collaboration across all sectors of society, particularly in a place like Baja California where communities can be hundreds of kilometers apart and enforcement of environmental laws virtually impossible.

The Grupo Tortuguero de las Californias, a grass-roots organization, formed to promote sea turtle recovery in the region, represents a crucial component of sea turtle recovery in northwestern Mexico. The first meeting of this group was held in 1999 and was attended by NGO's, representatives of several local fishing co-operatives, governmental institutions, members of academia, and field researchers. This meeting represented one of the first interdisciplinary co-operative sea turtle management attempts in the region (Nichols and Arcas 1999). The group decided to meet annually to provide a forum for discussion of new research results, management ideas and training workshops. In January 2000, the group of Baja California fishing community members and conservationists who participated in the second annual meeting increased to more than 100 members. At this meeting, a variety of topics related to sea turtle biology and conservation were discussed. Workshops on data collection, turtle identification, and measurement techniques were organized. Biologists from sea turtle nesting beaches in Michoacan and members of the Seri Indian community offered their perspectives on sea turtle declines. Fishers attending this meeting now form the core of the Network and returned to share the information in their communities. For many, this meeting represents the first time that they have actively participated in conservation and research. The third annual meeting of the group is planned for January 2001 and will focus on the development of a regional recovery plan and building a long-term strategy.

Because of the intimate relationship between the turtles and the Bahía Magdalena communities, the use of community-based conservation strategies is extremely important. Developing the knowledge and trust of the fishers of Bahía Magdalena has been crucial to recent research and conservation efforts. Because of the illegality of hunting turtles, community members have been very suspicious of any questions about the topic and have been quiet and reserved in their discussions. It has taken a great deal of time and patience to establish rapport within the community. However, a dialog has begun and the results are encouraging. This dialog is crucial to the success of conservation projects in the area. These conversations have given managers and researchers access to an understanding of the human issues surrounding sea turtle recovery, as well as a forum for making recommendations. Involving local knowledge has been beneficial to achieving research objectives. Some fishers have provided us with advice in finding the best locations to capture turtles for sampling and tagging. Others have taken us to locations where they have seen and/or caught turtles.

Local education and communication via town meetings has led to fishers providing valuable data such as tag returns and fisheries-related mortality information. Of note during the1999 field season were tag returns from Japan, southern Mexico, and California, USA. Fishers indicated that they typically discard tags due to fears of legal repercussions. Positive responses to those fishermen who do offer flipper tags will foster trust and lead to a further exchange of information. Furthermore, we have heard from increasing numbers of fishermen who return tagged turtles to the water unharmed, after recording tag numbers and capture locations. The most skilled research team members are former turtle hunters. One fisher, Javier Miramontes, was featured in an article and photograph in the La Paz, Baja California Sur, newspaper (El Sudcaliforniano) after finding a flipper tag from a Japanese loggerhead. This type of positive reaction to collaboration and involvement with conservation projects is extremely important to future success.

Sea turtle recovery will ultimately occur one turtle, and one fisher, at a time. Favourable actions will occur anonymously and quietly, out of sight of enforcement agents, conservationists, and resource managers. Knudsen (1995), in his thoroughly reported series on the Sea of Cortez, recounted a relevant story:

> While fishing near La Paz last year, Mario Coppola and his friends spotted something unusual: a live sea turtle hooked on a piece of commercial fishing gear.
>
> "My friend said, 'Oh, we're going to have turtle soup tonight," said Coppola..."and I said, 'Yes, we are.'"
>
> "So we took the hook off very carefully. It was a small turtle, maybe 3 years old. I said, 'Let me hold her.' And my friend said, 'Don't let her go.' And I said, 'No, I won't.' Then, I just let her go.
>
> "My friend looked at me surprised. I said, 'It's against the law. Plus, you had turtle soup last week. This one turtle will grow up and make a thousand turtles for you and your children.'"

While quantitative signs of sea turtle recovery may be years off, social changes—increasing interest and participation in sea turtle conservation, the results of these participatory research projects, and the development of community-based protected area initiatives—are encouraging.

CONCLUSIONS AND RECOMMENDATIONS

Recent progress and examples from ongoing efforts to recover the sea turtle populations in Baja California, Mexico, demonstrate that a robust, multidisciplinary approach, while difficult to implement and often intractable, can lead to tremendous, otherwise unattainable, conservation progress. By moving beyond platitudes and putting the "conservation mosaic" approach into operation, we are beginning to realise some of the original intentions behind the laws currently protecting these endangered animals.

Although the legislation is in place to protect Baja California's sea turtles, enforcement is prohibitively expensive in such a vast area. Commercial fishing activities completely overlap sea turtle foraging areas. Laws and enforcement have not adequately abated hunting of and declines in turtle populations, especially in rural areas where the laws are misunderstood or disregarded and enforcement is infrequent. Partnerships between government, NGO's, and community groups to sustainably manage coastal resources reduces costs to the government, increases compliance with national and international regulations, and provides a means of gathering and networking important monitoring and assessment information.

Community-based solutions should be considered in concert with standard vigilance practices. Such an approach can lead to a sense of responsibility for the resource and feelings of empowerment through their direct contribution to the conservation of the turtles that inhabit the coastal waters near their home. Murphee (1994) states that "*conservationists now often prefer treating local people and their behaviours as a most effective vehicle for furthering their aims rather than unfortunate stumbling blocks*" (p. 404). In order to successfully implement community-based strategies, the local communities must be provided with ongoing technical assistance, current information on the status of the populations, and timely assessments of successful actions. In other words, the community-based approach must be a two-way process.

Existing protected areas in Baja California, including the Bahía Loreto National Marine Park, special reserves for gray whales in Pacific lagoons and bays, and the Vizcaíno Biosphere Reserve are large enough to encompass home ranges of foraging green turtles. These areas should be considered starting points for the establishment of sea turtle sanctuaries.

> One key to successful sea turtle recovery is having the fishers and current resource users help develop and implement the management plan. Fishers best understand the issues and often wish to protect their own resources. Sea turtles are an important part of the Baja California cultural fabric (Garcia and Nichols 2000).

The fishing cooperatives must become excited, involved, and determined to improve their own fishery resources, find their own solutions to the problems (with advice from researchers), and develop their own sea turtle recovery plan.

A mosaic approach to sea turtle conservation integrates the best of community and co-management approaches with the technological and political realities of the globalized modern world in which we live. We must embrace and celebrate the connections between humans and the species we seek to protect, not pretend that they don't exist.

By combining community-based approaches and media/education/awareness campaigns with a strong base of sound scientific inquiry, a multifaceted, "conservation mosaic" approach will be continued until East Pacific green turtle populations reach stable levels—approximately 5,000 nesting females annually for three consecutive years in the mainland Mexican stock (Black Turtle Working Group 2000). Other marine species will benefit from the model employed in this sea turtle conservation initiative.

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Table 1. Principles of the conservation mosaic model and community-based co-management (adapted from the Coastal Conservation Network 1996).

1. Delegation of authority. Co-management requires legislation that will give co-management groups authority to develop and implement policy, and to undertake management activities.

2. Role of fishers is primary. In all co-management activities, fishers are recognized as the primary participants. Fishers and their families play a central role in making decisions about policy, planning, regulation and allocation, and enforcement and monitoring.

3. Community involvement. In a co-management system, the communities' involvement is essential. Members and representatives of communities will play an important role in decision making where co-management activities affect the marine environment, and where the communities are likely to be seriously impacted by management policy, regulations and allocation.

4. Accountability. All participants in the management process must be accountable to their communities and to the people they represent. This is necessary to build trust between partners.

5. Appropriateness . Representation of the various stakeholders in decision-making must appropriately reflect the level of impact the issue has on them. Co-management participants who have little or no interest in a particular fishery will be involved in decision making primarily on an advisory basis.

6. Build consensus where possible. The decision making process will be guided by the principle of consensus building whenever possible. Consensus building requires negotiation and recognition that compromises must be made.

7. Sustainability. The principles of sustainability should be a key factor in decision making. All co-management activities should be undertaken in a manner that will support the establishment and maintenance of a sustainable fishery, both from an ecological perspective and from a socio-economic perspective.

8. Fair and equitable resource sharing. Management activities should recognize the need for decisions that are fair and equitable. Management decisions should not unduly reward one individual, group, or community at the expense of another.

9. Staff and financial resources. Co-management requires sufficient staff and financial support. Financial support for management activities and for the co-management teams, committees, etc. should be made available by the participants. The industry, the community, and the various levels of government should share the financial responsibility for fisheries co-management.

10. Information. Sufficient and reliable information is needed for successful fisheries co-management. This information should be made available freely to the co-management group from all participants in the fishery without compromising the source of the information. The co-management group should recognize the value of traditional knowledge and anecdotal information.

11. Communication. Effective communications between all participants is essential for successful co-management. All participants must be willing to take part in frequent and open communication. In addition to written correspondence and meetings, telecommunication systems such as Internet could be helpful in increasing the ability of participants to communicate.

12. Education. Co-management requires a public education process directed at all stakeholders (fishers, processors, shore-based workers, other community members, and government workers). Training and education should increase the skills and knowledge of present stakeholders as well as future generations.

13. Change. There is no one model for conservation. Communities and natural resources are dynamic and constantly changing, even in response to the most subtle management actions.

Table 2. Definition of the natural resource co-management approach (adapted from www.co-management.org August 23, 2000).

1. Co-management is a partnership arrangement in which government, the community of local resource users, external agents (NGOs, academic and research institutions), and other resource stakeholders share the responsibility and authority for the management of a resource.

2. Co-management covers various partnership arrangements and degrees of power sharing and integration of local (informal, traditional, customary) and centralized government systems.

3. Co-management partnerships are pursued, strengthened and redefined during the management process, depending on existing policies and the legal environment, government support for community-based initiatives, and the capacities of community organizations to become partners.

Table 3. Long-distance recoveries of sea turtle tags from Californian waters. Long distance tag recoveries highlight the international nature of sea turtle conservation and the need for interdisciplinary collaboration.

Place tagged/ Location recovered	Species	Source of information
Michoacan, Mexico/ Baja California, Mexico (numerous)	Chelonia mydas	Alvarado and Figueroa (199M)
Michoacan, Mexico/ Bahía Magdalena, BCS	Chelonia mydas	This study*
Panama (unconfirmed report)/ Bahía Magdalena, BCS	Lepidochelys olivacea	This study*
Dana Point, CA, USA/ Bahía Magdalena, BCS	Caretta caretta	This study*
Okinawa, Japan/ Bahía Magdalena, BCS	Caretta caretta	This study*
Okinawa, Japan/ southern California, USA	Caretta caretta	Uchida and Teruya 1988

* see Chapter 1

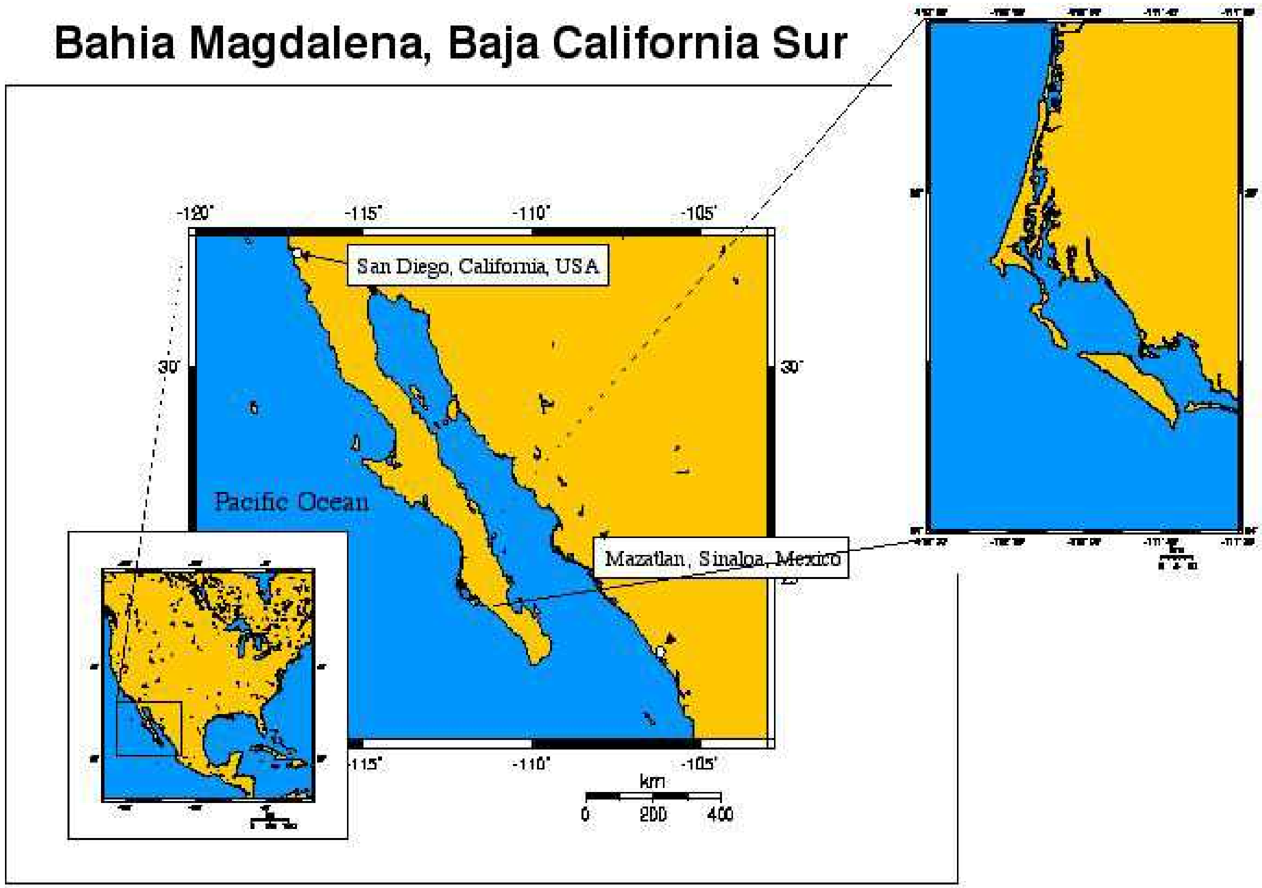

Figure 1. Map of the Bahía Magdalena region, Baja California Sur, Mexico.

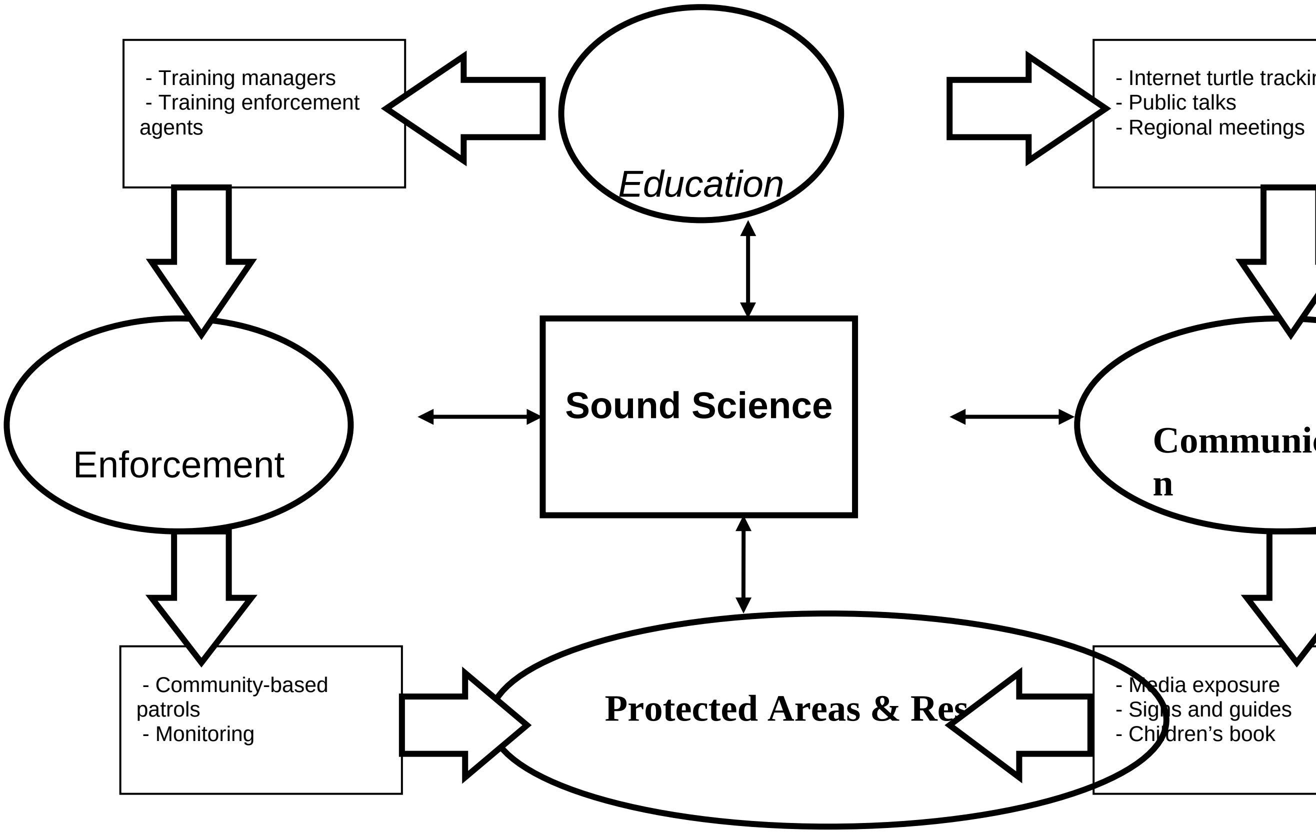

Figure 2. Graphic representation of the "conservation mosaic" concept, including several components of the Baja California sea turtle conservation program.

CHAPTER 9

RESEARCH SUMMARY AND CONSERVATION RECOMMENDATIONS

SUMMARY

The summary of biological findings of this project is expanded in Chapter 1. In short, this work has demonstrated that Baja California waters, including the Gulf of California and the Pacific coast, provide critical development and foraging habitat for all five species of Pacific sea turtle. Turtles using Baja California waters originate on nesting beaches as far away as Japan, Hawaii, and southern Mexico. The most common species are the East Pacific green turtle, *Chelonia mydas*, and the loggerhead turtle, *Caretta caretta*. The hawksbill turtle, *Eretmochelys imbricata* has become extremely rare.

Subsistence use of sea turtles in northwestern Mexico dates back to indigenous groups. By the 17th century, turtles were hunted as food for European explorers, expeditions, and whalers. Large-scale market exploitation of sea turtles began in the early 20th century and continued until 1990, when the Mexican government, in response to dire population trends and their endangered status, established a permanent ban on sea turtles. Subsistence and clandestine markets for sea turtles still exist. The strong tradition of eating turtle meat has been difficult to deter. The overall result has been the ecological extinction of most sea turtle species from northwestern Mexican waters.

The main threats facing sea turtles, described in Chapter 3, are related to direct hunting and incidental take. In Baja California annual sea turtle mortality exceeds 7,800 animals—mostly green turtles—and may be as high as 30,000.

Loggerhead turtles, originating on Japanese nesting beaches, make 12,000 km transpacific migrations to Baja California. They feed on the abundant red crabs that occur in upwelling areas along the Baja California coast. At maturity, loggerhead turtles migrate back to their natal beaches in Japan. Mortality, as well as conservation efforts, in Baja California will have Pacific-wide ramifications.

East Pacific green turtles had never been tracked during their homing migrations. The tracks of three homing green turtles from Baja California feeding grounds to nesting beaches in Michoacan, Mexico, followed the mainland Mexico coastline and ranged from about 1,000 to 2,000 km. Homing turtles swam, on average, 45 km/d, significantly faster than during station keeping movement on feeding grounds and near nesting beaches. In order to reach nesting beaches in late October, green turtles must depart feeding grounds in late summer. The shallow waters along the continental shelf of Sonora, Sinaloa, and Nayarit, Mexico, should be made safe for migrating sea turtles during this time.

The results of this tracking project demonstrate the long distance migratory abilities of sea turtles and support natal homing hypotheses.

Tracking and tagging data are supported by molecular genetics. Analyses of genetic markers (mtDNA) of sea turtles indicate that the majority of the green turtles foraging in Baja California originate from Mexican rookeries. A small fraction of the turtles are apparently from Hawaiian rookeries. It is hypothesized that about 21% of the turtles foraging in Baja California are from Isla Revillagigedo rookeries. Surveys of additional minor rookeries and other feeding grounds to the south will resolve the remaining questions. Mortality of green turtles in Baja California waters will have the strongest impact on mainland Mexican stocks.

The recent debate over the taxonomic status of the East Pacific green turtle has suffered from a lack of basic information and several authors suggest that specific status has been used as a geopolitically motivated conservation tool. Qualitative and quantitative examination of turtles from the Mexican stock indicates that the *agassizii* form has considerable variability. Size, shape, and color overlap with the adjacent rookery in Hawaii. None of the characters previously used to describe the East Pacific green turtle —or black turtle—can be used to consistently distinguish Mexican stocks. Nevertheless, political factors unrelated to the green turtle's taxonomic status impede conservation efforts in Baja California.

Recovery of eastern Pacific sea turtles will require conservationists to use many tools. A "conservation mosaic" approach has been initiated at several sites in Baja California. This approach incorporates scientific investigation, community participation, education, enforcement, and monitoring. The recent finding regarding the region's relevance to Pacific-wide conservation efforts has been emphasized in these programs. The expanding activities of the Grupo Tortuguero de las Californias have resulted in many notable conservation successes, including the initiation of sea turtle conservation areas, community-based research projects, patrols, and monitoring, and biannual grassroots information and training meeting. Following are some recommendations for sea turtle conservation.

RECOMMENDATIONS

1) Establish marine reserves or sea turtle sanctuaries in areas with high contemporary and historic sea turtle densities. Ideally, areas where success is likely should be chosen first—such as locations with existing protected status, proximity to research centers, etc.

2) Expand the activities and membership of the grassroots Grupo Tortuguero de las California. The influence of the group has consistently grown each year. The importance of a non-governmental group, based on membership of fishermen, will help advance conservation goals.

3) Research should be extended to resolve remaining basic questions regarding sea turtle life history. The most urgent projects are those related to fisheries-sea turtle interactions and the human dimensions of sea turtle conservation.

4) Non-consumptive uses of sea turtles should be promoted. In Mexico, particularly in Baja California, marine mammals are conserved, protected and studied with regard to their "new" use as a tourist attraction based on non-consumptive observation. Scientific investigation is encouraged as a component of the ecotourism activities as well as to develop adequate protection for these animals. Their abundance is good for tourism and whales are now "consumed" in a new and sustainable way. This approach is particularly applicable to sea turtles as they nest on beaches in the cape region. A sea turtle "checklist" for the 5 species could be developed and sites where species are likely to be seen publicized. For example, olive ridley and leatherback turtle nesting in the cape region, loggerhead basking offshore of Bahía Magdalena, and green turtle foraging sites in Bahía de Loreto National Marine Park.

5) Considerations for subsistence use of sea turtles should be investigated. If enforcement schemes, particularly community-based ones, can be established, a limited fishery—once populations reach stable levels—should be considered. One possibility is to permit sea turtle use during the semana santa (Easter week) when the demand is highest. This approach will provide a strong conservation incentive.

6) Information on sea turtles in Baja California should be made public. The use of newspapers, TV, and the internet can help achieve this. A public database of sea turtle sightings and strandings has been initiated.

7) International collaboration and communication, considering the vast migrations of sea turtles occurring in Baja California waters, should be encouraged and expanded.

8) Establishment of sea turtle research groups at research institutions such as CIBNOR, CICESE, and UABCS (La Paz, Baja California Sur) and CISESE and UABC (Ensenada, Baja California) should be considered a priority. Sea turtles are considered one of the most important marine vertebrates to the regional economy and culture. Multidisciplinary research at the local universities would produce valuable new knowledge.

APPENDIX A: ACRONYMS & ABBREVIATIONS

BC	Baja California, Mexico
BCS	Baja California Sur, Mexico
BLA	Bahía de Los Angeles, BC, Mexico
BLNMP	Bahía de Loreto National Marine Park
BMA	Bahía Magdalena, BCS, Mexico
CC	*Caretta caretta*, loggerhead turtle
CCL	Curved carapace length
CEC	Centro para Estudios Costeros (School for Field Studies, Puerto San Carlos, BCS, Mexico)
CIB	Centro de Investigaciones Biologicas del Noroeste/Northwestern Center for Biological Research (La Paz, BCS, Mexico)
CICIMAR	Centro Interdisciplinario de Ciencias Marinas/Interdisciplinary Center for Marine Sciences (La Paz, BCS, Mexico)
CRIP	Centro Regional de Investigaciones Pesqueras/Regional Center for Fisheries Research (La Paz, BCS, Mexico)
CRIP-ECITM	Centro Regional de Investigaciónes Pesqueras- Estación de Conservacion e Investigación de Tortugas Marinas (Bahía de los Angeles, BCS, Mexico)
CM	*Chelonia mydas*, green turtle
DC	*Dermochelys coriacea*, leatherback turtle
EI	*Eretmochelys imbricata*, hawksbill turtle
EPGT	East Pacific green turtle (*Chelonia mydas*)
ESSA	Exportadora de Sal, S.A. de C.V./Salt Exporting Company (Guerrero Negro, BCS, Mexico)
FG	Feeding grounds
FWS	Fish and Wildlife Service (U.S.)
GEA	Grupo Ecologísta Antares, A.C. (Loreto, BCS, Mexico)
GMT	Generic Mapping Tools
GMT	Greenwich Mean Time
INE	Instituto Nacional de Ecologia/National Institute of Ecology (Mexico)
INEGI	Instituto Nacional de Estadistica, Geografia e Informatica/National Institute of Statistical and Geographical Information (Mexico)
JUN	Juncalito, BCS, Mexico
LC	Location class (ARGOS)
LO	*Lepidochelys olivacea*, olive ridley turtle
LSI	Laguna San Ignacio, BCS, Mexico
NB	Nesting beach
NMFS	National Marine Fisheries Service (U.S.)
NOAA	National Oceanic and Atmospheric Administration (U.S.)
PAO	Punta Abreojos, BCS
PROFEPA	Procuraduria Federal de Proteccion al Ambiente/Federal Attorney General's Office for Environmental Protection (Mexico)

SCL	Straight carapace length

APPENDIX A - *Continued*

SCT	Secretaria de Comunicaciones y Transportes/Secretariat of Communications and Transportation (Mexico)
SECTUR	Secretaria de Turismo/Secretariat of Tourism (Mexico)
SEDESOL	Secretaria de Desarrollo Social/Secretariat of Social Development (Mexico)
SEDUE	Secretaria de Desarrollo Urbano y Ecologia/Secretariat of Urban Development and Ecology (Mexico)
SEMARNAP	Secretaria de Medio Ambiente, Recursos Naturales, y Pesca/Secretariat of the Environment, Natural Resources, and Fisheries (Mexico)
SWFSC	Southwest Fisheries Science Center, La Jolla, California, USA
UABCS	Universidad Autonoma de Baja California Sur/Autonomous University of Baja California Sur (La Paz, BCS, Mexico)
UNAM	Universidad Nacional Autonoma de Mexico/National Autonomous University of Mexico (Mexico City, D.F.)
UNESCO	United Nations Educational, Scientific, and Cultural Organization

APPENDIX B: RESEARCH PERMIT NUMBERS

SEMARNAP Permisos Pesca de Fomento Numbers:

#150496-213-03,

#280597-213-03,

#190698-213-03, and

#280499-213-03]

Instituto Nacional de Ecología (INE):

Oficio No. DOO 750-07637/97

CITES Permit Numbers:

#US786600 and

#MEX11556

APPENDIX C: SEMI-STRUCTURED INTERVIEW QUESTIONS

I. Informant Data

1987 Name (optional)
1988 Sex
1989 Age
1990 Address (optional)
1991 Occupation (specific: years at occupation, type of fishing, etc.)

II. Species of Sea Turtle in the Area

1987 How many different kinds of sea turtle are in the area? Describe them.
1988 What are their local names?
1989 How do they rank in abundance?
1990 Do you know of any other types of turtle that are unusual or rare? If so, what are they called? Describe them.

III. Seasonality & Ecological Distribution of Foraging Adults

1995 Do fully-grown, mature turtles occur here? Which species?
1996 Which species live in local waters year round?
1997 During which seasons do other species occur here?
1998 If turtles are seasonal here, do you know where they go? How do you know?
1999 Do turtles arrive and depart on predictable or variable schedule?
2000 In what area does each species occur? (place names, habitat, etc.)
2001 How many of each species did / do you catch in a year?
2002 On a good day during turtle season, how many turtles (total) would you catch?
2003 How many days per month would you fish for turtles?
2004 Where and when have you seen adults feeding?
2005 Where and when are turtles most numerous?
2006 Do you ever see turtles offshore in open water? How far out? Which species?
2007 Are they in groups?
2008 What sizes?

IV. Seasonality and Ecology of Developmental Stages

a) What sizes of each species do you see?
b) Which species of small turtle live here year round?
c) What is the best location to find each type of small turtle?
d) Is there a time of the year when there are more of a certain size turtle?
e) What is the largest turtle of each species that you have seen? Smallest?

V. Nesting and Copulation

1983 Do (did) sea turtles nest locally? Which species? Where? When?
1984 Have you seen white / yellow eggs inside turtles? Which species? When?
1985 Have you seen copulating turtles? Which species? When?
1986 Do you see mature male turtles? Which species? When?
1987 Out of one hundred turtles, how many would be males?
1988 How are male turtles different?
1989 During which months are males found here?

VI. Changes in the Population

1973 Are numbers of sea turtles generally more rare, more abundant, or about the same as they were in the past? 10 years ago? 25 years ago? 50 years ago?
1974 How would you rate (numerically) abundance now compared 10 years ago? 25 years ago? 50 years ago?
1975 To what do you attribute these changes?

VII. Migratory Routes

a) At certain times of the year, do you see turtles that seem to be migrating to nesting beaches?
b) Which species? Sizes? In groups or alone? How many in a group?
c) Describe the route that they seem to be taking.
d) Describe the daily movements of turtles locally.

VIII. Exploitation

1980 Was turtle meat sold locally? Was there a demand for the meat from elsewhere? How about now?
1981 What was the price of turtle meat per kilo? Per whole turtle? Now?
1982 Was the meat exported to the US, to mainland Mexico? Now?
1983 How important was the turtle meat in the local diet? Now?
1984 How important was the income from turtle fishing?
1985 Did turtles have importance beyond nutrition and a source of income?
1986 How was turtle meat prepared?
1987 Which species were eaten?
1988 Which parts of the turtle were used?
1989 Was there a market for the shell? Who bought it?
1990 Did people fish for turtle solely for personal consumption?
1991 Was there an organized turtle fishing cooperative? Describe it (dates).
1992 When did restrictions on turtle fishing begin? What were they?
1993 What have been their effects?
1994 How important is the turtle to the local community now?

IX. Overwintering Behavior

1995 Describe the behavior of turtles during the winter.
1996 Which species are here during the winter months?

1997 How are turtles captured during the winter months?
1998 How long do turtles stay submerged during this time of the year?
1999 Have you ever seen / heard of turtles burying themselves?
2000 How big are the turtle in the winter?

X. Tags

a) Have you ever seen a turtle with a flipper tag? Where? What kind of tag? What happened to the tag?
b) Have you ever seen a turtle tangled in the net by a tag? By any other objects (i.e. epibionts)?
c) Would fishermen that you know return a tag if they found it?
d) Do you know anyone who has seen a tag on a turtle?
e) Would a reward make a difference?

XI. Fishing Techniques

a) What techniques were used locally to catch turtles?
b) Which were most effective?
c) Which are used now?

XII. Laws, Poaching, Smuggling

a) Do you consider laws that prohibit catching turtles fair or unfair? Why?
b) Are the laws well enforced?
c) Do people respect the laws?
d) Have you ever heard of someone getting caught selling turtles?
e) What is the penalty?
f) How do poachers avoid enforcement officers?
g) How many people do you suppose are involved in furtive turtle trade locally?
h) Are there areas in Baja California where more turtles are hunted?
i) Do you think that the turtle population will ever return to its former level?

XIII. Incidental Catch

a) Do trawlers work in local waters? During which months?
b) Do they catch sea turtles?
c) Which species do they catch?
d) Do they use TEDs?
e) What usually happens to captured turtles?
f) What other kinds of fishing activities catch turtles accidentally?
g) Are they used locally?
h) Approximately how many turtles are caught accidentally each year?
i) What usually happens to those turtle?

XIV. Miscellaneous

a) Have you ever seen a turtle being eaten by another animal?

b) Have you ever found a small turtle inside a fish? How big was the turtle/fish? What species of turtle/fish?
c) Have you ever caught turtles with abnormalities? Tumors? What species? Where? Describe the abnormality.
d) Have you ever seen turtles with other species living on them (barnacles, algae, snails or leeches)?

APPENDIX D: PARTIAL RESULTS OF MEDIA/OUTREACH CAMPAIGN (1996-2000) FOR SEA TURTLES IN BAJA CALIFORNIA

Amelio, G.F. Personal letter. December 20, 1996.

Personal letter from Mr. Gil Amelio, CEO of Apple Computers, congratulating us on our research project and thanking us for our support of their producst.

Apple Outlook. 1997. Apple product catalog. May 1997.

Apple product catalog featured sea turtle tracking project as part of their "Dear Apple…" section. They subsequently donated a computer to the project.

Apple Computers, Inc. 1997. National advertising campaign.

Four page advertisement in many popular magazines such as Time, Newsweek, PC World, etc. highlighting sea turtle tracking efforts by "researchers at the University of Arizona"

Anonymous. 1997. Eco watch: Hi-tech turtles on the move in Baja. Baja Life Magazine. 7:34-35.

This article describes the educational sea turtle tracking program, community involvement and general research on sea turtle conservation efforts in Baja California.

Anonymous. 1997. World watches Adelita's Pacific migration. Environmental News Network Daily News**.** June 23, 1997. <http://www.enn.com/enn-news-archive/1997/06/062397/06239710.asp>

Anonymous. 1998. Turtle's journey inspires further study. Environmental News Network Daily News. May 20, 1998.

Anonymous. 1998. Rosita cruises the Pacific. Earthsavers: National Wildlife Federation Newsletter. Fall 1998.
http://www.nwf.org/earthsavers

Brief article in NWF Newsletter on the migration of the loggerhead turetle Rosita from Mexico to Japan.

Bairstow de Perez, L. Turtle preservation project crosses boundaries. Vallarta Today. June 30, 1994.

Summarizes nesting beach conservation projects in Nuevo Vallarta and San Pancho, Mexico which were initiated shortly after WJN and JAS surveyed nesting beaches in summer 1993.

Connections. 1996. Lynn Jimenez's students are becoming wild about turtles. First Quarter 1996.

Sycamore Junior High School Newsletter article highlighting L. Jimenez's experience as a volunteer and the subsequent involvement of her students. This involvement eventually led to their sponsoring a satellite transmitter and seven of her students traveled to Baja California to help deploy it during the 1997 field season.

Denogean, A.T. 1998. UA student tracking sea turtles. Tucson Citizen. November 9, 1998.

Highlights collaborative project between UA researchers and Mexican biologists.

Dragonfly Magazine. 1998. May/June 1998

Dragonfly Net. 1996-7.

Internet website devoted to grades 3-6 education. Tracked sea turtles tagged by this project.

Feagans, B. 1996. Satellite broadcasts turtle's tireless trip. The News. December 10, 1996.

Mexico City daily English language newspaper describing our efforts to study loggerhead migration in the Pacific and the educational aspects of the project.

Field Life. 1998. The mystery of the loggerheads' Pacific journeys. Amway Nature Documentary. 23 November, 1998.

A documentary filmed in Baja California, Mexico and Japan highlighting the transpacific migration of the loggerhead turtle and the involvement of children in the tracking project.

Ghantous, K. 1996. Turtle satellite tag. Sycamore Junior High School Newspaper.

Kevin Ghantous, one of Lynn Jimenez's students wrote this article in the school newspaper about the turtle tracking project highlighting email messages between students and scientists.

Harrison, J. 1997. Eyes on Adelita: sea turtle's quest may solve migratory riddle. Lo Que Pasa. Vol. 21 No. 21. June 26, 1997.

Update article on the migration of Adelita in the University of Arizona staff and faculty newspaper.

Holtcamp, W. 1998. It takes a village: Baja communities play a key role in sea turtle conservation. Animals Magazine. Nov.-Dec. 1998.

An article about community based conservation in Baja California that focuses on our work in Bahia Magdalena, BCS.

Kirschner, S.K. 1998. Newsfronts: Web Watch. Popular Science Magazine. December 1998.

Highlights internet sea turtle tracking website.

Luoma, J.R. 1998. It's 10:00p.m. We know where your turtles are. Audubon. Sept.-Oct. 1998.

Article on wildlife telemetry highlighting our turtle tracking website.

Machan Message. 1997. Mrs. Crane's class uses the Internet! William T. Machan Elementary School Newsletter. Phoenix, Arizona. March 31, 1997.

Article highlights Roberta Crane's classes efforts to track Baja California sea turtles via the Internet website and her classes subsequent library research on sea turtles.

Mistilis, J.D. 1997. Middle school teacher an expert on turtles. Birmingham, AL.

Article highlights Anne Steele, a member of the International Order of Turtle, a teacher at Oxford Middle School in Mississippi, and volunteer who received a

Phil Harden Fellowship to participate in our project and who returned to her classroom after her experience in Mexico and incorporated her experiences into her curricula. She is still in touch with the project and uses tracking data in her Mississippi classroom.

Morrissey, B.A. 1993. Students seek to protect sea turtles. Arizona Daily Wildcat. April 14, 1993.

University of Arizona daily newspaper article highlighting our initial efforts to survey all of Mexico's nesting beaches. A four month trip that covered over 8,000 miles of coast.

National Geographic Explorer. 1996. Sea turtles of Baja California. November 1996. National Geographic Television, Inc.

A brief documentation of the work with black sea turtles in Loreto, Baja California, Mexico highlighting the migration of the black turtle from the Gulf of California to Michoacan and the involvement of local fishing communities.

National Geographic Explorer. 1997. Researcher highlights, Bahia de Los Angeles. November 1997.

Highlighted sea turtle research in Bahia de los Angeles, particularly use of critter cam technology on sea turtles within the bay (Seminoff dissertation work).

Nature Production. 1998. Go! Go! Brian: Active Kids' English Club. Volume 7.

A Japanese publication for children. Educational magazine, workbook and CD-ROM. Featured loggerhead tracking project, website and U.S. and Japanese student participation.

Nichols, W.J. 1998. Adelita's journey. Dragonfly. May-June 1998.

An article for kids in grades 3-6 in the award winningDdragonfly Magazine. The focus of this issue of Dragonfly, a magazine for young investigators, was "maps and navigation". Accompanying articles are on how turtles navigate and a teacher's guide. One accompanying article "Finding her way: the story of Adelita" was written by the 5th grade class at E.H. Greene School, Cincinnati, Ohio.

Nichols, W.J. and D.C. Nichols. 1999. Grupo Tortuguero de Baja California: First meeting of sea turtle group in Loreto sets goals for marine conservation in Baja California. Currents. Winter 1998-1999.

Article in the Oceanic Resource Foundation's journal describing the first annual meeting of the BCSTG. <www.orf.org>

Sterba, J. 1997. Giant turtle swims the Pacific. Arizona Summer Wildcat. June 11, 1997

Article in the summer edition of the University of Arizona campus newspaper on turtle tracking project.

Sullivan, K. 1996. Shell games: Junior high students track turtles. Cincinatti Herald.

Article highlighting Lynn Jimenez's students' efforts to raise funds for turtle project and WJN's lecture to the Sycamore Junior High School.

Webster, G. 1996. Turtle-tracking e-mail: researchers to follow journey to Japan. Arizona Republic. August 4, 1996.

Webster, G. 1996. Turtle-tracking e-mail: researchers to follow journey to Japan. The Carapace: Newsletter of the National Turtle and Tortoise Society. Volume XII, number 6. November/ December 1996

Webster, G. 1997. Going home: scientists, kids track turtle's 6,000-mile trip. The Tribune. May 27, 1997

Several articles by journalist Guy Webster describing the release of Adelita, a loggerhead turtle that we eventually tracked from Baja California to Japan.

Weiss, R. 1998. Following loggerhead turtle's compass. Washington Post. Page A02. February 16, 1998.

Public Presentations, Lectures and Workshops

Earthwatch San Francisco Member Group. "An Endangered Species Evening". Presentation at Fort Mason Center. September 23, 1997.

Baja Sea Turtles Presentation. October 28, 1997. Maritime Aquarium. Norwalk, CT.

Biology and Conservation of Sea Turtles. 1993-1997. Annual lectures for University of Arizona Marine Biology, Oceanography and Conservation Biology classes.

Sea Turtles of Baja. October 1997. Earthwatch Institute Conference. Harvard University, Massachusetts.

Biology and conservation of the sea turtles of Baja California, Mexico. Primer Seminario 1998. Universidad Nacional Autonoma de Mexico, Insituto de Ciencias del Mar y Limnologia, Estacion Mazatlan, February 1998.

Tortugas marinas en Baja California Sur, Mexico: biologia y manejo. 1998. First Symposium on Use and Management of Reef Species in Baja California Sur. National Autonomous University, La Paz, Baja California Sur. November 17-19, 1998.

Books

Nichols, W.J., D. Navarro, D., and R.Snodgrass. 2000. Chelonia: El retorno de la tortuga marina. Sea Challengers Press, Monterrey, CA.

Bilingual children's book describing the life history of an East Pacific green turtle, rescued by a young girl and her father off the Baja California coast.