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Distribution of juvenile leatherback sea turtle *Dermochelys coriacea* sightings

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ABSTRACT: Data on the location, date, sea temperature, and turtle size for 98 small (<145 cm) leatherback sea turtles *Dermochelys coriacea* demonstrate that leatherbacks less than 100 cm in carapace length occur only in waters warmer than 26°C.

KEY WORDS: Leatherback · *Dermochelys* · Juvenile · Temperature requirements · Developmental habitat · Endangered species

INTRODUCTION

One of the great mysteries of sea turtle life history is where young turtles reside between the time they first enter the sea as hatchlings and when they return to coastal habitats as juveniles. This period can span a few to many years. Brongersma (1968) proposed that loggerhead sea turtle *Caretta caretta* hatchlings from US Atlantic beaches move directly offshore and, as young juveniles, reside in the pelagia passively drifting to Atlantic Europe. He proposed that after some indeterminate period they returned to benthic habitats on the US eastern seaboard. Carr (1986) provided additional evidence for this pattern of dispersal. Similar migrations have been described for the loggerhead in the Pacific (Bowen et al. 1995) and are suspected for other species, with 2 exceptions. The Australian flatback turtle *Natator depressus* may remain in coastal waters throughout its life (Walker & Parmenter 1990), whereas the leatherback remains pelagic.

Despite a growing understanding of the developmental life stages and habitats utilized by the young of most sea turtle species (Musick & Limpus 1997, van Dam & Diez 1998), there is no information on where hatchling leatherback turtles *Dermochelys coriacea* go after leaving the nesting beaches (Brongersma 1970). Deraniyagala (1936) suggested that they remain in the open ocean, based on the sighting of a juvenile 20 km from shore.

METHODS

There are very few records of juvenile leatherback sightings or occurrences in the scientific literature. Thus, for insights into the distribution of juvenile leatherbacks, I gathered primary material from sea turtle and marine mammal stranding coordinators, published literature, museum records and reports, and personal communications with qualified sea turtle biologists. Because such data are often gathered in a manner less rigorous than optimal, I was very careful to evaluate each report for accuracy. If there was any question as to location accuracy, size of turtle or other such information, the record was rejected from my analysis. Of particular concern was the size of the turtle, as often the data records only list estimated size, or it was unclear how size was determined. In such cases the data were rejected. Fortunately, because the morphology of the leatherback is so distinct, species misidentification was rarely a concern as it might be with other species of sea turtle. I restricted data to turtles with measured curved carapace lengths (CCL) <145 cm. For 2 turtles of 11.5 cm and 19.0 cm length, I accepted the straight line measure, because

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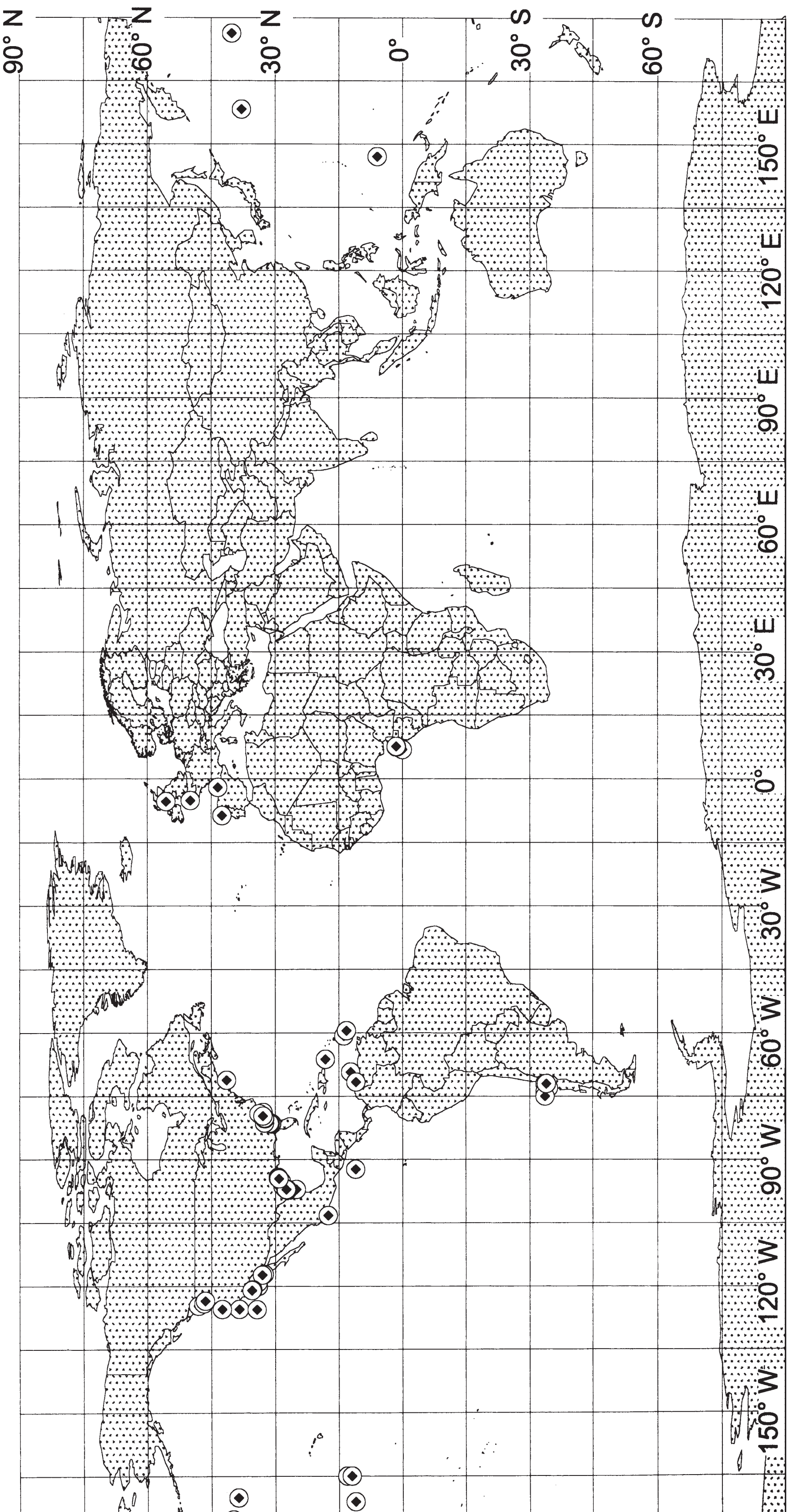

Fig. 1. *Dermochelys coriacea*. Locations of juvenile (<145 cm curved carapace length) leatherback sightings or strandings utilized for this analysis

such small turtles have relatively little curvature to their carapaces and there should be little difference between the 2 measurement methods. Date, location, and water temperature (if available) were noted. If water temperature (whose accuracy could be confirmed) was not available at the location of the sighting, I used satellite sea surface temperatures (SSTs) for the time and location of the sighting (see http://podaac.jpl.nasa.gov/mcsst/). Such data are readily available on the worldwide web for the period from 1 January 1987 to 20 November 1999. For a detailed discussion of the accuracy of this information see Vazquez et al. (1998). In cases where no SST data were available on the same date as the sighting due to cloud cover or poor satellite coverage, I used the nearest good date (±4 d).

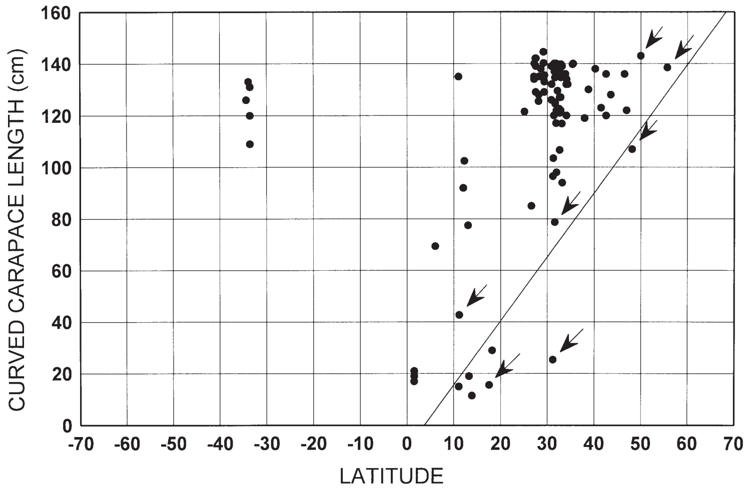

Fig. 2. *Dermochelys coriacea.* Scatterplot of juvenile sizes compared with latitude of the sighting or stranding. A linear regression was plotted against the highest latitude sighting within each (20 cm) size class (arrows)

RESULTS

One hundred records of juvenile leatherbacks qualified for my analysis. Of these, 26 were from the published literature (Brongersma 1969, 1970, 1972, Frair et al. 1972, Greer & Wright 1973, McCoy 1974, Rhodin & Schoelkopf 1982, Standora et al. 1984, Horrocks 1987, Johnson 1989, Frazier 1990, Eckert 1993, Sparks 1993, Acuna & Toledo 1994, Grant 1994, Pino & Pino 1996), 66 were from United States (State or Federal) sea turtle or marine mammal stranding network coordinators, 4 were from fishery observer records, 2 were from museum records, and 2 were from unpublished data. (Work & Balazs unpubl., M. Stinson pers. comm.). Their latitudinal distribution extended from 56.75° N to 33.58° S, with the majority of records from the Northern Hemisphere (Fig. 1). Of the records, 5 were discarded from further analysis due to their carapace size being listed as straight length. A scatterplot of the size of turtles and latitude suggested a positive and gradual increase in turtle size with increasing latitude. To confirm that this relationship was positive and statistically significant, a correlation test was conducted against Northern Hemisphere sighting data, (Pearson product-moment correlation, $r = 0.693$, $p < 0.05$). To confirm the gradual nature of the increase, size data was divided into 20 cm size classes and the most northern sighting of each size class was used in a linear regression analysis ($r = 0.85212$) (Fig. 2). In contrast, the relationship between juvenile leatherback distribution and water temperature was not gradual (Fig. 3). Rather, there appeared to be a sharp break in the distribution at 100 cm CCL, with turtles less than 100 cm found only in waters warmer than 26°C and turtles slightly larger than 100 cm found in waters as cool as 8°C. While there is a significant ($p < 0.05$) negative correlation between CCL and temperature, the statistic is weak ($r = -0.33$,) (Fig. 4).

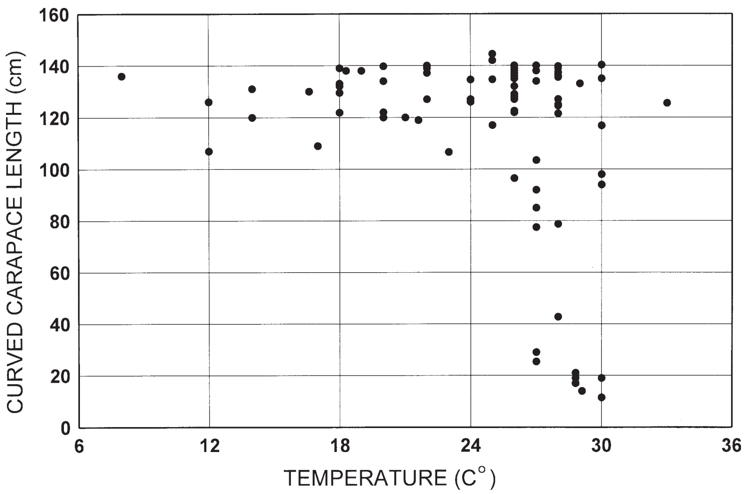

Fig. 3. *Dermochelys coriacea.* Scatterplot of juvenile sizes compared with surface water temperature at the location of the sighting or stranding

DISCUSSION

Leatherbacks have long been considered to be facultative homeotherms capable of maintaining ele-

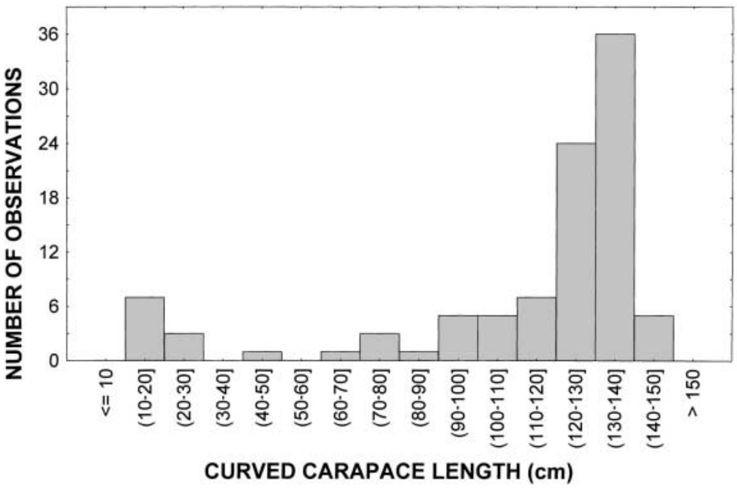

Fig. 4. *Dermochelys coriacea.* Curved carapace length distribution of sightings utilized in this study. Maximum size was limited to 145 cm

vated internal body temperature and thus able to extend their range into cold northern waters (Frair et al. 1972). Morphological and physiological characteristics enhance the leatherbacks' ability to stay warm, including a cylindrical body form, large body mass, thick fatty insulation and countercurrent circulation to reduce heat loss in their extremities (Greer et al. 1973). They are also reported to have temperature independent cellular metabolism (Spotila & Standora 1985, Paladino et al. 1990, Spotila et al. 1991, Penick et al. 1998).

The restriction of smaller leatherbacks to warmer waters implies that size may play a role in the ability of the species to exist in colder waters. Larger turtles have a larger mass to surface-area ratio and greater thermal inertia which could facilitate living in progressively cooler waters as they grow. Therefore while growth and development are poorly understood in leatherbacks, it would be reasonble to assume that they grow gradually over time, and that this gradual growth would be reflected in a gradual movement of the turtles into cooler waters with increasing size. The positive relationship between turtle size and latitudinal distribution, which is gradual, support this contention if it is assumed that higher latitudes are cooler than lower latitudes. However, the higher latitude sightings of leatherbacks <100 cm CCL occurred only where the water temperature was above 26°C. Further, the relationship between temperature and distribution of juvenile leatherbacks does not support a gradual increase. Rather, there is a distinct transition at 100 cm CCL, with turtles smaller than this found only in waters of at least 26°C, and those only slightly larger (107 cm) found in waters as cold as 12°C. One explanation for such a rapid transition to a cold-water existence could be developmental. If leatherbacks are able to generate heat metabolically as proposed by Pennick et al. (1998), then the data presented in this paper would imply that this capacity may be developmentally induced, and support the theory that heat generation is physiological rather than simply a function of morphology. At approximately 100 cm in carapace size there may be an onset of thermogenerating capability which is not found in younger or smaller leatherbacks.

The relationship between the distribution of small leatherbacks and temperature is an important clue to understanding the life history of this unique species. Leatherbacks appear to spend the first portion of their lives in tropical waters. Once they exceed 100 cm CCL they can move into the cooler waters that have long been considered the primary habitat for the species.

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