Herpetological Review, 2005, 36(1), 36–38.

"Shark Fishing": A Method for Determining the Abundance and Distribution of Sea Turtles at Shallow Reef Habitats

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The size and distribution of local marine turtle populations is critical for managers who need to know where and when the turtles congregate, what resources attract turtles to a given location, and how both the turtles and those requisite resources can be managed and protected. But obtaining this information is often difficult. Home ranges may be large, water clarity can be limited, and the turtles may avoid observers by fleeing or hiding before they can be detected.

The Palm Beach County, Florida (USA) Department of Environmental Resource Management has been aware that juvenile Green Turtles (*Chelonia mydas*) often were observed by local swimmers and divers near shallow water (1–5 m deep) reefs (Fig. 1). These reefs are long (up to 0.5 km), narrow (≤ 12 m wide), hard-bottom formations that parallel the shore along the Atlantic coast of southeastern Florida. In parts, the hardbottom is colonized by living worm reef, structures formed by the secretions of a colonial sabellariid polychaete (*Phragmatopoma lapidosa*). Throughout these reefs, sponges, soft and hard corals, and algae adhere to the hardbottom surface. Turtles feed on the macro-algae and seek shelter under ledges and within reef crevasses when inactive (especially at night; Wershoven and Wershoven 1988). Because the reefs provide food and shelter, they may constitute an important "developmental" (age-specific, temporarily utilized) habitat (Musick and Limpus 1997) for the turtles.

The reefs are popular boating and snorkeling sites. For that reason, we suspected that in-water observers towed behind a slowly moving, small boat would be an effective census method because the animals should be acclimated to both boat traffic and swimmers. This surveying method, colloquially referred to as "shark fishing" (derived from the towing of large "baits" [observers] through the water) is used in Hawaii by trap and spear fishers to locate prey. To our knowledge, no published studies have reported the use of this technique for estimating turtle abundance. We estimated the density of turtles in the shallowest of these discontinuous reef formations, and determined whether turtles were more abundant over the reefs than over the sandy areas separating reefs. Our results indicate that the method works in clear water and might be useful at other subtropical and tropical reef locations worldwide. We also describe its limitations.

Methods.—In-water surveys were performed by two observers wearing a mask and snorkel, each holding one end of a 5-m long tagline. The other end of each line was attached to each side of a slowly (2–3 nautical miles/h) moving small (~ 6 m long) powerboat, traveling directly over the reef axis parallel to shore. Observers visually scanned the bottom directly below and to the left (port observer) or right (starboard observer), as far as water clarity permitted (typically, 8–12 m to each side). When a turtle was seen, the boat operator was informed and stopped the boat to record the time, water depth, and the turtle's geographic position (using a GPS and depth sounder).

We surveyed the county's three primary shallow reefs (north, south, and middle reef), as well as three sand bottom areas at similar depth between the reefs (Fig. 1). The total length of the reef (12.1 km) and sand (10.0 km) surveys accounted for ca. 30% of the county's shoreline. Surveys were carried out in July–August 2001 (over 9 days), and in July–September 2002 (over 5 days).

The short north and south reefs were surveyed in a single day; the longer middle reef required several transects done over a 2–4 day survey period, with each sequential transect beginning where the previous transect ended. Longitude and latitude were noted at the start and end of each transect, as well as at five min intervals during each survey so that both transect paths and turtle sightings could be accurately depicted on nearshore maps. Surveys were usually made between 0800 and 1200 h to avoid afternoon thunderstorms.

Results.—We observed 62 turtles over the reefs during the 2001 survey, and 79 turtles during the 2002 survey; none was seen over open sand (2001 survey). Turtles either were resting on the bottom, swimming over the reef, or feeding (apparently, on benthic macro-algae). As we passed them, most turtles within 5 m swam away slowly to one or the other side of the boat's path. Turtles observed at greater distance ignored us.

During the 2001 survey, 68% (42 of 62) of the turtles were separated by short distances (≤ 40 m) from one another (Fig. 2). This pattern did not change during the 2002 survey.

Discussion.—Our shore-parallel surveys assume that all of the turtles can be sighted because the animals confine their movements to a certain (in this case, elongated reef) area (Gerrodette and Taylor 1999). Support for this assumption is provided by studies in progress. One of us (CM) recently attached sonic tags to six turtles from the middle reef; each has confined its movements entirely to a discrete home range located directly over the reef. These results provide further support for the hypothesis that juvenile Green Turtles establish home ranges over reef substrates

(Balazs et al. 1987; Brill et al. 1995, for Hawaiian turtles; Guseman and Ehrhart 1990; Wershoven and Wershoven 1988, for Florida turtles; Seminoff et al., *in press*, for Baja California turtles).

"Shark Fishing" as a survey technique has several advantages. It is (i) technically simple, (ii) time-efficient (5–9 d required to survey 12 km of reef), (iii) requires no permit (and lengthy review process), and (iv) does not appear to disturb the turtles. But the method also has limitations. Good visibility (≥ 7 m) is required. Because turtles are not individually identified they may be counted more than once, especially when reef tracts are long and require several days to survey. The method assumes that the population is static (no immigration or emigration) during the survey period. At our site that assumption is probably correct during the summer when the turtles occupy fixed home ranges, but not during the spring and fall when juvenile Green Turtles are known to seasonally migrate (Bresette et al. 1998). Because size is estimated (rather than precisely measured), information on size class distribution is limited.

In Palm Beach County and elsewhere in South Florida, similar reef formations are also located in deeper water, and Green Turtles are routinely observed there (J. Abernathy, SCUBA adventures, pers. comm.; Ben Harkanson, Palm Beach County Reef Research Team, pers. comm.). Thus, our survey is an incomplete assessment of reef-dwelling population density; counts made by divers (using SCUBA) over the deep reefs are also required.

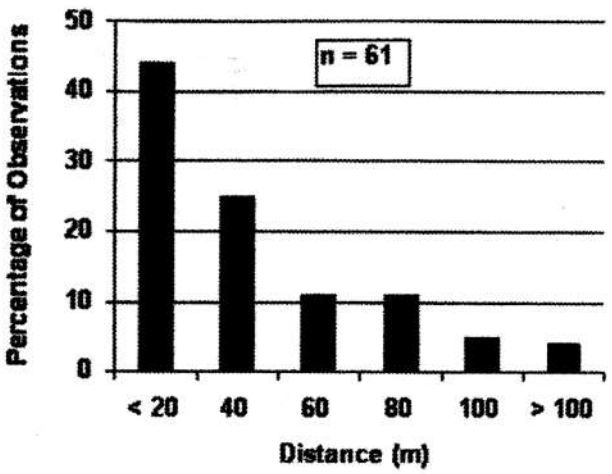

FIG. 2. Distribution of distances between turtles observed over the reef, 2001 field season. N = number of intervals.

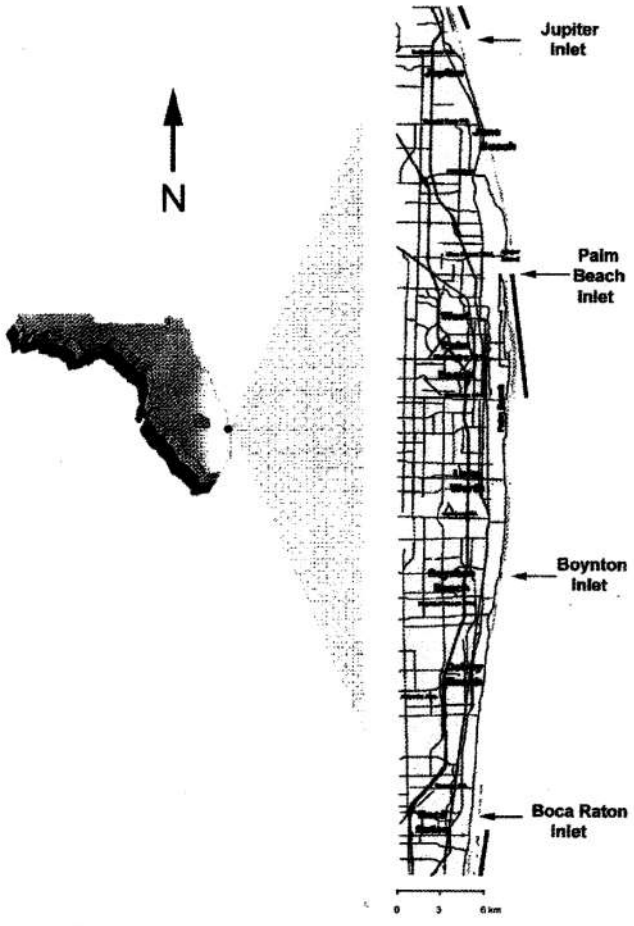

FIG. 1. Coastal shoreline of Palm Beach County, showing the major inlets and the approximate location of the north, middle, and south inshore reefs (dotted lines).

At other developmental habitats in Florida, different methods are used. One procedure is to count the number of turtles seen surfacing to breathe as a boat and its operator travel along a transect line. This method is useful where water clarity is limited, but is compromised when the water surface is disturbed (by waves or rain) or the turtles occur at low densities (reducing the probability of detection; Gerrodette and Taylor 1999). We observed only five turtles breathing at the surface during our 2001 survey. Additionally, surface counts must be corrected for turtles that are submerged at the time of the survey and, because individuals are not identified, some turtles may be counted more than once. Thus, headcount surveys (including those obtained by shark fishing) can be used to estimate densities of turtles, but not their absolute population sizes.

Another procedure, useful in shallow lagoons and tidal channels where visibility is limited, involves the use of tangle nets (Ehrhart and Ogren 1999). Captured turtles are marked using flipper tags. Their recapture probabilities are determined over repeated net sets. The procedure is labor intensive, but it is effective for estimating relative abundance if continued over several months or years. Population estimates based upon mark and recapture techniques, however, also carry assumptions (e.g., there are no deaths, immigration and emigration rates are constant, tags are not lost, tagging does not affect recapture probability, etc.). Nonetheless, this is the preferred method at some habitats, such as the Indian River Lagoon (Ehrhart and Ogren 1999; Mendonça 1983; Mendonça and Ehrhart 1982). Netting is difficult at oceanic nearshore reefs where tidal flow and surge can cause the net to be caught on, and damaged by, the reef. However, it has been successfully employed to estimate Green Turtle relative abundance and seasonal occupancy at habitats where water clarity precludes direct observation (Guseman and Ehrhart 1990).

In-water "Shark Fishing" surveys are an effective procedure for estimating Green Turtle population densities in clear water habitats. These observations can be enhanced by using sonic and/or satellite telemetry to pinpoint daily and seasonal movements. This information is essential for specifying home range characteristics, and for insights into both ecological requirements as well as for effective management and protection strategies (Mendonça 1983; Musick and Limpus 1997). Our two-year study, for example, provided important baseline information to Palm Beach County personnel. A beach restoration project is planned for the coastline adjacent to the middle reef where the Green Turtles are most concentrated. Pumping sand to the beach can have consequences that seriously compromise the integrity of near-shore reef habitats (Crain et al. 1995). Our data will make it possible for the County to assess these effects on Green Turtles, which are currently listed as endangered under the authority of the Endangered Species Act (National Marine Fisheries Service and U.S. Fish and Wildlife Service 2002).

Acknowledgments.— Funding for this study was provided by the National Save-The-Sea-Turtle Foundation of Fort Lauderdale, Florida. We thank Robert Ernest, Jeanette Wyneken, and an anonymous referee for their comments.

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