Marine Pollution Bulletin 58 (2009) 287–289

Contents lists available at ScienceDirect

Marine Pollution Bulletin

journal homepage: www.elsevier.com/locate/marpolbul

Note

Leatherback turtles: The menace of plastic

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ARTICLE INFO

Keywords:
Conservation
Food intake
Jellyfish
Leatherback
Plastic
Sea turtle

ABSTRACT

The leatherback, *Dermochelys coriacea*, is a large sea turtle that feeds primarily on jellyfish. Floating plastic garbage could be mistaken for such prey. Autopsy records of 408 leatherback turtles, spanning 123 years (1885–2007), were studied for the presence or absence of plastic in the GI tract. Plastic was reported in 34% of these cases. If only cases from our first report (1968) of plastic were considered, the figure was 37%. Blockage of the gut by plastic was mentioned in some accounts. These findings are discussed in the context of removal of top predators from poorly understood food chains.

1. Introduction

The leatherback turtle, *Dermochelys coriacea*, is the most widely distributed reptile, occurring in tropical, temperate and sub-arctic seas around the world. This huge turtle, weighing as much as 640 kg (James et al., 2007), subsists almost entirely on jellyfish and other gelatinous zooplankton (Fig. 1). In the last century, in addition to incidental catch in fishing gear, collision with boat propellers, and development on its nesting beaches, a new menace has arisen: plastic. Planktonic plastic may easily be mistaken for jellyfish. Whether this results from the cues being too similar or from an indiscriminate foraging strategy is a fine point (James and Herman, 2001). Whatever the case, unfortunately an animal that can gulp down a toxin laden Portuguese-man-of-war does not necessarily survive eating an inert plastic bag.

In many parts of the world there are enormous quantities of plastic garbage floating in the sea and washing up on beaches, but the extent to which leatherbacks actually ingest plastic is inadequately documented. In this paper we collect and collate leatherback necropsy reports going back to the late 1800s. From these we estimate how commonly leatherbacks eat plastic, and see if we can learn anything else about this phenomenon.

2. Methods

Information was obtained by searching the literature, and by contacting people in charge of marine animal stranding networks and other individuals. Since the number of records varied greatly from one year to the next, data were expressed as the percentage of leatherbacks necropsied that contained plastic.

Special attention was paid to learning whether turtles with empty stomachs were included in reports. In a few cases, leatherbacks with plastic in their GI tracts were excluded from our sample because of insufficient information about the number and results of autopsies on other individuals.

Turtles with curved carapace length <100 cm were excluded in case small leatherbacks have different diets. Leatherbacks with lengths as short as 105 cm have been reported on nesting beaches (Stewart et al., 2007). By taking a 100 cm cut-off we chose to include turtles that might have been foraging in the same habitats as were larger adults rather than to exclude individuals that might not have quite reached maturity. In any case, any categorization based on size in a retrospective survey of this kind is problematic since information on size was sometimes not given, and sometimes suspect. However, because leatherbacks intermediate in size between hatchlings and near adults are so seldom encountered (Eckert, 2002), exclusion of <100 cm size makes virtually no difference to the numbers in the sample.

Most records contained information on the month when the specimen was found. A few cases lacking this information were nevertheless included, provided the year in question was clear.

The supplementary material gives the data on date, location, presence or absence of plastic, and source of information for each individual. Occasional mentions of cellophane were put in the with-plastic category.

3. Results

For the years 1885–2007, we found 408 reports which we were reasonably confident were unbiased with respect to omission of

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doi:10.1016/j.marpolbul.2008.10.018

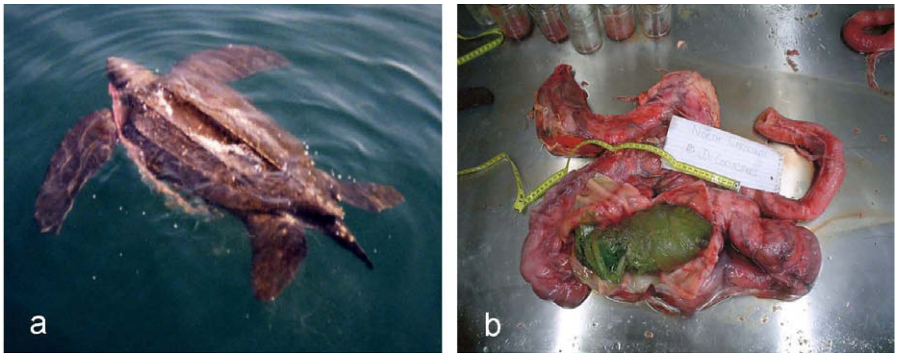

Fig. 1. (A) Leatherback turtle eating a jellyfish; long reddish-brown strand along left side of turtle is one of the tentacles (photo by Canadian Sea Turtle Network) and (B) plastic lining the gut of a leatherback and obstructing the passage of food (photo by N. Desjardin).

cases with empty GI tracts. Of these 408, 33.8% (n = 138) indicated the presence of plastic. The first mention of plastic in the GI tract was for 1968. Of the 371 autopsies from that year and onwards, 37.2% revealed the presence of plastics.

Breaking down the data into decades, one sees a rapid increase in the incidence of ingestion of plastic from the late 1960s to the 1980s with leveling off after that (Fig. 2). The apparent dip in the 2000s (Fig. 2, top) should not be over interpreted; it might stem from sampling artifacts related to different geographic regions being differentially represented in the decades. The main result for the last few decades overall is that ingestion of plastic has remained common, with it being conservative to estimate that about one third of adult or large leatherbacks have ingested plastic (Fig. 2 bottom). Some other accounts of plastic in the GI tract of leatherbacks lack details necessary for our analysis but nevertheless corroborate the view that this is a frequent occurrence (Fritts, 1982; Sadove and Morreale, 1990).

In our sample, bags were the most common plastic item mentioned, but fishing lines, twine, fragments of mylar balloons, a plastic spoon, and candy and cigarette wrappings were also mentioned.

Of the 138 reports of leatherbacks with plastic, 12 (8.7%) mentioned amounts or location of plastic that appeared to be obstructing the passage of food sufficiently to be likely to cause or to have caused death (Fig. 1).

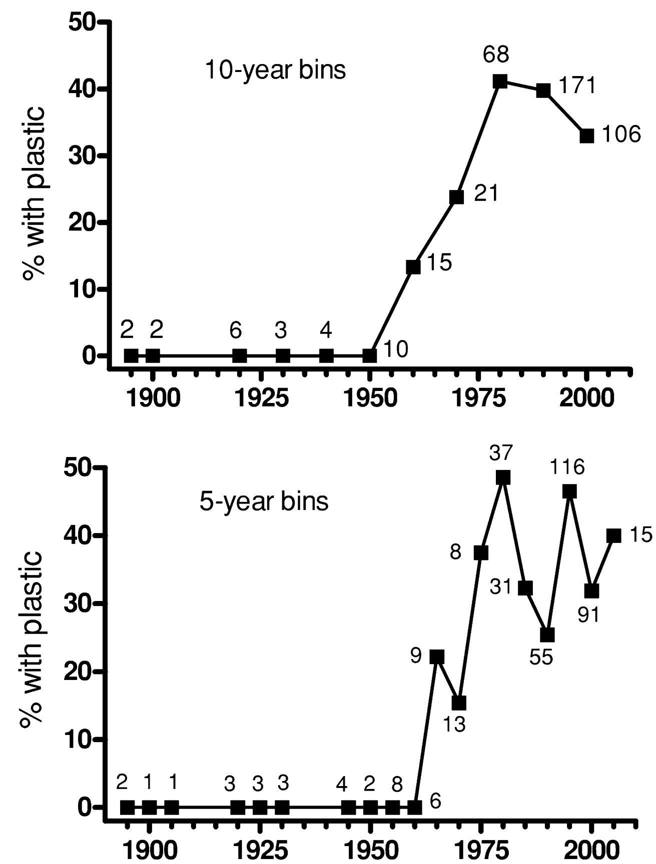

Fig. 2. Percent of autopsies in which plastic was found in the GI tract. N values beside points are numbers of turtles examined. Top: data plotted in 10-year bins, starting at the dates shown on the x-axis, except for the first point, which is for all cases prior to 1900. Bottom: the same but with data plotted in 5-year bins.

4. Discussion

Plastic blocking the gut to an extent plausibly considered lethal may appear relatively infrequent (8.7% of cases with plastic, 3.2% of all autopsied cases from the date plastic was first noted in our sample). However, this problem is probably more serious than it appears because some of the sources do not provide information relevant to blockage of the gut. Also, non-lethal amounts of plastic, by reducing the extent of the gut from which absorption can occur, may well impair health and reproduction. For instance, in the summer, in the NW Atlantic, leatherbacks migrate to foraging habitats off the Canadian Maritime Provinces. There the turtles become markedly fat, and these extra reserves are assumed to support the fall migration southwards to tropical waters, and the subsequent mating and egg laying (James et al., 2005). Whether decreased rates of energy assimilation delay departure southwards until cooler months, or whether departure occurs on time, but with smaller energy reserves, it might well reduce reproductive output. Even if everything is normal, feeding off prey that is in the order of 95% water (Hsieh et al., 2001) may be enough of a challenge in itself.

The impact of floating plastic debris – plastic jellyfish as it has been called (Mrosovsky, 1981) – may extend beyond detrimental effects on the turtles themselves. Those who have observed leatherbacks foraging suggest that they may consume about 10 large jellyfish (*Rhizostoma pulmo*) per hour (Duron, 1978). If they feed for a number of hours each day, 50 or more jellyfish per day could easily be taken. Calculations based on the energy content of jellyfish suggest that a 250 kg leatherback requires 65–260 kg per day of jellyfish, *Cassiopeia* sp. (Lutcavage and Lutz, 1986); that could be as much as its own weight. Other calculations based on the caloric content of prey and the energy requirements needed to support migration and reproduction provide figures in the order of 100–200 kg per day (Wallace et al., 2006). There are assumptions in these estimates, but they all suggest that leatherbacks could remove considerable numbers of jellyfish when encountering dense aggregations.

What if this consumption is reduced by declines in leatherback populations? In other food chains, when the top predators are removed, inhibitions are removed on the predators occupying intermediate positions in the food chain. Unchecked numbers of these meso-predators can have disastrous effects on stocks low down in the food chain (Myers et al., 2007). Adult leatherbacks are not right at the top of their food chain as they are sometimes attacked by killer whales (Pitman and Dutton, 2004) but they are certainly high up. So it may be asked, for instance, whether the proliferation of jellyfish off the coast of Namibia and the associated decline in fish stocks there (Lynam et al., 2006) might result from too few turtles or, to put it the other way round, whether increased numbers of leatherbacks would result in a rebound of fish stocks. A number of other problems are associated with massive blooms of jellyfish (Hay, 2006), so it may be wise to attend to what is happening to species higher up on the food chain, such as leatherbacks.

Looking further ahead, we do not know what impact, if any, an increased demand for jellyfish by Asian markets (Omori and Nakano, 2001; Hsieh et al., 2001) could have on leatherback turtles. It has been speculated that leatherbacks off the coast of France take in more plastic in cooler months when jellyfish are scarcer (Duguy et al., 2000). If it is correct that commercial harvests of jellyfish reduce the availability of this prey item, will ingestion of plastic by leatherbacks increase?

Food chains involving jellyfish are poorly understood (Mills, 2001); intervening by allowing so much plastic to enter the oceans seems unwise. A hopeful sign is that some cities, communities, and individuals are restricting their use of plastic bags. Historical baselines, such as the present collection of information on leatherback turtles, are needed to assess amelioration or deterioration of the situation.

Acknowledgements

This survey would have been much diminished without the help and advice of many people who generously contributed data. Their names are given in the supplementary material. Funding came from the Natural Sciences and Engineering Research Council of Canada (Grant to NM, post-doctoral fellowship to MCJ).

Appendix A. Supplementary data

Supplementary data associated with this article can be found, in the online version, at doi:10.1016/j.marpolbul.2008.10.018.

References

Duguy, R., Moriniere, P., Meunier, A., 2000. L'ingestion des déchets flottants par la tortue luth *Dermochelys coriacea* (Vandelli, 1761) dans le Golfe de Gascogne. Annales de la Société des Sciences Naturelles de la Charente-Maritimes 8, 1035–1038.

Duron, M., 1978. Contribution à l'étude de la Biologie de *Dermochelys coriacea* (Linné) dans les Pertuis Charentais (Ph.D. Thesis). Bordeaux, France: Université de Bordeaux 1.

Eckert, S.A., 2002. Distribution of juvenile leatherback sea turtle *Dermochelys coriacea* sightings. Marine Ecology Progress Series 230, 289–293.

Fritts, T.H., 1982. Plastic bags in the intestinal tracts of leatherback marine turtles. Herpetological Review 13, 72–73.

Hay, S., 2006. Marine ecology: gelatinous bells may ring change in marine ecosystems. Current Biology 16, R679–R682.

Hsieh, Y-H.P., Leong, F-M., Rudloe, J., 2001. Jellyfish as food. Hydrobiologia 451, 11–17.

James, M.C., Herman, T.B., 2001. Feeding of *Dermochelys coriacea* on medusae in the northwest Atlantic. Chelonian Conservation Biology 4, 202–205.

James, M.C., Ottensmeyer, C.A., Myers, R.A., 2005. Identification of high-use habitat and threats to leatherback sea turtles in northern waters: new directions for conservation. Ecology Letters 8, 195–201.

James, M.C., Sherrill-Mix, S.A., Myers, R.A., 2007. Population characteristics and seasonal migrations of leatherback sea turtles at high latitudes. Marine Ecology Progress Series 337, 245–254.

Lutcavage, M., Lutz, P.L., 1986. Metabolic rate and food energy requirements of the leatherback sea turtle, *Dermochelys coriacea*. Copeia 1986, 796–798.

Lynam, C.P., Gibbons, M.J., Axelsen, B.E., Sparks, C.A.J., Coetzee, J., Heywood, B.G., Brierley, A.S., 2006. Jellyfish overtake fish in a heavily fished ecosystem. Current Biology 16, R492–R493.

Mills, C.E., 2001. Jellyfish blooms: are populations increasing globally in response to changing ocean conditions? Hydrobiologia 451, 55–68.

Mrosovsky, N., 1981. Plastic jellyfish. Marine Turtle Newsletter 17, 5–7.

Myers, R.A., Baum, J.K., Shepherd, T.D., Powers, S.P., Peterson, C.H., 2007. Cascading effects of the loss of apex predatory sharks from a costal ocean. Science 315, 1846–1850.

Omori, M., Nakano, E., 2001. Jellyfish fisheries in southeast Asia. Hydrobiologia 451, 19–26.

Pitman, R.L., Dutton, P.H., 2004. Killer whale predation on a leatherback turtle in the northeast Pacific. Pacific Science 58, 497–498.

Sadove, S.S., Morreale, S.J. 1990. Marine mammal and sea turtle encounters with marine debris in the New York Bight and the northeast Atlantic. In: Shomura, R.S., Godfrey, M.L. (Eds.), Proceedings of the Second International Conference on Marine Debris, Honolulu, Hawaii, 2–7 April 1989. U.S. Dep. Commer., NOAA Tech Memo. NMFS, NOAA-TM-NMFS-SWFSC-154, pp. 562–570.

Stewart, K., Johnson, C., Godfrey, M.H., 2007. The minimum size of leatherbacks at reproductive maturity, with a review of sizes for nesting females from the Indian, Atlantic, and Pacific Ocean basins. Herpetological Journal 17, 123–128.

Wallace, B.P., Kilham, S.S., Paladino, F.V., Spotila, J.R., 2006. Energy budget calculations indicate resource limitation in Eastern Pacific leatherback turtles. Marine Ecology Progress Series 318, 263–270.