Behavior of Green Sea Turtles in the Presence and Absence of Recreational Snorkellers

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There has been a large increase in in-water tourism focused on sea turtles (Balazs 1996), especially in areas like Hawaii where sea turtle numbers have increased greatly (Balazs 1998). Research and management regulations and guidelines for human-sea turtle interactions are well established for nesting beach and egg laying situations (Hirth 1997). However, federal regulations in the United States for in-water interactions do not exist beyond the general prohibitions against take and harassment in the Endangered Species Act and recommendations to leave them an escape route (NOAA Wildlife Viewing Guidelines: http://www.nmfs.noaa.gov/prot_res/MMWatch/MMViewing.html). There has also been little study of human-sea turtle interactions in the wild (Booth & Peters 1972; Hirth 1997).

I studied human-sea turtle interactions using focal-animal activity budget observations in the presence or absence of recreational snorkellers to examine effects of such interactions on green sea turtle (*Chelonia mydas*) behavior. Behavior of the turtles was characterized and used in this assessment. Data were also gathered to document the normal approach distances and behaviors of recreational snorkellers and the distances at which sea turtles made obvious reactions to the snorkellers.

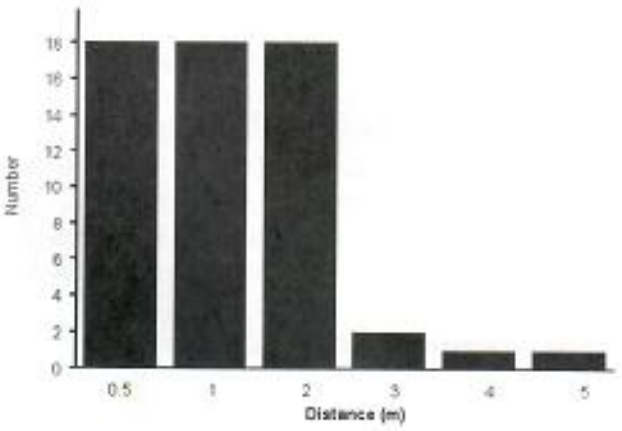

Figure 1. Distance of first obvious reaction of turtles to snorkeller presence. Note: some turtles exhibited no response to snorkellers up to the closest distance of approach: 13 turtles showed no reaction at 1 m from person, 10 at 2 m, 9 at 3 m, 5 at 4 m, and 11 at greater than 5 m.

Green sea turtles in Hawaii were exploited in the past, by natives and visitors to the island (Balazs 1980), and there continues to be cases of turtles being captured even today. Protection was made official under federal law in 1979. Recovery of the population in the Hawaiian Islands has been noted over 22 plus years of nest monitoring (Balazs 1998; Balazs pers. comm.). There have been some unusual changes in green turtle behavior in Hawaii that have not been generally noted elsewhere that may influence the results of this study. For example, Balazs (1996) reported shifts in feeding to daytime in some areas, and more tolerance to humans in the water nearby, probably as a result of habituation to the more frequent interactions with people during the day.

The research was conducted between April 2002 and April 2003 along the lee coast of the island of Maui, Hawaii. Local tour operators include small and large boats, kayak tours, and shore-based snorkeling tours with 10 to 150 participants. SCUBA tours can also focus on sea turtles, but interactions with divers are not considered here. There are a number of locations along the 50 km or so of coastline where green sea turtles are abundant and accessible enough to be targeted for recreational snorkeling. Most sites typically have water depth of 2-10 m with moderate to high coral coverage. Most tour boats spend approximately one hour at the turtle location. I focused on larger tour boats as a source of snorkellers as their schedules were predictable. It is possible the results of this study could be biased relative to effects of snorkellers from smaller boats or shore but this is unlikely as those sources of snorkellers are active in the same general areas and with the same turtles as those from larger boats. Additional observations of snorkellers from these other sources were not noticeably different (Meadows unpublished data). I conducted surveys at all tour sites I could access from shore and observations took place between 0730 and 1130 in the morning, the times when most snorkeller-turtle interactions occur in this area.

We conducted 5 min focal-animal activity budget observations of individual turtles with or without recreational snorkellers present. Researchers also snorkelled and stayed at least 5 m from the focal turtle.

I recorded the duration (to nearest 5 sec) for the following five mutually exclusive behavior categories: swimming in the water column, being at the surface (generally to breathe), being inactive on the sea bed, actively moving about on the bottom, and feeding. In addition to the individual behavior categories, the sum of all bouts of all behavior categories observed during the 5 min period was used to examine whether there was a general effect on behavioral transitions. The amount of time a turtle was being cleaned by fishes, and the number of breaths and bouts of breathing (other behaviors that might be affected by human presence), were recorded separately. I also recorded the number of chases and touching of the turtle by the snorkellers. Data on turtle size (estimated to ± 5cm straight carapace length), sex (for turtles large enough to be sexed by tail length), and fibropapilloma (FP) tumor intensity (Balazs 1991) were recorded as possible covariates. However, only 18 turtles could be sexed and 74 of 105 had no observable tumors. Thus, sample sizes for covariate analysis were not large enough to provide any meaningful power. Average depth of water, average distance of snorkellers to the turtle, closest approach distance of snorkellers to turtle, and distance of first obvious reaction of turtle to snorkeller (usually a rapid change in direction or activity) were estimated to ± 0.5m.

A total of 69 activity budgets in the absence of snorkellers and 36 in the presence of snorkellers were gathered. No turtles were known to have been surveyed more than one time. Data were analyzed with one-way ANOVA or Kruskal-Wallis tests, depending on whether parametric test assumptions could be met, using Minitab 10.2. Data and error bars are presented as mean ± one standard deviation, range.

An average of 5.8 (±5.3, 0-20) recreational snorkellers were watching turtles at the beginning of a focal-animal observation and 2.7 (± 2.7, 0-12) were watching at the end of the 5 minutes. Average turtle size observed was 47 cm (± 9.5, 30 - 75). The average distance snorkellers were away from the sea turtles was 5.0 m (± 1.4, 2 - 8), with the average closest approach distance being 1.9 m (± 1.4, 0.25 - 5). The number of chases (with or without touching) averaged 0.31 (± 0.98, 0 - 5) per 5 min period. The distance of first reaction for almost all turtles was less than 3 m (Figure 1). Average depth (with snorkellers: 5.5 m ± 0.7, 4 - 7; without snorkellers: 5.8 m ± 1.8, 3 - 10) and turtle size (with snorkellers: 47.6 cm ± 8.4, 30 - 65; without snorkellers: 47.0 cm ± 10.0, 30 – 75) did not differ between turtles observed in the presence or absence of recreational snorkellers ($F_{1,103} = 1.2$, $p = 0.27$; $F_{1,103} = 0.1$, $p = 0.73$, respectively).

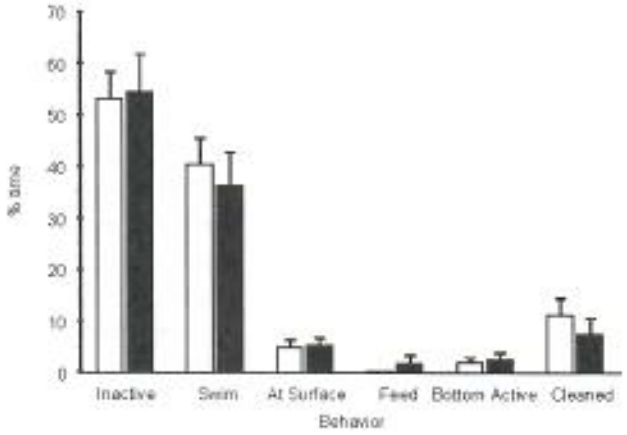

Figure 2. Mean time (%) for turtles in various behaviors in the presence (solid bar) and absence (open bar) of recreational snorkellers. All behavior categories do not differ significantly with snorkeller presence (all Kruskal-Wallis $H < 3.0$, $p > 0.05$). Note: Total percentages for first five categories add to 100%, but cleaning was not mutually exclusive from other behaviors and thus all six behaviors do not sum to 100%.

The proportion of time turtles spent in various behaviors did not differ in the presence or absence of snorkellers (Figure 2). The proportion of time at the surface in this study (5%) was similar to the results of Nelson (1994) who used radio/sonic tags, suggesting the short behavioral observation period did not affect reliability of this type of observation. The number of bouts of all behavior categories except being inactive on the sea bed, increased in the presence of recreational snorkellers, but this was only significant for being at the surface and total behavioral bouts overall (Fig. 3). The number of breaths taken (with snorkellers: 1.2 ± 1.8, 0 - 6; without snorkellers: 1.0 ± 2.2, 0 – 9) per 5 min activity budget did not differ with snorkeller presence (Kruskal-Wallis $H = 1.6$, $p = 0.2$). Sex, size, and FP intensity did not affect behavior (all $H < 1.6$, $p > 0.20$), but as previously mentioned, sample size was very low.

Five minutes is a relatively short time for behavioral observations, but was necessitated by the short duration of most snorkeller-turtle interactions. I also recorded activity budgets for 15 min time periods for turtles in the absence of recreational snorkellers and compared those results to the 5 min budgets in the absence of snorkellers. There were no significant differences between the 5 min and 15 min activity budgets (Meadows unpublished data), suggesting the data are

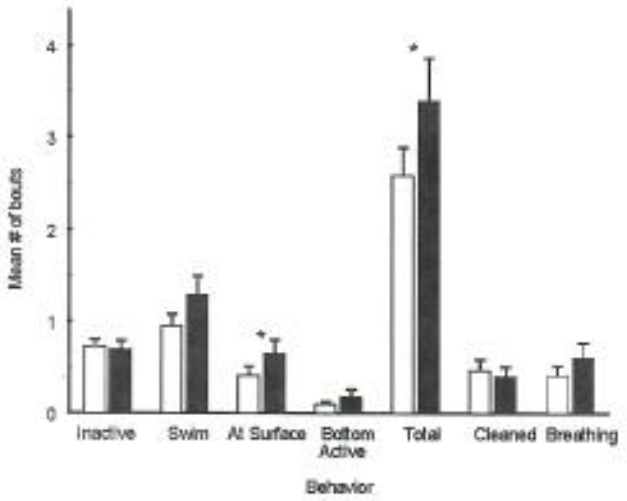

Figure 3. Mean number of bouts of each behavior type in the 5 min activity budgets in the presence (solid bar) and absence (open bar) of recreational snorkellers. The "total" category includes all behaviors to the left of that category since cleaning and breathing were not mutually exclusive of the other behaviors. Significant differences between turtles with recreational snorkellers present vs absent are indicated by an * (at surface: $H = 3.8$, $p < 0.05$; total: $H = 4.0$, $p < 0.05$).

representative of turtle behavior over longer time spans.

The results of this study provide the first quantitative evidence on the interaction between snorkellers and sea turtles. Snorkellers were shown to make regular close approaches towards turtles at a rate of 4 per hour (extrapolating from the rate during the 5 min activity budget results of focal animal observations). The results also show that a small number of recreational snorkellers are associated with an increase of over 30% in total bouts of behavior. This is likely a consequence of the turtles switching from one behavior to another as a result of attempts by snorkellers to chase, touch, and/or ride them. Whether these more frequent changes in behavior result in increased energy expenditure or other costs remains to be determined. Since turtles and snorkellers use the same sites daily, if such changes in behavior are found to be energetically expensive, potential negative effects on growth or fecundity could occur. Tagging or photo-identification of turtles in areas of high tourism use could be valuable to address this issue. These results make clear that the common notion of non-consumptive exploitation as a solution to the conservation threat to sea turtles is somewhat simplistic.

It is not clear how well the results of this study can be extrapolated to other areas given the previously mentioned differences in behavior of Hawaiian green turtles (Balazs 1996). Future studies could also address the duration of individual snorkeller interactions with turtles using focal-human observations to better understand that aspect of these interactions. While individual interactions with turtles were short, it is possible for single turtles to be sequentially harassed by multiple snorkellers throughout the day as many tour boats and tourists visit many sites at all times of day. Studies on other species of sea turtle and whether there are stress hormone or other physiological responses to the presence of snorkellers would also be desirable. Possible effects of the presence of a researcher could not be eliminated and may bias the data. Observations made via remotely operated video or other technology might be used to address this issue, but these have their own biases as well. Nevertheless, overall the relatively small effects found here show that consumptive uses are a much greater threat to sea turtle populations.

The results of this study should be examined carefully by resource managers. These results suggest the possibility that sea turtles may be negatively affected by snorkellers. As all sea turtles in the USA are protected from harassment, it is suggested that regulation and enforcement action incorporating approach distance rules on the order of 2 to 5 m (with a conservative buffer on at the large end of this range) to sea turtles should be implemented by management agencies. It is unlikely that studies could feasibly be done showing long-term effects of snorkellers on growth or reproduction given the long lifespans of these animals. Thus, the changes I have shown in frequency of behavior as a result of presence of snorkellers are likely to be the most relevant evidence available.

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BALAZS, G.H. 1980. Synopsis of biological data on the green turtle in the Hawaiian Islands. NOAA Technical Memorandum, NMFS, Honolulu, Hawaii, 141 pp.

BALAZS, G.H. 1991. Current status of fibropapillomas in the Hawaiian green turtle, *Chelonia mydas*. In: G.H. Balazs & S.G. Pooley (eds.). Research Plan for Marine Turtle Fibropapilloma. NOAA Technical Memorandum NMFS-SWFSC-156, pp. 47-57.

BALAZS, G.H. 1996. Behavioral changes within the recovering Hawaiian green turtle population. In: J.A. Keinath, D.E. Barnard, J.A. Musick, & B.A. Bell (compilers). Proceedings of the 15th Annual Symposium on Sea Turtle

Biology and Conservation. NOAA Technical Memorandum NMFS-SEFSC-387. pp. 16-20.

BALAZS, G.H. 1998. Sea Turtles, 3rd edition. In: S.P. Juvick & J.O. Juvick (eds.). Atlas of Hawaii. University of Hawaii Press, Honolulu, HI. p. 115

BOOTH, J. & J.A. PETERS. 1972. Behavioural studies in the green turtle (*Chelonia mydas*) in the sea. Animal Behaviour 20:808-812.

HIRTH, H.F. 1997. Synopsis of the biological data on the green turtle *Chelonia mydas* (Linnaeus 1758). U. S. Fish and Wildlife Service Biological Report 97(1).

NELSON, D.A. 1994. Preliminary assessment of juvenile green sea turtle behavior in the Trident submarine basin Patrick AFB, Florida. In: K.A. Bjorndal, A.B. Bolten, D.A. Johnson, & P.J. Eliazar (compilers). Proceedings of the 14th Annual Symposium on Sea Turtle Biology and Conservation. NOAA Technical Memorandum NMFS-SEFSC-351. pp. 104-108.

Turtle Strandings in the Southern Eritrean Red Sea

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Marine turtle populations are under increasing pressure worldwide due to pollution, over-harvesting of eggs and adults, destruction of nesting sites by coastal development, and accidental killing in the nets of fishing vessels. Eritrea is unusually fortunate, in that the long struggle for independence resulted in over 20 years of extremely low levels of human impact on turtles and their habitats in the coastal, marine and island (CMI) areas. The CMI environment of Eritrea is thus generally in very good condition. With independence a decade ago the development of Eritrea's coast and seas began, and turtles are now threatened at the local and national levels by activities including fisheries, coastal development, tourism, and oil exploration.

Little is currently known about the status of turtle populations in the Eritrean Red Sea (ERS), although available evidence indicates that it is a turtle resource of global significance (Hillman & Gebremariam 1995). At the moment, green turtles (*Chelonia mydas*) and hawksbill turtles (*Eretmochelys imbricata*) are relatively common in the ERS. Eritrea's Coastal, Island and Marine Biodiversity (ECMIB) Conservation Project has proposed a turtle conservation programme (initially in the form of a local pilot project in the Fatuma Island group near the port city of Assab). This will be a nationally and regionally significant development, and will be an important addition to other proposed turtle conservation initiatives elsewhere in the Red Sea and Gulf of Aden region.

Stranding Event

In April 2003, the ECMIB Project received a report from the Ministry of Fisheries in Assab of large numbers of dead turtles stranded on islands near Assab and on beaches near some smaller coastal villages (Figure 1) in the ERS. A team of marine biologists from the ECMIB Project, Ministry of Fisheries and University of Asmara conducted a one week field trip to Assab to investigate the reports. The major objective of the field trip was to investigate the cause of death of the turtles, but also to record any evidence of turtle exploitation by fishing communities. The team contacted the local fishermen and military servicemen who made the original reports, and visited island and coastal sites where turtles were reported to have washed ashore.

A total of 16 decomposing turtle carcasses were recorded during the field trip, of which 12 were identified as green turtles with curved carapace lengths (CCL) between 64 cm and 104 cm (Figure 2). Six were found on Fatuma Island near Assab, two at Bihta beach, near Beilul, and four on Rachmat peninsula, near Barasole (see Figure 1). Four other carcasses could not be identified. As all the turtles were decomposing, only carapace measurements were taken.

Local fishermen reported that over 250 dead turtles were washed ashore during a one-month period from early March to early April 2003. The number of turtles stranded may represent only approximately a quarter of the actual mortalities (Murphy & Hopkins-Murphy, 1989). The actual number of turtles killed may therefore be considerably higher. As the Eritrean coastline is so sparsely inhabited, the reported strandings may represent an even smaller fraction of the total actual mortalities. Furthermore, in the absence of strong onshore winds many floating carcasses may not have been washed onto the beach (Musick pers. comm.).

Reports from the fishermen interviewed indicated that dead turtles were being carried on currents from