

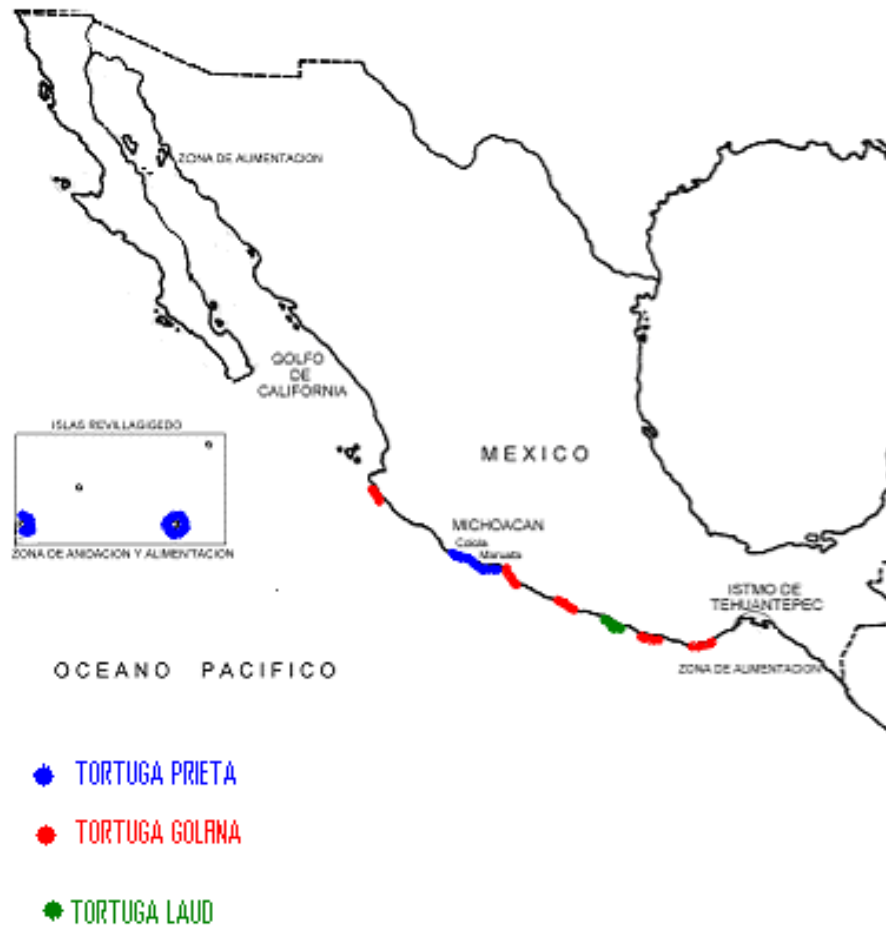
# **Advances on the monitoring of the eastern pacific green turtle *Chelonia mydas* 2001-2004**

## **INTRODUCTION**

The coast of the Mexican Pacific provides food and protection for five of the seven species of sea turtles known worldwide. The eastern pacific green turtle *Chelonia mydas*, the loggerhead *Caretta caretta*, the olive ridley *Lepidochelys olivacea*, the leatherback *Dermochelys coriacea*, and the hawksbill (Cliffon et al. 1995). Besides feeding, eastern Pacific greens, ridleys, and leatherbacks also reproduce in the Mexican Pacific (Fig. 1; Cliffon et al. 1995; Plotkin, 1995). The five species were once extremely abundant off Mexican coasts (Cliffon et al. 1995; Cliffon, 1990; Nichols, 2003), however they are now considered endangered by the International Union for the Conservation of Nature and Natural resources (IUCN) in the Red Data Book (Hilton, 2000). Under the same terms, they are included in the Convention of International Trade in Endangered Species of Wild Fauna and Flora (CITES; Plotkin, 1995; Márquez, 1996; Nichols, 2003), as well as in the NOM-059-ECOL-2001, and the Carta Nacional Pesquera of 2004 in México.

Historically, the Mexican coast has been recognized as one of the areas with the most diversity and abundance of sea turtles in the world (Cliffon et al. 1995). However systematic exploitation of eggs, juveniles and adults for commercial purposes, that developed substantially by the end of the last century and reached its maximum during the sixties and seventies (Alvarado y Figueroa 1990a), undermined the populations of all sea turtle species. Between 1980 and 1990, many bays and coastal lagoons in the country known for their sea turtle abundance, presented an impressive scarceness of these organisms (Seminoff, 2000; Nichols, 2003).

Despite the protection to which turtles are subjected since the presidential decree of 1990, mortality caused by illegal harvesting and by-catch, mainly affecting young turtles (Gardner and Nichols, 2001; Koch et al., 2002), are still the strongest threats to their survival (García-Martínez y Nichols, 2000). Since the waters of Baja California are considered one of the most important feeding and developing sites for the eastern Pacific green turtle in the Mexican Pacific (Nichols, 2003), the sea turtle group (Grupo Tortuguero) is undertaking monitoring activities in order to determine the actual status of the population and to establish efforts towards their conservation.



**FIGURE 1.** Main nesting beaches of sea turtles in Mexican Pacific coasts (adapted from Clifton et al. 1985)

### GOALS OF THE PROJECT

The general goal of this research is to determine the status of the eastern Pacific green turtles in the waters of Baja California and to generate information in order to improve the conservation strategies by giving the basis for the establishment of natural protected areas.

The specific goals are:

- 1) To determine the distribution and population structure along the peninsula.
- 2) To determine growth rates using mark recapture techniques in each of the monitoring sites to identify growth differences of the organisms in each of these sampling sites.
- 3) To determine if there is site fidelity through mark and recapture of organisms, and to evaluate connectivity among the different sites.
- 4) To compare the relative abundance between sites using the capture per unit effort (CPUE), and to determine annual changes in the abundance at each site (population trends) as a way to measure the effectiveness of conservation efforts.

## MONITORING SITES

(Figure 2)

These sites were chosen because they were traditional places of abundant poaching of sea turtles, and because of the eagerness of local people to participate within this program.

◆ During the first year, two sites were sampled in the Gulf of California: Bahia Los Angeles and Loreto. On the Pacific coast, sampling took place in Laguna Ojo de Liebre (Scammon's Lagoon), Punta Abrejos, Laguna San Ignacio, and Bahia Magdalena.

◆ In the second year Cabo Pulmo, in the Gulf of California, was included.

◆ In 2004, Mulegé and Canal del Infiernillo were also included; Bahia de Los Angeles left the group.

**Magdalena Bay**, the sampling site Estero Banderitas is located at the north of the lagoon complex, 24° 54' N and 112° 05' W, is the biggest estuary in the area and is highly influenced by tidal currents. Salinity at the mouth of the estuary is 36.9-38.7 ppt. Water temperature varies from 18-31° C, and depth goes from 1-7 m. In the shallow parts, algae and seaweed cover huge areas, with mangroves in most of their margins (Álvarez Borrego et al. 1975).

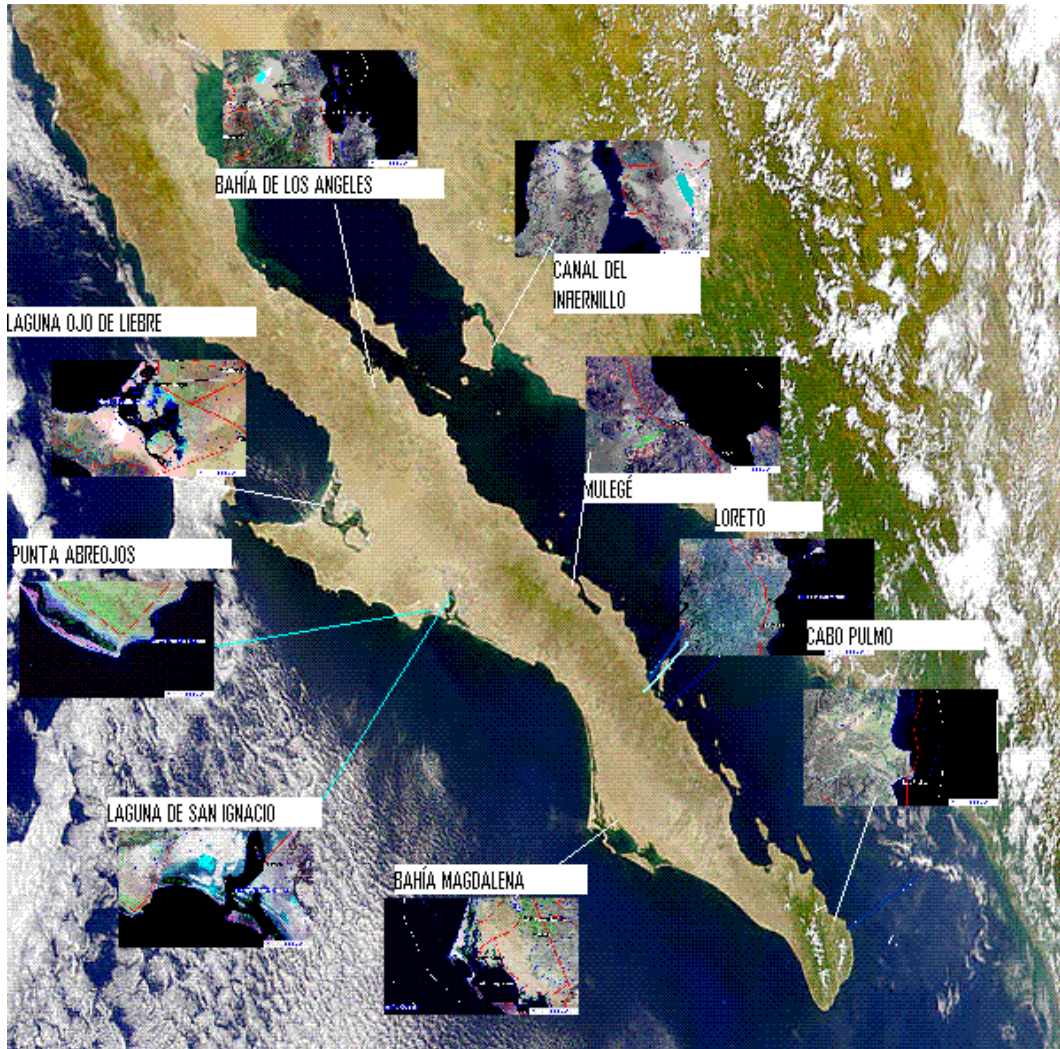
**Laguna San Ignacio** is located in the Vizcaino biosphere reserve on the Pacific coast of Baja California Sur. It comprises an area of 17.5 Km<sup>2</sup>, it is characterized by wide channels that go from 6 to 14 m in depth. Algae and seaweeds are abundant; mangroves are found along most of the coastline. It presents a tidal range of 1 to 6 meters and salinity varies from 36 ppt in the mouth to 11 ppt in the most internal part (Núñez-López et al. 1998). The sampling site (El Remate) is located at 26° 58' N and 113° 16' W

**Punta Abrejos** is also part of the Vizcaino Reserve; the sampling site is Estero Coyote, 26° 48' N and 113° 27' W. It is a small and uninhabited lagoon with characteristics very similar to San Ignacio Lagoon. It has abundant algae, seaweeds, and mangroves. There is not much traffic of boats or humans that alters the area, so is almost unexploited.

**Laguna Ojo de Liebre** is located in the Vizcaino Biosphere. This 36.6 Km<sup>2</sup> lagoon is characterized by the presence of algae and seaweeds covering the bottom (Águila-Ramírez 1998). The channels are 20 m deep and tidal currents of more than 2.5 knots give a range of 1 to 3 m (Phleger and Swing, 1962). Salinity varies from 35 to 39 ppt (with a maximum salinity record of 47 ppt), and temperature goes from 18 to 25.5° C. (Acevedo, 1997). The sampling site El Uno is located at 27° 38' N y 114° 20' W.

**Loreto** the sampling site is located within Loreto Bay National Park in the Gulf of California, Baja California Sur. This park was created by a presidential decree in 1996; it comprises an area of 2062 Km<sup>2</sup> and includes five islands. The habitats present in this park vary from rocky islands and sandy beaches, to submerged reefs (Nichols, 2003). The sampling site Playa Notri is located at 25° 35 N and 110° 45 W.

**Bahia de Los Angeles** is located in the east coast of Baja California. It comprises an area of approximately 60 km<sup>2</sup> and is separated from the Gulf of California by an archipelago of 17 islands. Maximum depth is 40 to 50 m and tidal range is 4 m. Water temperature varies from 14° C to 31° C, and air temperature varies from 12° C to 31° C (Resendiz, 2002). The bottom is soft and sandy with algae on the south and west margins (Seminoff, 2000). The sampling site Playa Blanca is located at 28° 58' N and 113° 33' W.



**FIGURE 2.** Location of sampling sites (taken and adapted from Baja-expo.com and mapmart.com).

## METHODS

Every month during a 24-hour period and during dead tides, turtles are captured with turtle nets that are approximately 100 m long by 8 m high. Each net is kept floating with small buoys and has enough weight on the bottom line to maintain the net in position but to allow entangled turtles to go to the surface and breath. Nets are checked every hour. The exact place of capture is registered with a

GPS. Every turtle captured is provided with a code formed by the place and date of capture, as well as the number of capture on that date. As an example, for the third turtle capture in Laguna San Ignacio on October 25<sup>th</sup>, 2003, the code is LSI25OCT03-03.

Once captured, turtles are taken to the beach where each is measured and weighed (Table 1), also a metallic tag (Iconel, style 681, National Band and Tag Company, Newport, KY) is placed in each of the rear flippers for future identification in case of recapture. Once all monitoring data is collected, the turtles are released at the same place of capture.

One unit effort is defined as 100 m of net in the water for 24 hours. In each sampling the total time in which the nets are in the water is recorded. With this, the number of organisms captured during the 24-hour period is divided by the units of effort and capture per unit effort is obtained:

$$CPUE = \frac{\text{Number of organisms captured}}{\text{Units effort}}$$

Data from CPUE will be used to obtain the relative abundance of organisms in each monitoring site. Comparisons will be made using graphics to determine variations in the number of individuals sampled and with that infer if the population presents a positive or a negative trend.

Growth determination will be obtained using the increase of the straight carapace length (SCL), and the time elapsed between capture and recapture. Annual growth is determined by dividing growth by the difference in days of capture and recapture, and multiplying the result by 365:

$$\text{Total Growth} = \text{SCL at recapture} - \text{SCL at capture}$$

$$\text{Annual Growth} = \frac{\text{Total growth (cm)}}{\text{Recapture date} - \text{Capture date (in days)}} \times 365$$

Since Cabo Pulmo is a protected area (Cabo Pulmo National Marine Park), use of nets of any type is prohibited, therefore the team captures turtles by hand using SCUBA and records sightings.

**TABLE 1:** Measurements for turtles, taken from Farzan and Tennant, 2003.

ABBREVIATIONS	MEASUREMENTS	GEAR	DESCRIPTION
SCL	Straight carapace length ( cm)	Big caliper	Is taken from the margin of the carapace behind the neck and to the end of the biggest posterior scute
CCL	Curved carapace length (cm)	Measuring tape	Same as the one before but keeping the measuring tape right over the carapace
SCW	Straight carapace width (cm)	Big caliper	Is measured at the widest point of the carapace
CCW	Curved carapace width (cm)	Measuring tape	Same as the one before but keeping the measuring tape right over the carapace
PTL	Post-cloacal tail length (cm)	Vernier	Holding the tail, measure from the cloaca to the tip of the tail.
TTL	Total tail length (cm)	Vernier	Holding the tail, measure from the midline of the posterior margin of the plastron to the end of the tail.
PL	Plastron length (cm)	Big caliper	From base to tip following the midline
HW	Head width (cm)	Big caliper	The widest point of the head is measured horizontally
	Body depth (cm)	Big caliper	The highest point of the carapace is measured vertically
	Weight (Kg.)	Spring scale	Place turtle in a net or mesh support, it is then suspended from the scale. Weight of the net has to be subtracted from total weight

## RESULTS

Results presented here are those from Bahia de Los Angeles, Cabo Pulmo, Loreto, and Laguna Ojo de Liebre in 2001 to 2003; and from Punta Abreojos, Laguna San Ignacio and Bahia Magdalena from 2001 to 2004. No access to Canal del Infiernillo data has been obtained and in Mulegé permits have not been granted from Federal authorities.

A total of 868 turtles have been captured, most of them on the Pacific coast of the Baja California peninsula, of these 455 organisms were captured in Punta Abreojos, representing 51% of the total capture (Table 2). The location with the most units of effort employed (83) was Bahia de Los Angeles however they only presented 28 captures. Bahia Magdalena follows with 71 units of effort and 108

organisms. Laguna Ojo de Liebre and Punta Abrejos have the same units of effort (50), the former with 103 captures and the later with 445 as mentioned before. Finally, Laguna San Ignacio has 38 units of effort and 71 captures. A total of 121 recaptures were registered, Loreto was the only site with no recaptures and Punta Abrejos had the most of them (53) representing 44% of the total of captured organisms.

Cabo Pulmo is analyzed on its own due to their methods of capture (Table 3). A total of 6 captures were recorded from which 4 were olive ridleys, 1 hawksbill, and 1 black turtle. In addition 3 sightings were reported: 2 hawksbills, and 1 black during a total of 27 hours 45 minutes of SCUBA diving.

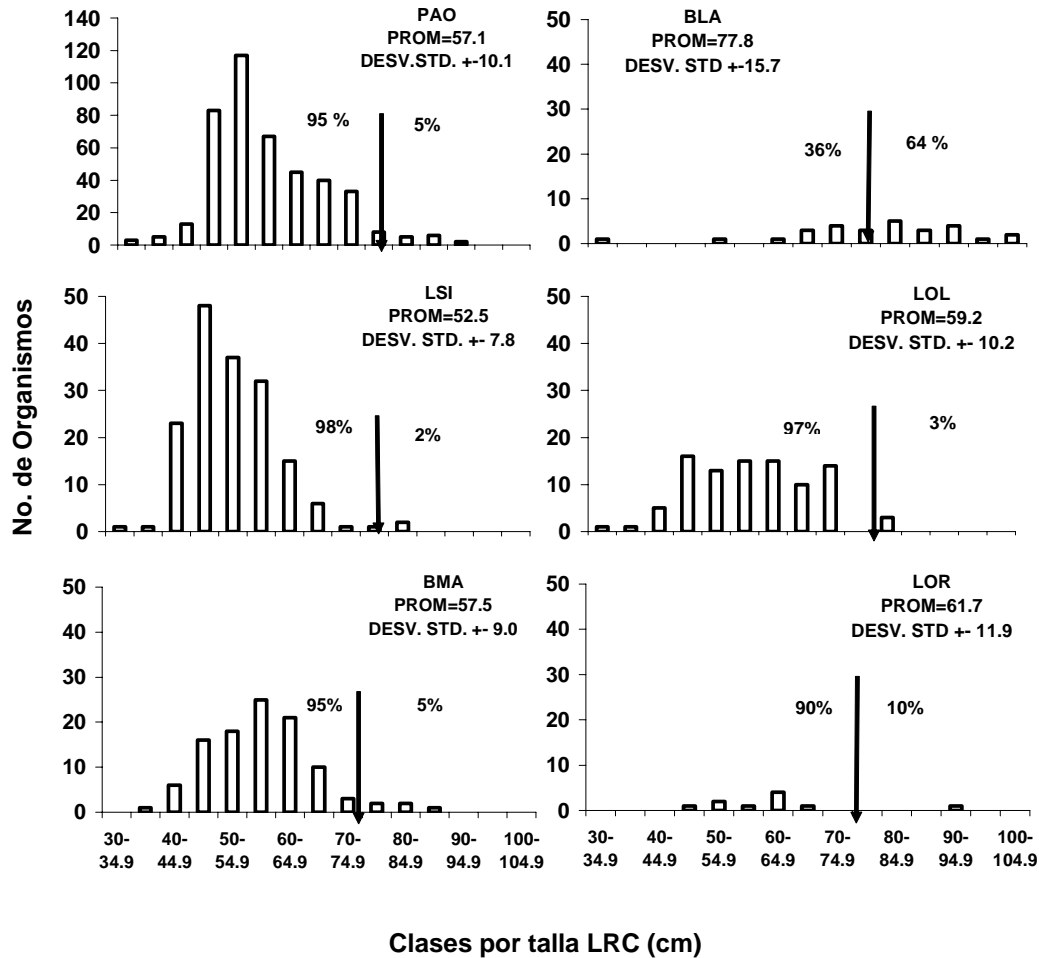
**TABLE 2:** Total capture and recapture of sea turtles, units of effort employed and Capture Per Unit Effort of each monitoring site.

<b>SITE</b>	<b>TOTAL # OF ORGANISMS</b>	<b>TOTAL UNITS EFFORT</b>	<b>CPUE</b>	<b>TOTAL # OF RECAPTURE</b>
BLA	28	83	0.3	8
LOR	10	44	0.2	0
CP	6	---	---	---
LOL	103	50	2.1	15
PAO	445	50	8.9	53
LSI	168	38	4.4	16
BMA	108	71	1.5	29
<b>TOTAL</b>	<b>868</b>	<b>336</b>	<b>17.4</b>	<b>121</b>

**TABLE 3:** Results from the monitoring in Cabo Pulmo.

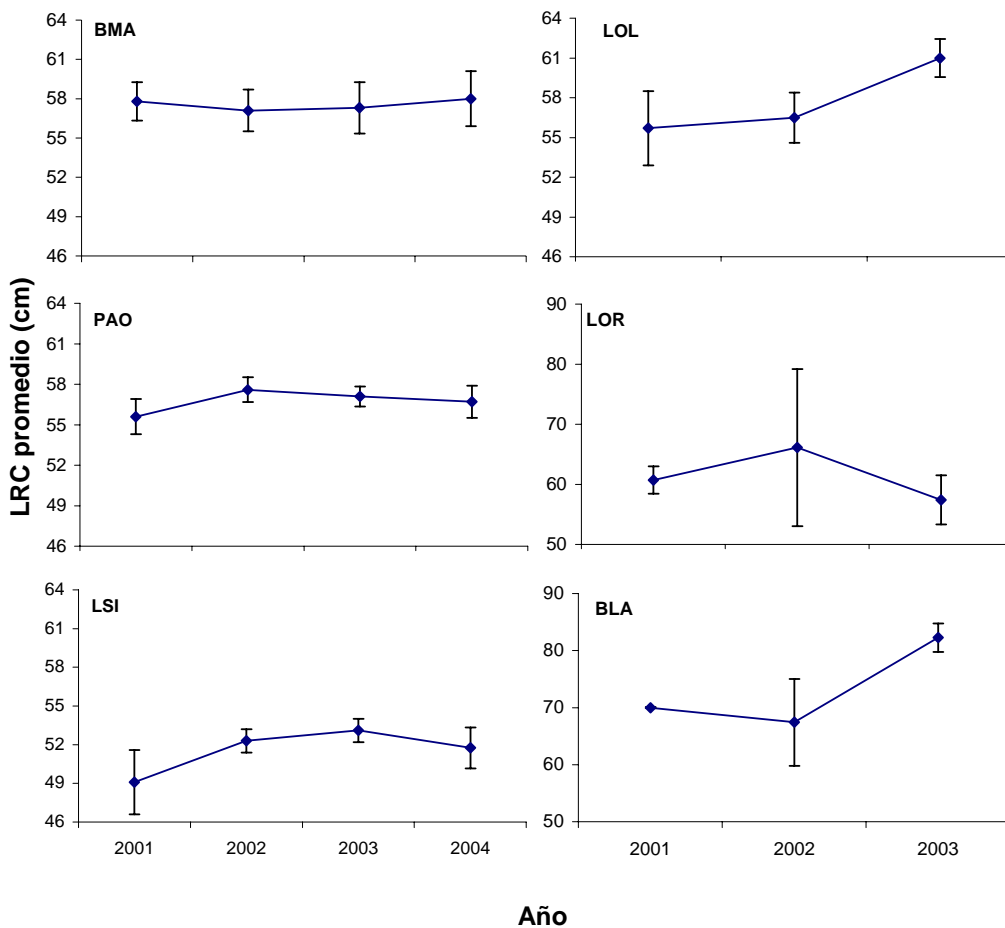
	<b>SIGHTINGS</b>	<b>CAPTURES</b>	<b>TOTAL TIME (HOURS)</b>
CP	3	6	27.7

For the analysis of size structure (Figure 4), sizes were grouped in 5 cm intervals and the number of individuals on each was obtained. Every site was analyzed. It is observed that in Loreto, Ojo de Liebre, Magdalena, Punta Abrejos, and San Ignacio, most of the organisms captured are below 75 cm of SCL, indicating these are juveniles and subadults (black arrow). Only Bahia de Los Angeles presented a higher proportion of adults larger than 75 cm (see percentages at the sides of black arrow)



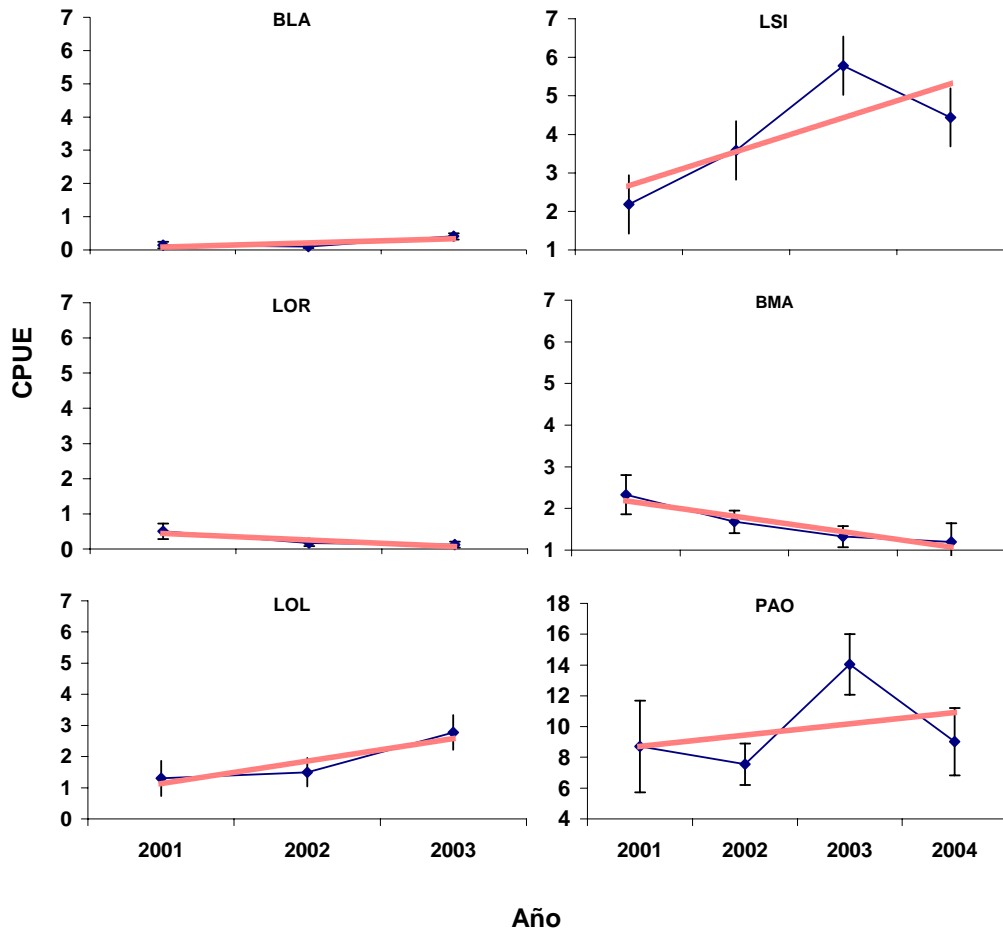
**Figura 4:** Estructura de tallas en longitud recta del caparazón (LRC) en los sitios de monitoreo con datos de 2001 a 2003 en Bahía de los Angeles, Loreto Cabo Pulmo y Ojo de Liebre; y de 2001-2004 en Bahía Magdalena, Punta Abreojos y La Laguna de San Ignacio; en cada gráfica se observa el nombre del lugar abreviado, promedio y desviación estándar; la flecha negra indica la LRC de madurez sexual (75 cm.) y los números a los lados de estas flechas nos indican porcentaje de juveniles o adultos; la escala en el número de organismos de Punta Abreojos es diferente a las otras gráficas.

When analyzing the average size in each of the monitoring sites (Figure 5), we observed that in the Pacific coasts the general tendency is positive, being mostly evident in two sites: Laguna San Ignacio where, of all the sites, the smallest average sizes are recorded; and Laguna Ojo de Liebre where the largest average size was registered. In the Gulf of California, Bahía de Los Angeles presents an evident positive trend with averages running from 67.4 to 82.7 cm. Loreto presents a negative trend with average sizes of 66.1 in the first year and 57.4 cm in the last monitoring.



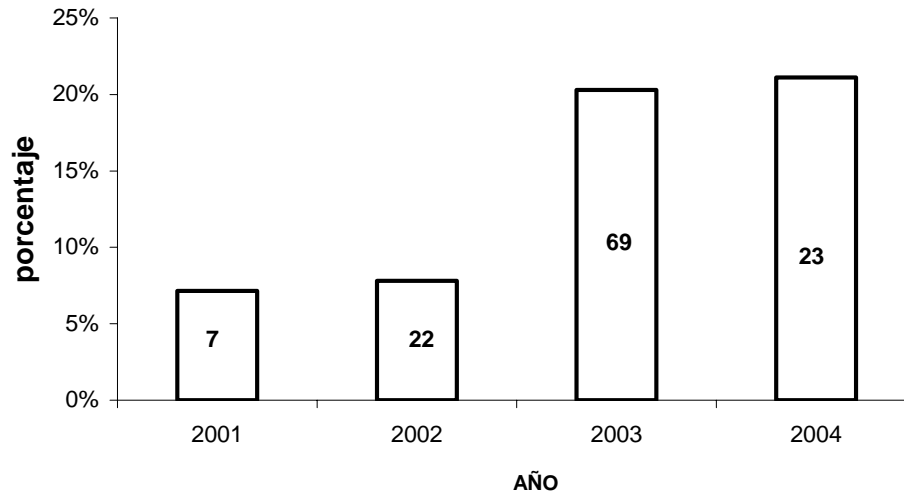
**Figura 5:** Promedio de tallas LRC anuales de todos los sitios de monitoreo, los datos son de 2001-2003 en Bahía de los Angeles, Loreto y Laguna Ojo de Liebre; y de 2001-2004 para Laguna de San Ignacio, Bahía Magdalena y Punta Abreojos; se nota una tendencia hacia el aumento en la LRC promedio anual, con excepción de Loreto. Las LRC promedio mayores están en Bahía de los Angeles y Laguna Ojo de Liebre en el 2003, y la LRC promedio menor se reportó en la Laguna de San Ignacio en el 2001. Las escalas en la LRC de Loreto y Bahía de los Angeles son diferentes.

In order to detect the tendency of the number of organisms captured with a standardized effort during this period, annual CPUE of each site was compared (Figure 6). A positive trend was identified (red line) in four of the six sites analyzed, and a negative trend was identified in Loreto and Bahía Magdalena.



**Figura 6:** Captura por unidad de esfuerzo anual para cada uno de los sitios de monitoreo, los datos son de 2001-2003 para Laguna Ojo de Liebre, Loreto y Bahía de los Angeles, y de 2001-2004 para Bahía Magdalena, Laguna de San Ignacio y Punta Abreojos; se incluyó una línea de tendencia (línea roja) que se observa positiva con excepción de Loreto y Bahía Magdalena.

By representing the percentage of total captures related to the total organisms sampled (Figure 7), a positive tendency is observed. Despite that in 2004 number of recaptures were lower because monitoring did not take place for almost two thirds of the year due to the lack of permits (permits were granted to all monitoring sites in August), percentage of recaptures was higher than that in 2003. Numbers inside the columns indicate the total number of recaptured organisms.



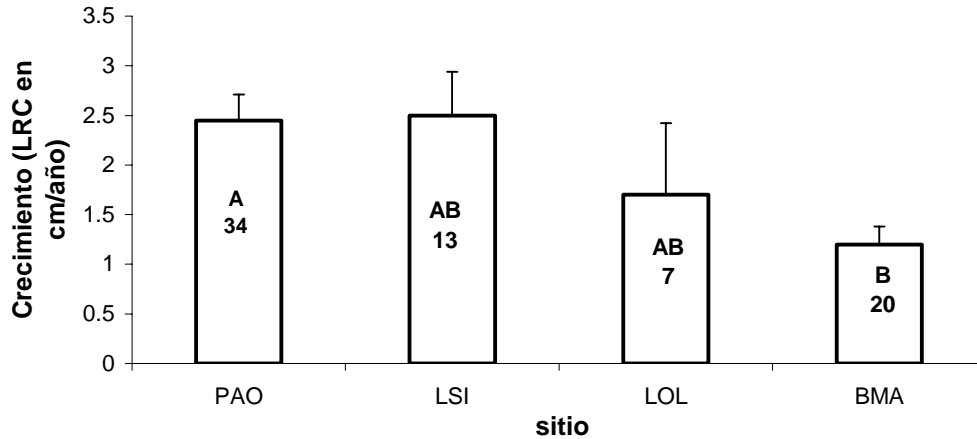
**Figura 7:** Porcentaje total de recapturas anuales; los números dentro de las barras representan el total de organismos recapturados, en el 2004 el número de tortugas recapturadas es menor debido a la falta de permisos para los muestreos, sin embargo el porcentaje aumentó un poco con relación al 2003.

With the purpose of determining significant differences in growth of the organisms at each monitoring site, an analysis of variance was conducted, excluding Bahia de Los Angeles since only data from one organism was obtained. The results showed that at least one of the growth averages was different (Table 4) so a DVS Tukey test modified by Spjotvoll and Stolne (Daniel, 1999) for cases in which sample size is different, was performed. This test showed that average growth in Bahia Magdalena is different from Punta Abrejos, but there is no difference with any of the other sites (Figure 8).

**TABLE 4:** One way Analysis of variance.

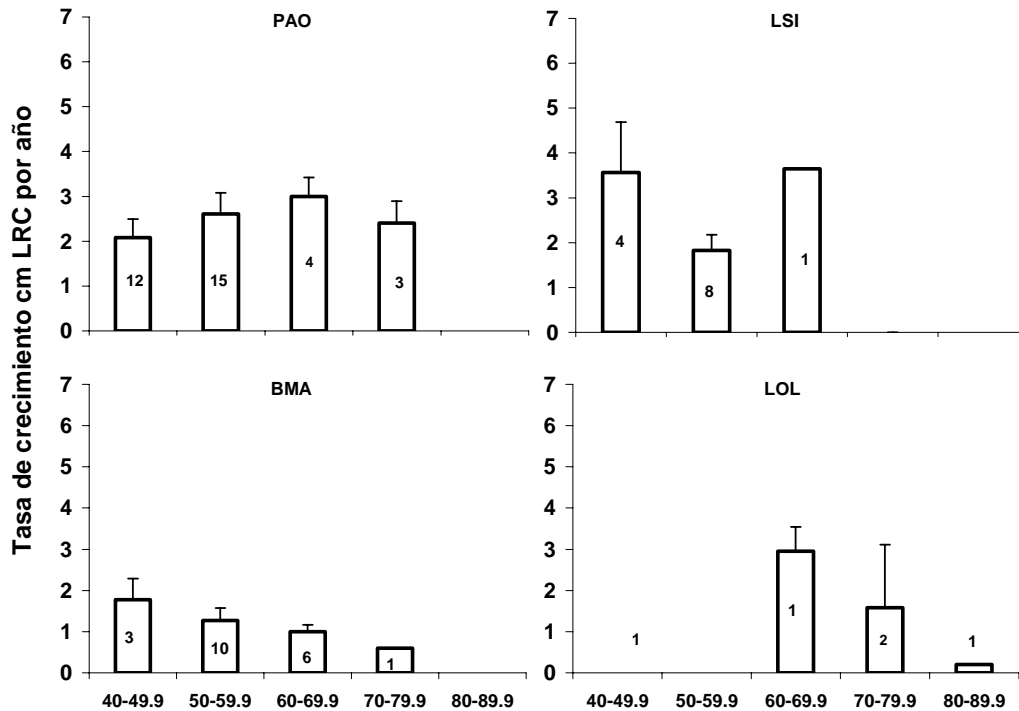
ANÁLISIS DE VARIANZA						
Origen de las variaciones	Suma de cuadrados	Grados de libertad	Promedio de los cuadrados	F	Probabilidad	Valor crítico para F
Entre grupos	22.56976	3	7.52325332	3.8811499	0.012587642	2.735541477
Dentro de los grupos	135.688584	70	1.93840835			
<b>Total</b>	<b>158.258344</b>	<b>73</b>				

como  $F$  es mayor que el valor crítico para  $F$ , se concluye que no todas las medias son iguales



**Figura 8:** Crecimiento promedio anual para cada uno de los sitios de monitoreo. Bahía de los Angeles no se toma en cuenta porque el crecimiento se midió en un organismo, y Loreto no tuvo recapturas. Los números dentro de las barras representan el número de organismos que se tomaron en cuenta para medir el crecimiento; las letras representan la igualdad de las medias. Como podemos observar Punta Abreojos no tiene diferencia de crecimiento con Laguna de San Ignacio y Laguna Ojo de Liebre, pero no con Bahía Magdalena, y Bahía Magdalena no tiene crecimiento promedio diferente a Laguna Ojo de Liebre y Laguna de San Ignacio, pero si con Punta Abreojos.

To determine growth increment at different sizes, growth was divided in 10 cm intervals (Figure 9). The numbers inside the columns represent the number of organisms recaptured at each size. It was observed that in Punta Abreojos, Laguna Ojo de Liebre, and Laguna San Ignacio sizes in which the biggest increment occur is the same (60-69.9 cm), and in Bahia Magdalena the size with maximum increment was between 40 and 49.9 cm.



**Figura 9.-** Crecimiento por rangos de talla de 10 cm., los números dentro o arriba de la talla correspondiente indican el número de organismos que aportaron datos para estas gráficas, en la Laguna Ojo de Liebre, hay un organismo que está entre los 40-49.9 cm. de LRC, pero no tuvo crecimiento, se observa que en Laguna Ojo de Liebre, Laguna de San Ignacio y Punta Abreojos el rango de talla donde se registra mayor crecimiento es de 60-69.9 cm y en Bahía Magdalena es de 40-49.5 cm

## DISCUSSION AND CONCLUSIONS

Results obtained so far indicate that most of the organisms captured are on the Pacific coast of the Baja California peninsula, and that Punta Abreojos has the highest success in captures. This is perhaps because fishing effort towards other species is minimal in this area and because it is part of the Vizcaino Reserve, which is a natural protected area. When analyzing the size structure of each of the monitoring sites, it can be seen that most of the organisms captured were juveniles and subadults under 75 cm and that they are found mostly on the Pacific. Whereas in the Gulf of California, most of the turtles are adults over 75 cm, even when organisms captured in Loreto and Cabo Pulmo are few, and Bahía de Los Angeles does not bring much data. Seminoff et al. in 2003 reported 195 turtles with an average size of 75.6 cm, a standard deviation of 9.5, and a size interval of 58.6 to 93.8 cm, suggesting that most of the organisms are adults.

The annual size average for each monitoring site shows an increasing trend of the capture size, which makes us assume a slight recovery of the population since in Fisheries Biology, changes in average size of captured organisms are taken as an indicator of the degree of exploitation. Annual percentages of recapture show an increment in time even when in 2004 monitoring only took place from September to December. This might indicate that the effort is starting to give results.

To date, no turtle has been recaptured in a different place other than the site of first capture, therefore, no evidence of connectivity among sites exists. Average growth indicates a difference between Bahia Magdalena and Punta Abreojos, unfortunately a comparison with Bahia de Los Angeles was not possible since from the total number of recaptures, only one organism gave growth information. The average obtained (2.7 cm) is different to that reported by Seminoff et al. (2003) of 1.5 cm for the corresponding size. Also, as obtained by Seminoff et al. in 2003, the graph shows that the increment is not the same for all sizes.

By taking CPUE as an indicator of relative abundance, we can infer whether the number of turtles that live in each of the monitoring sites has increased or decreased; and as we can see on the corresponding graphs, there is a positive trend in most locations. However a negative trend is observed in Bahia Magdalena, which indicates that the number of organisms has decreased probably because of illegal harvesting.

In general, we can say there is a positive trend toward the increase in number of organisms that live in feeding and nursing areas on the Baja California peninsula, especially in Natural Protected Areas in the Pacific. This indicator can be used to highlight Bahia Magdalena as an area that needs special consideration from federal authorities, since this was the only location where captures have decreased despite the effort from the Grupo Tortuguero in the area.

Among the main achievements of the Grupo Tortuguero, the following can be mentioned:

- To have stopped the indiscriminate consuming of sea turtles.
- Convincing some of the poachers in the area to stop their illegal activities and in some cases, to help directly in the protection of this resource.
- To obtain the first information of the sea turtles inhabiting this region.
- To unify the criteria among the people dedicated to studying sea turtles on the Baja California peninsula. And
- To increase the number of monitoring sites through the years.

Finally, it can be said that despite its short time, this project has been successful among the people, adding more individuals each year willing to participate in the conservation of sea turtles.

## ACKNOWLEDGEMENTS

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To all of them many thanks.

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