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Marine Debris and Human Impacts on Sea Turtles in Southern Brazil

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Dead stranded sea turtles were recovered and examined to determine the impact of anthropogenic debris and fishery activities on sea turtles on the coast of Rio Grande do Sul State, Brazil. Esophagus/stomach contents of 38 juvenile green *Chelonia mydas*, 10 adults and sub-adults loggerhead *Caretta caretta*, and two leatherback *Dermochelys coriacea* turtles (adult or sub-adult) included plastic bags as the main debris ingested, predominated by white and colorless pieces. The ingestion of anthropogenic debris accounted for the death of 13.2% of the green turtles examined. Signs of damage over the body and carapace indicated that fishing activities caused the death of 13.6% (3/22) of loggerheads and 1.5% (1/56) of green turtles. Therefore, it appears that direct and indirect effects of fishing activities may pose a threat to these species in Brazilian waters. Other sources of plastic debris should be investigated as well as the direct impact of fisheries, especially bottom trawl and gill nets, in order to establish effective conservation action. © 2001 Elsevier Science Ltd. All rights reserved.

Keywords: *Caretta caretta*; *Chelonia mydas*; sea turtle; Plastic debris; fishing interaction; Brazil.

Introduction

The green turtle *Chelonia mydas*, loggerhead turtle *Caretta caretta* and leatherback turtle *Dermochelys coriacea* are endangered species (IUCN, 1996). Wyneken *et al.* (1988) mentioned that the overall reduction of sea turtle populations has been directly or indirectly attributed to the destruction of habitats, to anthropic action on the nesting beaches, and also the strong evidence of predation of the young, theft of eggs and adults, predatory fishing, and pollution. Among the main obstacles to sea turtle survival is marine pollution by oils and persistent plastics, which could directly affect the turtles, their food supplies, or their habitats (Bourne, 1985). Sea turtles of all species are particularly prone to eating pieces of plastic and other floating debris (Carr, 1987). The five sea turtle species which nest in Brazil, North of 23° latitude (Marcovaldi and Marcovaldi, 1999), also occur in southern Brazilian waters: *C. caretta*, *C. mydas*, *D. coriacea*, *Lepidochelys olivacea* and *Eretmochelys imbricata* (Lema, 1994; Pinedo *et al.*, 1996). The three former species are frequently found stranded on the beaches of the State of Rio Grande do Sul. Throughout four years, from 1992 to 1995, 91 *C. caretta*, 58 *D. coriacea* and 24 *C. mydas* were found in Rio Grande do Sul (Pinedo *et al.*, 1996). Despite the relatively high number of stranded sea turtles on southern Brazilian beaches, there is no comprehensive study on the anthropogenic debris ingestion, and the studies on fishery interactions in the area are scarce. In this study we present data on debris intake by green, loggerhead, and leatherback turtles, and fishery interactions that may have an effect on the conservation of these species in southern Brazil.

Materials and Methods

From August 1997 to July 1998, stranded sea turtles were collected on 11 occasions, along 150 km of beach between Pinhal (30°15′S; 50°15′W) and Lagoa do Peixe (31°20′S; 51°05′W) in the Brazilian southernmost State of Rio Grande do Sul. One field trip was performed on a larger area, along the entire coast of Rio Grande do Sul State, approximately 620 km long, between Torres (29°20′S; 49°44′W) and Arroio Chuí (33°45′S; 53°22′W) (Fig. 1). We surveyed the beach monthly by car, at a speed of around 30 km h^{-1}, searching for stranded turtles. The curved carapace length (CCL) was measured for all individuals and the average ± 1SD calculated for each species. Age classes of stranded turtles were based on carapace length (Dodd, 1988; Hirth, 1997; Barata *et al.*, 1998). The digestive tract was removed from the esophagus to the initial portion of the bowel, preserved in 70% ethanol, and contents

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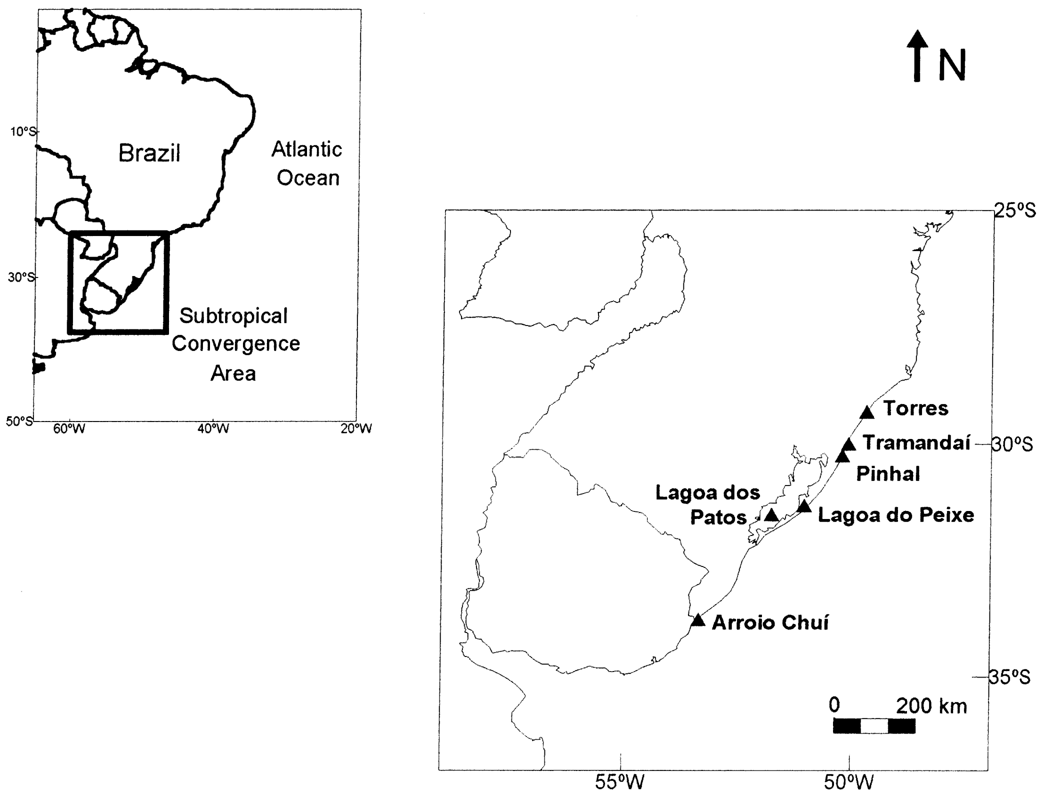

Fig. 1 Study area with the coastline sampled between August 1997 and July 1998 and the places cited in the text under influence of the subtropical convergence.

determined as soon as possible. Synthetic materials were separated into categories according to color and shape, dried and weighed on a digital scale, with 0.1 g precision.

Correlations between the CCL and both the number of plastic pieces ingested and the weight of the plastics were analyzed by Spearman rank correlation coefficient. The comparison of frequency of occurrence of debris in green turtles during the cold months (April–September) and warm months (October–March) was performed using the Yates χ^2-test (Zar, 1999). Results were considered significant in order to establish the possible source of the ingested plastics. Data were analysed using *Statistica for Windows* program, Release 5.1 (StatSoft Inc, 1995).

Results and Discussion

A total of 92 stranded sea turtles were found, of which 56 green, 16 loggerhead, and 2 leatherback turtles were measured, and 38, 10 and 2 gut contents collected, respectively. The CCL of green turtles found dead on the beaches of Rio Grande do Sul ranged from 28 to 50 cm ($\bar{x} = 37.7 \pm 3.1$ cm, $n = 56$). These individuals were all determined to be juveniles based on carapace length. Loggerheads ranged from 63 to 97 cm ($\bar{x} = 73.4 \pm 10.2$ cm, $n = 16$) and were classified as adults ($n = 6$; 77–97 cm) and sub-adults ($n = 10$; 63–73 cm) based on the minimum CCL (75 cm) of specimens on Brazilian nesting beaches (Barata *et al.*, 1998). The two leatherbacks measured 135 and 136 cm, and were classed as adults or sub-adults.

Anthropogenic debris ingestion

Anthropogenic debris were ingested by 60.5% (23/38) of the green turtles analyzed, the highest rate in the literature consulted. Bjorndal *et al.* (1994) found debris throughout the entire digestive tract of juvenile green turtles in Florida. If the stomach and esophagus alone were analyzed, the frequency of occurrence of plastics dropped from 56% to only 14%. Only the stomach and esophagus were analysed in the present study, thus although the frequency of plastics was high, it may have been an underestimate.

Although plastics were the most frequently ingested marine debris by sea turtles in this and other sites (Balazs, 1985; Bjorndal *et al.*, 1994; Plotkin and Amos, 1990; Sadove and Morreale, 1990; Shaver, 1991), Gramentz (1988) and Balazs (1985) mentioned tar as significant debris. Only one green turtle ingested oil in large amounts, and this occurrence was related to an oil spill which took place at the Tramandaí offloading terminal five days before the sampling date (Fig. 1). On the sampling date, crude oil was found on the beach along the whole delimited area (Pinhal to Lagoa do Peixe). Many dead seabirds had feathers impregnated with crude oil, and the frequency of oiled magellanic penguins, *Spheniscus magellanicus*, was higher than in other months (M.V. Petry, pers. obs.). Gramentz (1986) found that oil or tar, when ingested in large amounts, could immobilize and cause death from exhaustion in young sea turtles. Based on these considerations, the ingestion of oil may have led to the death of this specimen.

The main debris were plastic bags and plastic ropes (Table 1). The main colors of bags were transparent, white, and black, with a frequency of occurrence in gut contents of 39.0% (15/38), 28.9% (11/38), and 18.4% (7/38), respectively. White/transparent plastic bags were ingested by 47.4% of the green turtles, while bags of other colors (black, blue, red and gray) had a frequency of occurrence of 18.4%. Carr (1987) and Gramentz (1988) found a similar situation, and attributed this to turtles' mistaking these debris for jellyfish, a common item in the diet of sea turtles. Unfortunately, the availability of plastic debris and colors in the marine environment adjacent to the stranding location is not known, which makes it difficult to formulate a hypothesis about turtles' preferential ingestion.

The weight of the plastics ingested by each of the individuals was small ($\bar{x} = 0.53 \pm 0.83$ g, $n = 23$), and six samples presented a weight less than 0.1 g. The number of pieces of plastic ingested also varied considerably (1–29 pieces, $\bar{x} = 7.48 \pm 7.59$ pieces, $n = 23$). Plotkin *et al.* (1993) and Bjorndal *et al.* (1994) also found sea turtles ingested debris very frequently and in small amounts. The sub-lethal effects caused by anthropogenic debris are difficult to estimate (Laist, 1987) but are probably more common than lethal effects (National Research Council, 1990). McCauley and Bjorndal (1999) found post-hatchling loggerhead turtles had a limited ability to compensate for dietary dilution by increasing intake. This inability could result in reduced growth rates, longer developmental periods at sizes most vulnerable to predation, depleted energy reserves, decreased ability to reach appropriate offshore current systems and decreased survivorship (McCauley and Bjorndal, 1999). Plastics pose many different effects and threats to the survival of sea turtles (Balazs, 1985; Carr, 1987). Among the direct effects, Bjorndal *et al.* (1994) consider the obstruction of the digestive tract to be one of the most significant, and asserted that small amounts of debris can kill. We were able to attribute the death of four specimens to the above reason. These specimens had only 1.4–3.2 g of anthropogenic debris in their guts, but it appeared to be sufficient to completely obstruct the digestive tract. Thus the small amounts ingested by the turtles of this study could be dangerous to their health and may have contributed to their stranding.

TABLE 1

Frequency of occurrence of anthropogenic debris ingested by green turtle *C. mydas* ($N = 38$) in South Brazil, from August 1997 to July 1998.

Anthropogenic debris	Occurrence n (%)
Plastic bags	16 (50.0)
Plastic ropes	15 (39.5)
Cloth	6 (15.8)
Hard plastic pieces	4 (10.5)
Styrofoam	3 (7.9)
Oil	1 (2.6)
Paper	1 (2.6)
Other ropes	1 (2.6)

No significant correlation was found between the size of green turtles and the weight of the plastic ingested ($r_s = 0.061, t_s = 0.366, p = 0.716, n = 38$). The correlation between the CCL and the number of plastic pieces ingested was also not significant ($r_s = 0.043, t_s = 0.261, p = 0.796, n = 38$). Although Plotkin and Amos (1990) and Balazs (1985) found evidence of decreased ingestion of plastics with age, this study did not find this relationship, while, on the other hand, they agree with the results of Bjorndal *et al.* (1994).

It was hypothesized that the possible source of the plastics ingested by green turtles was related to debris discarded by the large number of holidaymakers on the beaches during the warm months. No significant statistical difference was found between the cold months (April–September, $n = 9$) and the warm months (October–March, $n = 28$) for ingestion of plastics ($\chi^2_{\mathrm{YATES}} = 1.53, p < 0.451$). No seasonal difference for the ingestion of plastics by green turtles may indicate that: (a) in spite of the frequency of occurrence being higher in summer, the number of samples was not sufficient to indicate significance; (b) plastics do not come from the coastal towns and/or the higher presence of summer holidaymakers at these places does not mean an increase in the amount of garbage reaching the sea; (c) other sources are important, such as the ship traffic in the area; (d) since plastics are persistent, they remain for a long time in the sea and/or are deposited on the beaches, returning to the oceans with storms, high tides and other events, masking seasonal differences. However, the data obtained do not allow us to assume which of these alternatives is correct.

One of the 10 loggerheads for which esophagus and stomach were recovered presented with a fragment of transparent plastic bag, weighing less than 0.1 g. One of the two leatherbacks ingested a rigid piece of plastic weighing 0.2 g. The low frequency of debris ingested by loggerheads compared to green turtles could possibly be explained by the wider alimentary tract of adult and sub-adult loggerheads, which may promote a shorter residence time of these debris in the esophagus and stomach. Lutz (1990) found small plastic sheets remained in the digestive tract of turtles that fed at sea for periods longer than four months. Furthermore, the benthic foraging habits may make these animals less likely to ingest these items (Plotkin *et al.*, 1993; author's unpub. data).

Interactions with human activities

Four of the 92 stranded individuals (one green and three loggerhead turtles) presented signs of direct interaction with humans. These signs consisted of cuts on the carapace and neck, clearly produced by sharp objects, in the case of one green and two loggerhead turtles, and the entire carapace removed and a vigorous rope tied around the neck of the remaining loggerhead. The rope was probably used by the fishermen to put the adult loggerhead back into the water after the removal of the shell. In some Brazilian cities there is an informal market for whole turtle shells for decorative purposes (Marcovaldi and Marcovaldi, 1999). The determination of death caused by interactions with fishing in beached individuals is rather difficult, because deaths by drowning, due to entanglement in nets, do not generally leave visible marks on the carcasses. Additionally, stranded turtles are a poor estimator of fishing-induced mortality (Epperly *et al*., 1996). In Atlantic waters of the USA, a maximum of 7–13% of the turtles which died due to interaction with fisheries are washed up on the beaches (Epperly *et al*., 1996). Deaths due to involvement with fishing activities are the greatest anthropogenic source of mortality of sea turtles (National Research Council, 1990), affecting mainly juveniles and sub-adults (Crowder *et al*., 1995). Thus, the 92 stranded turtles found in this study carried out over a period of one year, and the 230 specimens found by Pinedo *et al*. (1996) over a five-year period are a small part of the total sea turtles which died due to interaction with fisheries in southern Brazilian waters. Areco (1997) reported 37 juvenile green and one loggerhead turtle caught by estuarine fisheries near and inside the Lagoa dos Patos over a nine-month period, predominantly related to entangling nets and shrimp trawlers. Loggerhead and leatherback turtles are also captured in southern Brazil by tuna longliners (E. Secchi and A. Barreto, pers. comm. in Areco, 1997; Barata *et al*., 1998). Unfortunately, there are no accurate data on the entire longline fishing fleet, shrimp fisheries effort, and incidental turtle bycatch. In southern Brazil the major fisheries use bottom trawl and gill nets which operate in coastal and shelf waters and account for 61% of the fish catches (Haimovici, 1998). There is no information on the impact of these major fisheries on sea turtles. The scarcity of data makes it impossible to estimate the real direct impact on sea turtles in South Brazilian feeding grounds.

The data presented in this study indicate high frequencies of anthropogenic debris ingestion (60.5%), and green turtle mortality attributed to plastic and oil pollution (13.2%). Fisheries are also a mortality cause, probably largely underestimated in this study. Studies on the impact of fisheries on sea turtles are urgently required. Effective action which minimizes human impact, such as pollution by persistent marine debris and fisheries is required to promote the conservation of the endangered turtles in their feeding grounds.

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