# Green Turtle Diving and Foraging Patterns at Puako, Hawaii

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Puako, on the west coast of the Island of Hawaii (19°58.480' N, 155°50.650' W), is a 4.8 km stretch of submerged lava platform bordered by coral reef. The lava platform has large shallow areas of macroalgae providing substantial forage for green turtles, (*Chelonia mydas*). This area has been a study site of ours since the 1980's and nearly 200 green turtles have been tagged there (Balazs *et al.* 1998).

The primary food source for green turtles at Puako is an intertidal red alga, *Pterocladia capillacea*. The daily behavior patterns of juvenile and subadult green turtles in Hawaii have been studied by several investigators (Balazs 1980, 1981; Balazs *et al.* 1987; Brill *et al.* 1995; Laber and Waller 1994 and Rice *et al.* 2000). Green turtles spend most of their lives residing in coastal areas, where they alternate between periods of feeding and resting. Other studies have demonstrated long-term site fidelity of juvenile and subadult green turtles (Balazs, 1981; Laber and Waller, 1994), but information is limited about short-term movements and habitat use (Brill *et al.*, 1995). Detailed, long-term allocation of time to foraging versus resting behavior is still largely unknown. Our study involved determining the relative allocation of time spent foraging and resting, the distribution of these activities over the 24 hr day and the estimated home range of two subadult green turtles.

## Materials and Methods

Two subadult turtles were fitted with Wildlife Computer MK5 Time Depth Recorders (TDR) and Sonotronic CHP-87-L sonic tags. They were attached to the right third lateral scute (turtle T28) and the left third lateral scute (turtle T97) using silicon elastomer, fiberglass cloth and resin (Balazs *et al.* 1996). T28 had a straight carapace length (SCL) of 78.5 cm (65.9 kg) and T97 had an SCL of 64.4 cm (36.4 kg). T28 and T97 were each recaptured on four different occasions. Data were downloaded in the field using the Wildlife Computer's interface hardware and a Macintosh Powerbook. The length of time between downloads was dependent on our ability to capture the animal. The MK5 sampling protocol was set to record depth every minute and temperature every 3 minutes. Sampling was suspended if the TDR was dry (emergent) with time recorded. The data were graphed using Microsoft Excel.

## Results and Discussion

There were 55 visual observations made at the capture site during the study and presence/absence of the subject turtles was noted each time. In addition, there were reports of sightings of both turtles by scuba divers in the area (N=10). These observations were used to compare observed behavior with TDR data and helped us to define resting versus foraging behavior (**Fig. 1**).

Turtles T28 and T97 where monitored for 6 and 13 months respectively, and we obtained 77 full days of diving data from T28 and 187 days from T97. The two behaviors that show up relatively clearly are resting behavior and foraging behavior. Foraging is characterized by shorter dive times in shallower water (<10 min., <2 m) and resting in deeper water for longer periods of time (>10 min., >2 m) (Rice *et al.*, 2000). Diurnal and nocturnal behaviors were analyzed. Daytime was defined as 0600 to 1915 hr. One set of data from each turtle was corrupted and found unusable.

## Resting Dives

Resting dives showed a square profile (**Fig. 1**). The average number of resting dives in 24 hours was 11 for T28 and 18 for T97. Average dive length was 44 and 24 min,

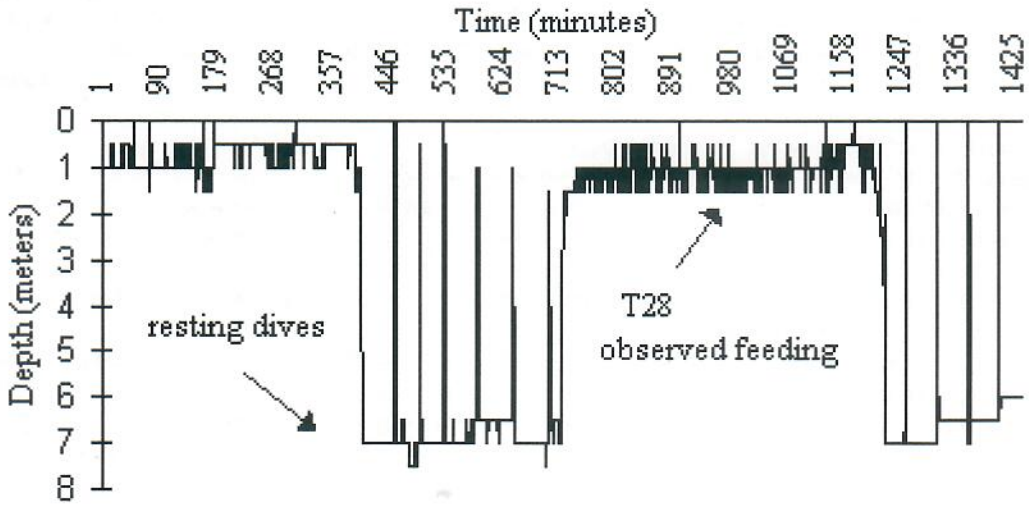


**Figure 1.** A 24 hr graph of the diving behavior of T28 starting at 0 hr

respectively. The maximum dive time was 75 min (T28) and 72 min (T97). The average amount of time spent on resting dives during a 24 hr period was 10 hr and 5 hr respectively. The maximum dive depth was 16 m (T28) and 40 m (T97). The unusually deep dive for 11 min to a depth of 40 m made by T97 is the deepest dive we have recorded on any TDR tagged green turtle in Hawaii. Other deep dives made by T97 were to 23, 30 and 31 m.

The resting dive data for T97 may be unusually low because this animal spent 30 full days (24 hr periods) out of 182 data days in water less than 2 m deep. None of this time was counted as resting time because we were unable to distinguish between foraging and resting dive profiles in water this shallow.

**Foraging Behavior**

T28 spent an average of 8.2 hr exhibiting foraging behavior during the day and 6 hr at night. This represents a significant difference ($P<0.01$). Turtle T97 spent an average of 9.6 hr exhibiting foraging behavior during the day and 9.4 hr at night. There is no significant difference between these two lengths of time ($P>0.5$). Again, the shallow water behavior of T97 may have had a significant impact on these values.

**Basking Behavior**

There was one incident of terrestrial emergence (basking) behavior. T97 spent 5.5 hours basking on 1/28/97 from 1609 hr to 2136 hr. This was the only time that the TDR data indicated dry conditions. Since the early 1990's, basking behavior by juvenile and subadult green turtles along the west coast of the Island of Hawaii has been on the increase.

**Probable Home Ranges**

The two turtles at Puako exhibited very predictable behavior over the course of the study. They were observed a total of 40 times feeding at the original capture site. They were seen only within approximately 1 km north or south of their original capture site. Since they feed predominantly in shallow water, their estimated feeding area is approximately 20,000 $m^2$ (assuming uniform distribution of forage and a 10 m wide algal growth band). Our turtles had a fairly small home range compared to those in the Kaneohe Bay study where study animals traveled a maximum of 3,000 m from the capture site (Brill *et al.* 1995). The size of the home range of the Puako turtles may also be a function of the distance between forage and resting areas. At Puako, this is only about 300 m. Although it was not studied, forage availability would be an important parameter in determining home range also.

**Time Allocation**

T28's and T97's diel patterns appear to be quite different from those of a turtle studied at Punalu'u, Hawaii using the same TDR technology (Rice *et al.* 2000). In the Punalu'u study there was a more marked diurnal feeding behavior than in the Puako study, and the total amount of time spent at foraging depths was greater for the Puako turtles. Mitigating circumstances at Puako may help explain the differences. Puako is a very protected area in the lee of the island. The shallow areas where the turtles feed at Puako are very calm and turtles could spend large amounts of time in the area resting, expending little energy. Conversely, Punalu'u is a high wave energy site which is rarely calm and turtles probably cannot rest in the shallow waters. In addition, the growth of macroalgae forage at Punalu'u, although unquantified, appears to be greater than that at Puako. This would potentially necessitate greater forage time to accumulate the same caloric value of macroalgae at Puako.

Both Puako and Punalu'u turtles appear to show strong site fidelity and a propensity to forage during the daylight hours in shallow waters. The home ranges of all three turtles are probably a function of the distance between their offshore resting site and their near shore forage pastures which direct observations have revealed to be within approximately 300 m at Puako and 500 m at Punalu'u.

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