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Sea Turtle Conservation in Ubatuba, Southeastern Brazil, a Feeding Area with Incidental Capture in Coastal Fisheries

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Abstract. – Since 1991, Projeto TAMAR-IBAMA, the Brazilian sea turtle conservation program, has maintained a station in Ubatuba, State of São Paulo, southeastern Brazil, a feeding area for sea turtles where incidental capture in coastal fisheries occurs. We present an overview of the local fishing methods, explain the conservation approach and field methods employed by TAMAR in the region, present biological data collected between 1991 and 1998, and provide an assessment of the conservation status of sea turtles in the Ubatuba region. During the study period, 2,515 captures of sea turtles were recorded, comprising four species: green turtles (*Chelonia mydas*, 98.4% of total captures, generally juveniles), loggerheads (*Caretta caretta*), hawksbills (*Eretmochelys imbricata*), and leatherbacks (*Dermochelys coriacea*). Most of the data come from turtles incidentally captured in fishing gear, mainly by artisanal methods. The available data suggest that Ubatuba is a developmental habitat for juvenile green turtles.

Key Words. – Reptilia; Testudines; Cheloniidae; Dermochelyidae; *Chelonia mydas*; *Caretta caretta*; *Eretmochelys imbricata*; *Dermochelys coriacea*; sea turtle; feeding area; fishing; incidental capture; community-based; conservation; Brazil

Sea turtles use a variety of habitats during their life cycle: nesting beaches, inshore coastal feeding areas, and the pelagic environment. All are necessary for their survival at some point in their lives (Miller 1997; Musick and Limpus 1997). Although sea turtles spend most of their lifetime in the water, most research and conservation efforts have focused on nesting beaches (Bjorndal 1999). Research activities and conservation measures also must be implemented at sea because sea turtle biology is poorly understood there (Bjorndal 1999) and because sea turtles are subject to a series of threats at sea, including direct exploitation, pollution, diseases, effects of man-made marine structures, and incidental capture in fishing gear (Lutcavage et al. 1997; Gibson and Smith 1999; Herbst 1999).

Five species of sea turtles nest in Brazil: the green turtle (*Chelonia mydas,* "*tartaruga-verde*" or "*tartaruga-aruanã*"), loggerhead (*Caretta caretta,* "*tartaruga-cabeçuda*"), hawksbill (*Eretmochelys imbricata,* "*tartaruga-de-pente*"), olive ridley (*Lepidochelys olivacea,* "*tartaruga-pequena*" or "*tartaruga-comum*") and leatherback (*Dermochelys coriacea,* "*tartaruga-de-couro*" or "*tartaruga-gigante*"). Sea turtle nesting in Brazil occurs essentially between the states of Sergipe and Rio de Janeiro and on three oceanic islands: Fernando de Noronha, Atol das Rocas, and Trindade (Marcovaldi and Marcovaldi 1999); scant nesting may occur elsewhere. In contrast, the entire coast of Brazil provides foraging habitat for these species, although different species occur at varying densities along the coast. There are records of turtles captured in fishing gear or stranded along essentially the entire Brazilian coast (Cunha 1975; Soto and Beheregaray 1997a, 1997b; Marcovaldi et al. 1998; Pinedo et al. 1998).

After the establishment of research stations at the main Brazilian nesting areas, Projeto TAMAR-IBAMA, the Brazilian sea turtle conservation program, decided in 1990 to start working at feeding areas having significant levels of incidental capture in local fisheries (Marcovaldi et al. 1998; Marcovaldi and Marcovaldi 1999). At that time, fishing was already recognized as an important threat to sea turtles worldwide (National Research Council 1990), but little was known concerning Brazil. The first Brazilian station near a sea turtle feeding area was created in 1991 in Ubatuba, São Paulo. No nestings were known to occur in Ubatuba, located south of the state of Rio de Janeiro, the southernmost limit of the regular nesting range in Brazil (Marcovaldi and Marcovaldi 1999), but there were indications of incidental captures of sea turtles in fishing nets there (Projeto TAMAR, unpubl. data, 1991). An exploratory survey indicated that captures, mainly of juvenile green turtles, occurred in great numbers, qualifying Ubatuba as an important site for conservation activities.

This article presents an overview of the local fishing methods that capture sea turtles in the coastal area of Ubatuba, explains the conservation approach and field methods employed by TAMAR in the region, presents biological data collected between 1991 and 1998, and provides an assessment of the conservation status of sea turtles there.

METHODS

Study Area. — Ubatuba (23°26′S, 45°05′W) is located on the northern coast of the state of São Paulo, in southeastern Brazil, about 240 km from São Paulo, the state capital. Ubatuba's coastline is about 100 km long (Fig. 1). Tourism is the main economic activity, with fishing also important. Ubatuba is located in the southern limit of the tropical zone, with mild temperatures and rainy weather (climate Cfa in Koeppen's classification [de Blij and Muller 1993]). Between 1961 and 1990, average monthly temperatures varied between 17.6°C (July) and 24.6°C (February), and the average yearly precipitation in that period was 2,616 mm (Estado de São Paulo 1996). Ubatuba's coastline alternates between sandy beaches and rocky shores. Among the more than 70 beaches in the municipality, some are quite isolated, backed by Atlantic rainforest and accessible only by foot trails or boat. Many beaches are occupied by traditional communities, for which artisanal fishing is the main source of income. Ubatuba also harbors a small-scale commercial fishery, targeting mainly shrimp.

Local Fishing Methods

Floating Weirs ("cercos flutuantes"). — This is trap made of nets anchored to the seafloor, extending through the water column, operating usually in waters 8–15 m deep. Mesh size varies at different parts of the nets, between 2 and 11 cm. This technique was introduced by Japanese fishermen and is now well known in Ubatuba. This is not a species-selective method, although it captures mainly migratory fish species such as the Serra Spanish mackerel and the blue runner. Fish captured in floating weirs stay alive and swim inside the walls formed by the nets. Likewise, turtles captured by this method usually do not entangle in the nets, and stay alive until the fishermen come to extract the fish, which occurs from 1 to 3 times a day. Each floating weir is operated by 4 to 5 fishermen, who work out of 2 canoes. The number of floating weirs taking part in TAMAR's conservation program in each year varied from 1 (in 1991) to 7 (in 1996). In 1998, 5 weirs collaborated with TAMAR out of 11 weirs operating in Ubatuba at that time.

Gill Nets ("redes de espera" or "redes de emalhar"). — These nets, usually 50–100 m long and 1.5–3 m high, are set by 1 to 3 fishermen, using a canoe, and stay from 6 to 12 hours in the water, which means that there is a low probability of survival if turtles are entangled in nets soon after they are set. Gill nets are usually placed in waters 2–15 m deep and can operate on the surface, in midwater, or at the bottom. Mesh size is usually 10–14 cm. Some species of fish most commonly captured in gill nets are whitemouth croaker, weakfish, Atlantic bumper, and snooks. We believe that in 1998 about 200 gill nets were in operation in Ubatuba; a precise estimate of their number has not been established due to their widespread use.

Encircling Gill Nets ("redes de tróia"). — This fishing method is most commonly used from May to September, when the main target species—mullets and the Serra Spanish mackerel—are found in Ubatuba. Encircling gill nets extend through the water column and usually operate at a depth of about 10 m. Mesh size is about 12 cm. Captured turtles are always found alive. This fishing method is regularly employed at only one beach in Ubatuba; it is very rarely used at a few other beaches.

Bottom Trawl Nets ("redes de arrasto"). — These nets are quite common in Ubatuba. Both the simple and "double-rig" kinds are employed by about 100 boats, generally less than 11 m in length; all of them use mechanical means to haul the nets aboard. These boats operate in coastal waters relatively far from rocky shores,

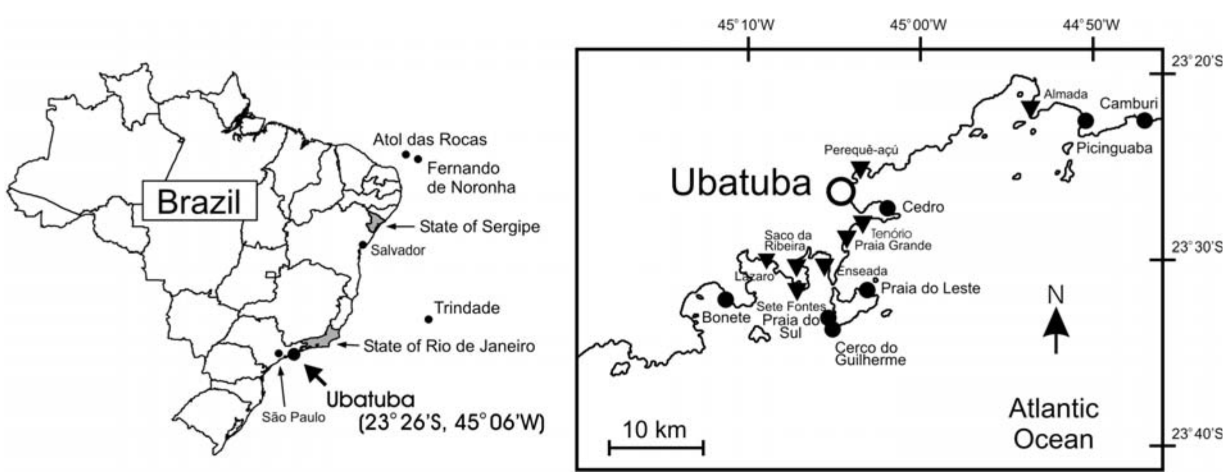

Figure 1. Map of Brazil, showing the location of Ubatuba (left), and map of the Ubatuba area (right) showing the main sites where turtles have been captured. Black circles indicate sites where fishing weirs have established an agreement with TAMAR; triangles indicate some of the main sites where other fishing gear are used by local fishermen.

at depths of up to 80 m. Target species are shrimp. In 1994, Brazilian governmental rules required the use of Turtle Excluder Devices (TEDs) by trawlers targeting the pink shrimp (*Farfantepenaeus brasiliensis*, *F. paulensis*), which is caught in Ubatuba. Since 1997, all shrimp fisheries in Brazil are required to use TEDs, although boats smaller than 11 m in length are exempt, as well as boats of any size that do not employ mechanical means to haul the nets aboard. However, to our knowledge, no trawlers operating in the Ubatuba area used TEDs during the study period, even those larger than 11 m in length. Brazilian regulations forbid shrimping during the "*defeso*" (protection), a closed period deemed necessary for shrimp reproduction, usually a three-month period from February to May; the *defeso* is usually observed by Ubatuba trawlers. TAMAR does not work regularly with shrimp trawlers in Ubatuba, so it is only opportunistically that reports on incidental capture of turtles are received.

Hook and Line. — This method is usually employed by local amateur fishermen or tourists. TAMAR receives reports only infrequently of sea turtles captured by hook and line. Turtles captured by this means are hooked not only through the mouth, but frequently through their flippers.

Besides the above-mentioned fishing methods, turtles are also captured intentionally in Ubatuba through free diving, by members of the TAMAR team. This method of capture is only occasionally employed because TAMAR does not include free diving as part of its regular program of activities in Ubatuba. Furthermore, turtles are also found stranded on the shore or floating (alive or dead) in the water.

Floating weirs are sometimes taken out of the water for maintenance or due to sea and/or weather conditions. Other kinds of fishing gear are also employed according to the fishermen's working schedules and/or weather conditions. TAMAR does not generally keep records of the actual fishing effort carried out in Ubatuba, as measured by the number of days floating weirs or other fishing gear stay in the water.

Establishing a Partnership with the Local Community

Between January and September 1991, personal interviews with fishermen were carried out to gather information regarding the occurrence and capture of sea turtles: the season with most captures, species, size of the turtles, fishing methods involved, the fate of the turtles (released, killed, consumed). The interviews also tried to assess the knowledge fishermen had about the conservation status of sea turtles and about Brazilian environmental regulations regarding the protection of these animals.

The interviews showed that several fishing methods captured sea turtles in Ubatuba, both in artisanal and commercial fisheries. Because the floating weirs have a fixed location, relatively easy access, a daily work routine, and a high number of sea turtles are incidentally captured through them, for operational reasons TAMAR opted to initially concentrate its field efforts on the monitoring of these nets. A partnership was then established with fishermen working with floating weirs, who agreed to communicate to TAMAR the incidental capture of turtles in weirs or in other fishing gear.

TAMAR does not maintain observers on beaches or fishing spots, nor is a regular search for sea turtles carried out by its technical team. TAMAR relies almost solely on fishermen's communications for information on captured turtles. Fishermen take part in the conservation program voluntarily, without any monetary compensation or direct gain. Their participation is entirely based on their understanding of the aims of the program and collaborative attitude with TAMAR's technical team. Sometimes the net is damaged by the turtle or when freeing the turtle; moreover, to free the turtle from the net, bring it to the beach and contact TAMAR not only takes up fishermen's time but also implies changing old habits regarding the killing and consumption of turtles.

Some positive aspects in the establishment of the partnership between TAMAR and fishermen are educational initiatives and the introduction to alternative income sources to those people and their families. Since they are requested to stop consuming turtles, TAMAR has fostered the development of alternative economic activities in Ubatuba, such as mussel culture (for sale to local restaurants), handicrafts (sold through TAMAR's stores), and a paper recycling workshop (run by local children and adolescents) (Giffoni et al. 1998; Marcovaldi and Thomé 1999).

Several methods are used by TAMAR to transmit the conservation message to fishermen, as well as to local residents, tourists, students, and the general public. Close, frequent personal contacts with the local communities play a key role here. Members of the TAMAR technical staff regularly visit the beaches where fishermen live, and take part by invitation in meetings where local people discuss their interests, as well as in festivals and other gatherings. Over time, these contacts make it possible for TAMAR personnel to talk to local people about sea turtles, their conservation, and about marine conservation in general. Furthermore, the TAMAR station in Ubatuba maintains a visitor's center, including display tanks containing several species of sea turtles. The TAMAR staff on demand gives talks to groups of local residents, schools and universities, and about 40 trainees (undergraduate university students) take part in TAMAR's sea turtle conservation training program in Ubatuba each year (Marcovaldi and Thomé 1999).

Field Methods

TAMAR has worked year round in Ubatuba since mid-1991. Whenever a communication is received, one person of the TAMAR team goes to the site and the turtle is identified to species, measured—curved carapace length (CCL, nuchal notch to posteriormost tip of carapace) and curved carapace width—and tagged. Until January 1993, only a single tag was applied, but since then, a double-tagging scheme has been used, with a tag being applied to each of the front flippers (Limpus 1992). Initially, monel tags (National Band and Tag Co., USA, style 681) were used, but since April 1995 only inconel tags (National Band and Tag Co., USA, style 681) have been applied. Turtles are tagged at the proximal positions L3/R3 (Limpus 1992). Whenever a turtle is recaptured with at least one tag, lost tags are replaced and damaged tags are substituted.

The presence or absence of tumors, which are identified by gross examination under field conditions, was recorded. Whenever possible, tumor samples were collected and sent to the University of São Paulo for histopathological analysis. In 1998, a skin sample was taken from green turtles for genetic analysis. If the captured turtle was found to be healthy, it was released back to the sea. Otherwise, it was taken to the TAMAR station for rehabilitation.

The TAMAR station in Ubatuba is sometimes requested to attend to sea turtles captured in fishing gear or found stranded in areas in the state of São Paulo outside of Ubatuba. Furthermore, at times turtles tagged in Ubatuba and found in Brazilian states other than São Paulo are reported to the TAMAR station in Ubatuba. Turtles captured in places other than Ubatuba will only be considered in this work when the movement of turtles to other regions in Brazil is at issue. All other analyses concern only turtles captured in Ubatuba.

Data Analysis

When analyzing the size distribution of the turtles, tagged and untagged turtles were dealt with differently. For tagged turtles, only the first CCL measurement in each year was included in the calculations; for untagged turtles all measurements were included, on the assumption that they were different individuals, since most (76.6%) of the untagged turtles were found dead. In the analyses of CCL concerning the form of capture, all captures were entered into the analyses. Whenever necessary, to compare the CCL of captured turtles to carapace length data found in the literature, straight carapace lengths in published data were converted to CCL by means of formulas in Teas (1993) for loggerheads; Bjorndal and Bolten (1989) for green turtles; and van Dam and Diez (1998) for hawksbills.

Turtles found stranded on the shore or floating in the water were analyzed together under the heading "stranded". For the analysis of tumor occurrences, turtles captured more than once in each year were counted only once in the year. Recapture interval is defined as the time interval between the first and last captures of a turtle.

Nonparametric Kruskal-Wallis and Mann-Whitney tests were used in the statistical analyses (Zar 1996). Percentages of turtles captured alive by species were compared through a contingency table analysis, by means of a Pearson's Chi-squared test (Fleiss 1981). Whenever possible, exact Kruskal-Wallis, Mann-Whitney, and Pearson's Chi-squared tests were computed, otherwise (whenever datasets were too large) a Monte Carlo approximation to the exact test was applied (Mehta and Patel 1998). All statistical computations were carried out with the software StatXact 4 (Mehta and Patel 1998). In the statistical analyses, the significance level was alpha = 0.05.

RESULTS AND DISCUSSION

Partnership with the Local Community. — The actual number of fishermen collaborating with TAMAR varied among the years. In 1998, approximately 40 fishermen were collaborating, and 25 of them worked with floating weirs. Regular contact with fishermen working with the floating weirs brought TAMAR into contact with other methods of capturing sea turtles in Ubatuba. Over time, other people (local inhabitants, tourists, public officers) learned to communicate with TAMAR about sea turtles found in the region.

Turtle Captures. — From May 1991 to December 1998, the TAMAR station in Ubatuba recorded 2515 captures of sea turtles. Four species were found: the green turtle ($n = 2{,}475$ captures or 98.4% of total captures), the loggerhead ($n = 13$ or 0.5%), the hawksbill ($n = 23$ or 0.9%), and the leatherback sea turtle ($n = 4$ or 0.2%). No leatherback turtles were observed alive in the Ubatuba coastal area (Fig. 2).

The very large proportion of green turtles in the sample does not necessarily imply that these turtles occur in an equally large proportion in the Ubatuba area, as the sample was strongly dependent on what was caught in the

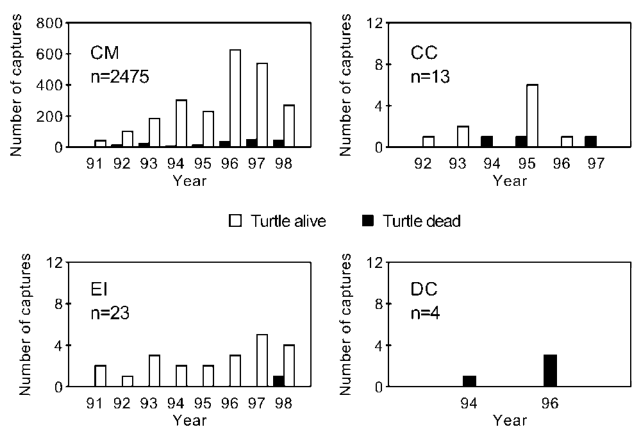

Figure 2. Number of recorded captures by year, species, and condition at capture, 1991 through 1998. Sample size is presented for each graph. Note the different vertical scales among graphs. Species abbreviations: CM = *Chelonia mydas*, CC = *Caretta caretta*, EI = *Eretmochelys imbricata*, DC = *Dermochelys coriacea*.

floating weirs, which capture mostly green turtles (see below). However, green turtles seem indeed to be the most abundant species near the Ubatuba coast (Gallo et al., *pers. obs.*, 2002).

The observed variation in the number of captured turtles among years (Fig. 2) has several explanations related to fishermen's and TAMAR's working schedules as well as possible annual variation in the occurrence of turtles in Ubatuba. For the first 5 years, the increase in the number of reported captures was basically due to the expansion of TAMAR's activities in Ubatuba. The year with the maximum number of floating weirs (7) operating cooperatively with TAMAR was 1996, and after that 2 weirs stopped participating in the conservation program. Furthermore, in 1996, an extraordinary number of captures ($n = 111$, mostly through gill nets and encircling gill nets) were reported from 1 of the beaches, Almada; before that, only 6 or fewer turtles were caught there annually.

Capture Methods and Size Distribution. — Floating weirs alone were responsible for 80.4% of all recorded captures (Fig. 3). Green turtles, the species most commonly captured, were captured by all fishing methods, although mainly (81.1%) through floating weirs (Fig. 3). Green turtles captured in floating weirs averaged 40.4 cm in CCL ($n = 1976$). There was no significant difference in CCL between green turtles found alive (average CCL = 40.4 cm, $n = 1913$) or dead (average CCL = 41.0 cm, $n = 63$) (Mann-Whitney test, U = 57,653, $p = 0.558$), which indicates that green turtle deaths in weirs (possibly caused by entanglement in the nets) were not related to the size of the turtles.

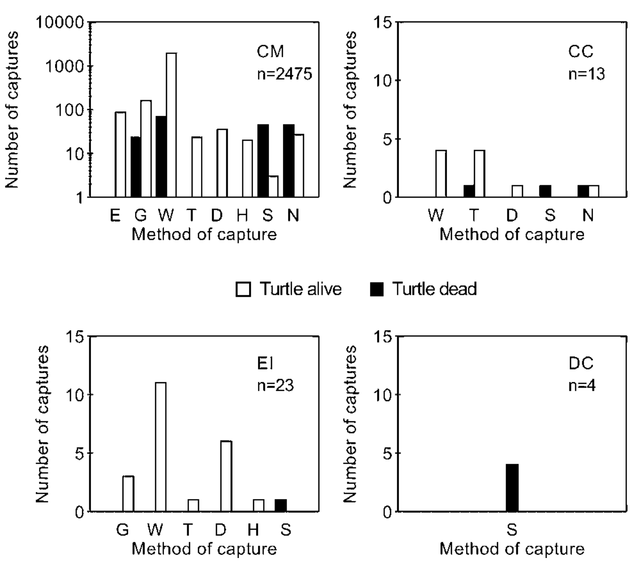

Figure 3. Number of captures by form of capture, species, and condition at capture, 1991 through 1998. Sample size is presented for each graph. Note the different vertical scales among graphs, and that the vertical scale in the top-left graph is logarithmic. Form of capture abbreviations: E = encircling gill net, G = gill net, W = floating weir, T = trawl net, D = free diving, H = hook and line, S = stranded, N = no information. "Stranded" includes turtles actually stranded plus those found floating in the water. Species abbreviations as in Fig. 2.

The overall average CCL for green turtles captured through methods other than the floating weirs was 41.0 cm ($n = 384$), and there was a significant difference in CCL for green turtles captured among them (Kruskal-Wallis test, H = 15.25, $p = 0.017$). However, the difference in CCL among methods was relatively small: average CCL ranged from 38.7 cm (encircling gill nets, $n = 87$) to 43.7 cm (trawl nets, $n = 22$). The difference in average CCL could be due to differences in the fishing gear, and/or to the different environments where they were employed. Furthermore, information about captures in trawl nets were only opportunistically reported to TAMAR, so sampling aspects could play a part in explaining that difference. For green turtles captured in gill nets, 12.6% were found dead (Fig. 3), and there was no significant difference in CCL between turtles found alive (average CCL = 41.8 cm, $n = 159$) and dead (average CCL = 38.7 cm, $n = 23$) (Mann-Whitney test, U = 2257, $p = 0.070$). Among stranded green turtles ($n = 48$), 93.8% were found dead. No green turtles were captured dead by hook and line, free diving, trawl nets, or encircling gill nets (Fig. 3).

Loggerheads were captured mostly in floating weirs (average CCL = 63.5 cm, $n = 4$) and trawl nets (average CCL = 66.6 cm, $n = 5$) (Fig. 3). Hawksbills were captured mainly in floating weirs ($n = 11$, average CCL = 45.4 cm), free diving ($n = 6$, average CCL = 37.3 cm) and gill nets ($n = 3$, average CCL = 44.7 cm) (Fig. 3). Leatherbacks ($n = 4$) were all found dead either stranded or floating (Fig. 3).

Figure 4 shows the size distribution of the turtles. Mean ± standard deviation and range of CCL (cm) for each species are: green turtles, 40.6 ± 8.3 (27.0–96.0) ($n = 2,254$); loggerheads, 63.0 ± 16.9 (32.5–85.0) ($n = 12$); hawksbills, 46.1 ± 11.6 (32.0–67.0) ($n = 22$); leatherbacks, 137.0 ± 16.7 (120.0–160.0) ($n = 4$). In Ubatuba, green turtles and loggerheads were generally juveniles, although there was some overlap between the

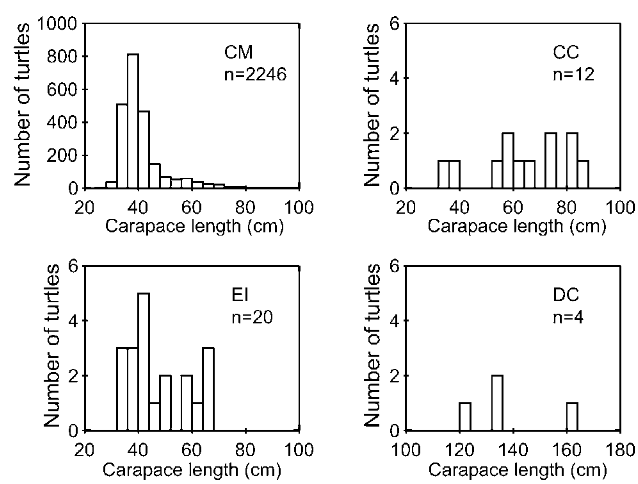

Figure 4. Curved carapace length (CCL) distribution, by species, 1992 through 1998. Sample size is presented for each graph. Note the different vertical scales among graphs. Maximum observed CCL for green turtles = 96 cm (not apparent in top-left graph). Species abbreviations as in Fig. 2.

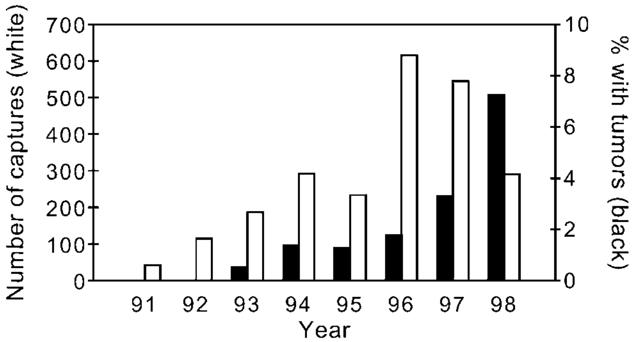

Figure 5. Number of green turtles captured in Ubatuba between 1991 and 1998 (white bars, left scale) and percentage of those turtles found with tumors (black bars, right scale). No turtles were recorded with tumors in 1991 and 1992. Total number of green turtles recorded with tumors was $n = 58$.

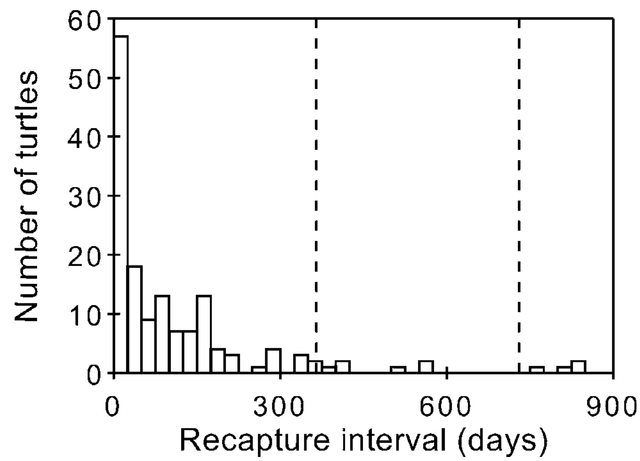

Figure 6. Distribution of the recapture interval between first and last captures of green turtles for those turtles captured two or more times, 1991 through 1998. Sample size, $n = 151$ turtles. Dashed lines indicate periods of one and two years.

range of CCL observed in Ubatuba and that observed for nesting females in other places in the Atlantic Ocean (Dodd 1988; Hirth 1997; Cejudo et al. 2000). All hawksbills were juveniles, smaller than those nesting elsewhere in the Atlantic (Witzell 1983). Leatherbacks were large juveniles or adult turtles (Márquez M. 1990).

Condition. — Between 1991 and 1998, 92.6% of the green turtles ($n = 2475$) were captured alive, as were 76.9% of the loggerheads ($n = 13$) and 95.7% of the hawksbills ($n = 23$); these percentages are not significantly different (Pearson's Chi-squared test, $\chi^2 = 4.90$, $p = 0.074$). Turtles found stranded or floating, which could possibly have been carried from a distance by sea currents, were usually dead (Fig. 3) or in bad condition (wounded and/or debilitated), and sometimes entangled in fishing gear debris. Worldwide, the entanglement in fishing gear debris, as well as the ingestion of plastics and other man-made debris, are known to pose significant threats to sea turtle health and survival (Lutcavage et al. 1997).

Between 1993 and 1998, 58 green turtles were observed with tumors, sometimes with many tumors. The annual proportion of captured green turtles that had tumors increased from 0.5% in 1993 to 7.2% in 1998 (Fig. 5). Although the prevalence of tumors in Ubatuba is apparently increasing, the results could be biased by the available sample, possibly due to increased awareness and recognition of the condition by TAMAR personnel.

Matushima et al. (2000) analyzed tumor samples from 11 juvenile green turtles from Ubatuba and from the states of Espírito Santo and Bahia (both to the north of Ubatuba); all samples examined had a histopathological confirmation of fibropapillomatosis.

Recaptures. — Most green turtles were not seen again after the initial tagging: of the 2071 green turtles captured and released in Ubatuba between 1991 and 1998, 136 were captured twice, 26 three times, and 2 four times. Of these animals, 151 had the date of first and last captures recorded, which allowed the computation of the recapture interval (Fig. 6). For most turtles (93.4%), this interval was less than one year. Indeed, the interval distribution is quite skewed: 83.4% of the turtles had a maximum recapture interval of less than 180 days, 59.6% of less than 90 days, and only four turtles had an interval higher than two years (Fig. 6). The average recapture interval was 113.2 days, and the median interval was 57 days. This suggests that the residency time of green turtles in Ubatuba may be low, generally less than one year, and for most turtles less than 180 days, and that Ubatuba is a developmental habitat for green turtles, mainly for small juveniles (Fig. 4). However, tag loss, turtle mortality, and the sampling scheme could be involved in an explanation of Fig. 6.

Seasonality. — The greatest number of captures occurred during winter, when some floating weirs were taken out of the water (Fig. 7). This suggests that the peak in the number of captures in that period of the year is not an artifact of the sampling scheme, since more captures were observed when a smaller number of weirs tended to be in the water.

There was a clear temporal correlation between the number of captures and the average body length (Fig. 7): average CCL was smallest in winter (around July), when the number of captures were highest, and the average CCL was largest in late summer (around February), when the number of captures were lowest. However, small green turtles (CCL < 40 cm) were found in Ubatuba throughout the year, although they occurred at a higher proportion during winter. Larger juveniles (CCL > 60 cm), although always less abundant than smaller ones (Fig. 4), were also found throughout the year, but at a higher proportion in late summer.

A seasonal pattern in the occurrence of juvenile green turtles in feeding areas has been observed in Texas, USA (Shaver 1994) and Florida, USA (Mendonça and Ehrhart 1982). However, in those instances peak occurrence was in summer in the northern hemisphere, around July or August, that is, these seasonal patterns were opposite to that found for green turtles in Ubatuba, where peak

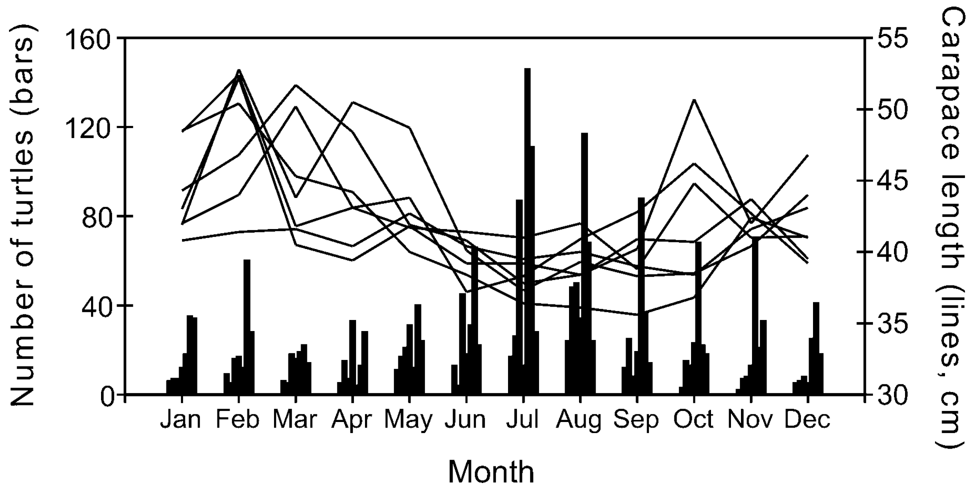

Figure 7. Seasonal patterns in the occurrence of green turtles and their size, 1992 through 1998. Bars, left scale: number of turtles captured by month (for each month, each of the 7 bars represents a year); lines, right scale: average curved carapace length (CCL) by month (each of the 7 lines represents a year). Total sample size, $n = 2246$.

occurrence occurred in winter (Fig. 7). It has been suggested that sea turtles may move to higher latitudes in summer, returning to lower latitudes as the temperature falls in winter (Shoop and Kenney 1992; Epperly et al.

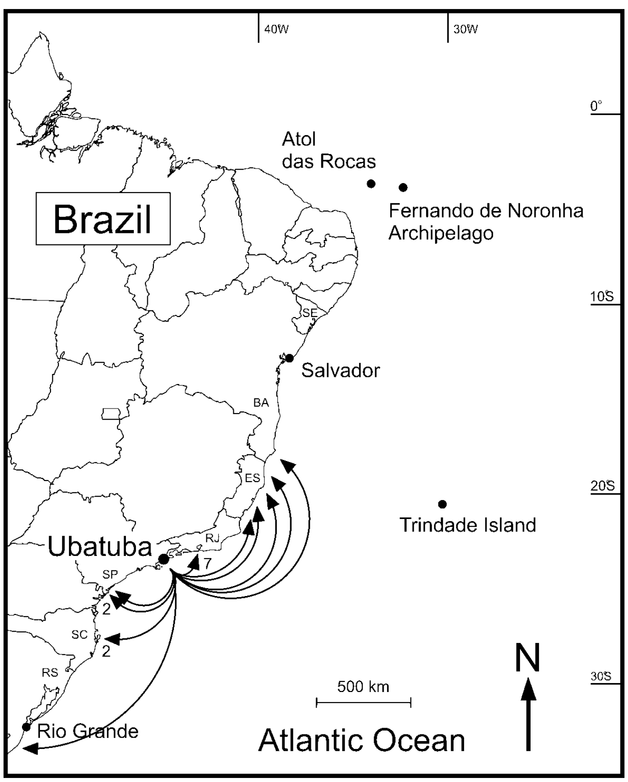

Figure 8. Displacements of green turtles tagged in Ubatuba and recaptured at distances greater than 150 km ($n = 18$). Arrows connect Ubatuba to recapture locations and do not imply actual travel routes. A number next to an arrow indicates that more than one turtle was recaptured at the location. Brazilian states identified in the map: SE = Sergipe, BA = Bahia, ES = Espírito Santo, RJ = Rio de Janeiro, SP = São Paulo, SC = Santa Catarina, RS = Rio Grande do Sul. The 3 main nesting grounds for green turtles in Brazil are shown on the map: Trindade Island, Atol das Rocas, and the Fernando de Noronha Archipelago.

1995). In Ubatuba, the generally short recapture intervals, less than 180 days for most green turtles (Fig. 6), seem to exclude the possibility of green turtle seasonal movements between Ubatuba and other places, and suggest instead the alternative explanation that Ubatuba is a developmental habitat for green turtles, mainly for small juveniles.

Although small juvenile green turtles were found in Ubatuba throughout the year, Figs. 6 and 7 suggest that they might arrive preferentially in wintertime and depart mostly around the end of summer, which is compatible with the data suggesting a short residency time in Ubatuba. This, however, should be regarded as tentative and a very general explanation for the seasonal occurrence of juvenile green turtles in Ubatuba and for their apparently short residency there. The relationship between turtle size and time of recruitment in Ubatuba, as well as a more thorough assessment of the sampling scheme adopted by TAMAR, and possibly the growth pattern of the turtles, should be considered in the analysis of the seasonal patterns presented in Fig. 7.

Movements. — Figure 8 shows the movement of green turtles tagged in Ubatuba and recaptured at a distance (along the Brazilian coastline) greater than 150 km. The average CCL at the initial capture in Ubatuba prior to the recapture was 38.6 cm ($n = 18$, range = 34–43 cm). The farthest recapture to the north occurred in Mucuri, southern extreme of the state of Bahia, about 900 km (along the coastline) from Ubatuba; the recapture interval was 596 days. The farthest recapture to the south occurred near Rio Grande, state of Rio Grande do Sul, about 1,200 km (along the coastline) from Ubatuba; the recapture interval was 483 days. Besides the movement patterns shown in Fig. 8, a few other green turtle displacements to locations in the states of São Paulo and Rio de Janeiro—which are less than 150 km from Ubatuba—were also recorded.

No apparent relationship can be seen in the data between the time of year of the last encounter in Ubatuba and the direction either north or south traveled by the turtles. In all distant recaptures (recaptures at distances greater than 150 km from Ubatuba, both to the north and south, $n = 18$ turtles, Fig. 8), the turtles were last observed in Ubatuba between April and October, wintertime.

CONCLUSIONS

The origin of the turtles found in Ubatuba is unknown. Genetic studies on mtDNA indicate that juvenile green turtle populations in feeding grounds can be formed by genetically distinct stocks, with contributions from several different nesting populations (Lahanas et al. 1998; Bass and Witzell 2000). Green turtles and other species of sea turtles found in Ubatuba could be connected to populations in feeding areas and nesting beaches quite distant from Ubatuba, possibly in countries other than Brazil, which would call for international cooperation in the protection of these populations (Bolten et al. 1998; Trono and Salm 1999).

Worldwide, a diversity of fishing methods, both artisanal and commercial, has been implicated in the capture of sea turtles (Lutcavage et al. 1997). In Ubatuba, artisanal fishing is part of the "*caiçara*" culture, a blend of Portuguese, Indian, and, to a smaller degree, African traditions (Diegues and Arruda 2001). Sea turtle conservation, as practiced by TAMAR in Ubatuba, is based on the involvement of local fishermen and communities and on the understanding of the role that fishing represents to these communities. Conservation is not regarded just as a biological matter, as it also depends on local, cultural, and economic components (Frazier 1999; Marcovaldi and Marcovaldi 1999). We believe that the results obtained by TAMAR in Ubatuba are significant when measured in several ways: captured turtles are no longer consumed at the main beaches and fishing spots, the environmental conservation message has been transmitted to local inhabitants and to visitors, TAMAR has fostered several alternative economic activities which have brought improvements to the quality of life of local inhabitants, and valuable biological information concerning the presence of sea turtles in Ubatuba has been gathered. The observed enthusiasm of children for the sea turtle program suggests that the conservation message will be felt for many years ahead.

Ubatuba's relative proximity to São Paulo, the state capital and largest city in Brazil (Fig. 1), has caused a great deal of activity there by environmental and welfare nongovernmental organizations and by governmental agencies regarding environmental conservation and educational programs for local communities. Most activities have been restricted to specific areas and of short duration. Frazier (1999) stated that a sufficiently long period is important for the success of a community-based conservation program. We believe that the continuity of TAMAR's actions in Ubatuba since 1991 has been one of the main causes for the support obtained from local communities. The experience obtained in dealing with artisanal fishermen and local communities will serve as a guide for future conservation actions in Ubatuba.

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