DIEL BEHAVIOR OF TWO ADULT BASKING TURTLES AT LANIAKEA, HAWAII

INTRODUCTION

Green turtles (*Chelonia mydas*) found in Hawaii primarily belong to a metapopulation that is genetically different from green turtles found elsewhere in the Pacific (Balazs & Chaloupka 2004). One unique behavior of members of this Metapopulation is terrestrial basking, which is unknown in other populations except for occasional basking in the Galápagos, and the Gulf of Carpentaria in Australia (Balazs & Chaloupka 2004). Also there has been a notable increase of basking in the main Hawaiian Islands since 1994 (Rice et al. 2002). Theorists have proposed several possible explanations for basking. Some of the more popular theories are energy conservation (Swimmer & Balazs 2000; Whittow & Balazs 1985), reduced exposure to marine predation (Green, 1998), and thermoregulation (Spotila & Standora, 1985). Basking behavior is most likely exhibited for a combination of reasons and is, for unknown reasons, notably more common in the Hawaiian Islands.

Since 1998, adult green turtles have basked at Laniakea, a white sand beach on the North Shore of Oahu (21° 6'N, 158° 10'W). It is a popular surf spot and frequently visited by tourists and locals. Juveniles and adult are turtles present in the area, but only adults bask on the beach, seemingly, unaffected by humans (fig 1). Motto-tool numbers were lightly etched into the carapaces of basking turtles to aid in individual identification. In 2003 a remote controlled video camera was placed at the site to allow continuous monitoring of basking behavior. Over the last decade or so dive computers often termed Time Depth Recorders (TDR's), have provided a considerably large amount of information about dive profiles and surfacing intervals of marine animals (Hays et al. 2004). In October 2003 TDR's were attached on habitual baskers that had been previously captured and tagged. This paper analyzes data collected from two male habitual baskers at Laniakea that were fitted with TDR's. The aim of this paper is to analyze the basking and resting behavior of these adult turtles and compare it with the behavior of two sub-adult turtles of unknown gender from Kiholo Bay studied in 2002 (Quaintance et al. 2003).

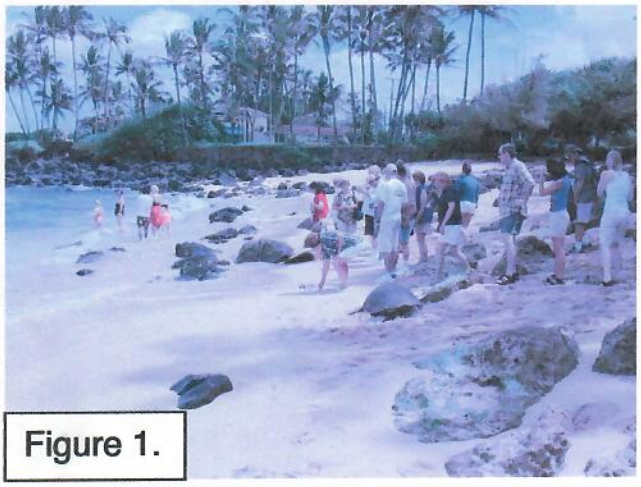


Figure 1.

Kiholo Bay lagoon is approximately 150 miles SSE of Laniakea on the Big Island's Kona/Kohala coast, at 19° 52'N, 155° 55'W. Researchers have observed sub-adults to juvenile turtles basking in Kiholo since 1994 (Quaintance et al. 2003). The shoreline of the lagoon consists primarily of basaltic rock and consolidated pahoehoe lava. The south shore, which separates most of the lagoon from the ocean, is made of rounded basaltic rocks, with a small gravel beach called "Turtle Beach". Turtles in Kiholo unlike Laniakea choose to bask on the gravel beach even though there is sand nearby and if they are approached they return to the water. Also there seems to be less food available at Kiholo, which may by limiting the population's growth. Food at Laniakea appears to be more abundant. The turtle were observed in similar was to the turtles at Laniakea with motto-tool numbers and remote controlled video cameras (Quaintance, In press).

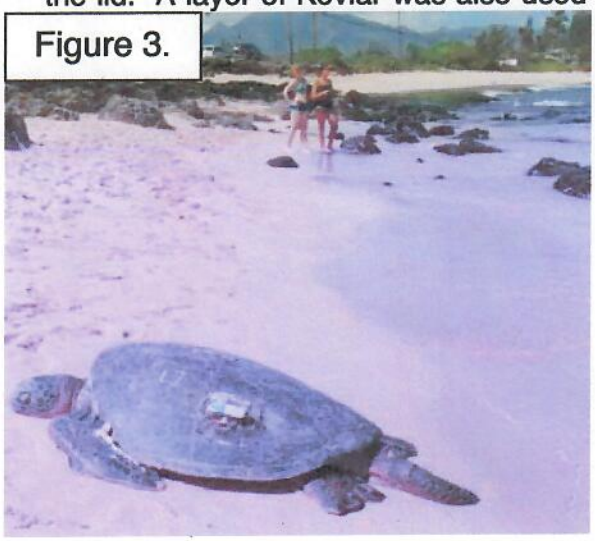
Figure 2. 67x17x17mm.

MATERIALS & METHODS

Motto-tool numbers were used to identify habitual baskers; they were labeled with "L" for Laniakea then consecutive numbers. L1 and L7 were fitted with a MK7 and a MK9 respectively (fig 2) because of their habitual basking behavior. The TDR's were programmed to record depth, temperature, and resistance (only on the MK9) every minute. Temperature recorded is external or ambient environmental temperature.

The TDR's were attached to each turtle's carapace with layers of fiberglass on the 2nd lateral scute (fig 3). A PVC box with a removable lid served as the container for the TDR. The TDR could easily be exchanged (removed) by taking the lid off, removing the TDR, placing a new TDR in the case and reattaching the lid. A layer of Kevlar was also used on the outside for added protection. A more detailed description of attachment procedure can be found in Rice et al (2000). This method of attachment has been used in several other studies and has been found to be very safe and secure (Glen et al. 2001, Quaintance et al. 2003, Rice et al 2000).

Figure 3.

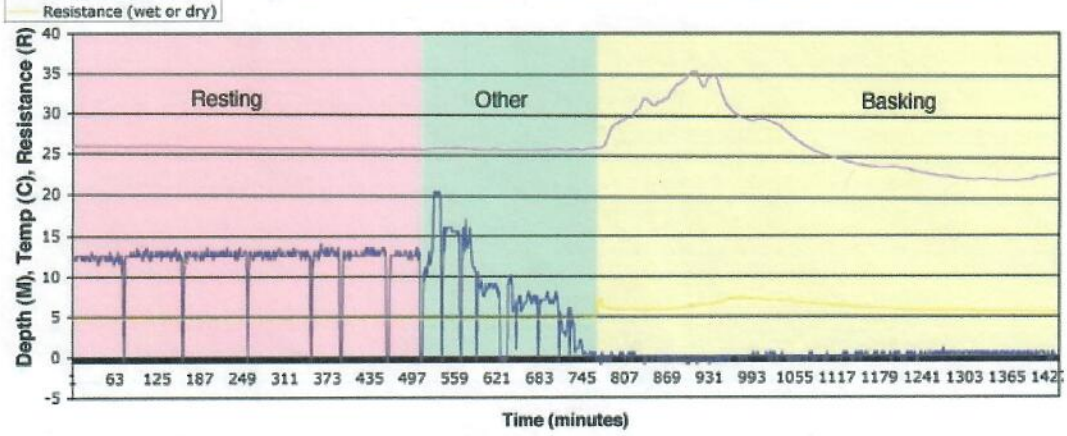


The data examined in this paper runs from December 28, 2003 to March 3, 2004 or 70 days for L1 and October 1, 2003 to February 27, 2004 or 155

days for L7. This data was recorded when the TDR's were attached until just before they left Laniakea to migrate to the French Fidget Shoals.

Behaviors were divided into three categories basking, resting, and other. In previous papers a foraging category was used (Quaintance et al. 2003) but because these turtles showed deeper non-resting dives that could have been foraging they were included in the same category rather than creating a new one. Behaviors were defined as follows; *Basking* behavior was indicated by a change of the conductivity reading in conjunction with an increase or decrease of 3 or more degree's in temperature for more than 10 minutes at a depth of 0-3m. *Resting* behavior was characterized by flat bottom dives deeper than 3 meters, more than 20 minutes long, and bottom depths varying no more than 3 meters during 90% or more of the dive. *Other* or feeding, diving and non-resting/basking behavior (fig 4).

Figure 4. L7 November 16, 2003; *Resting,Other and Basking*

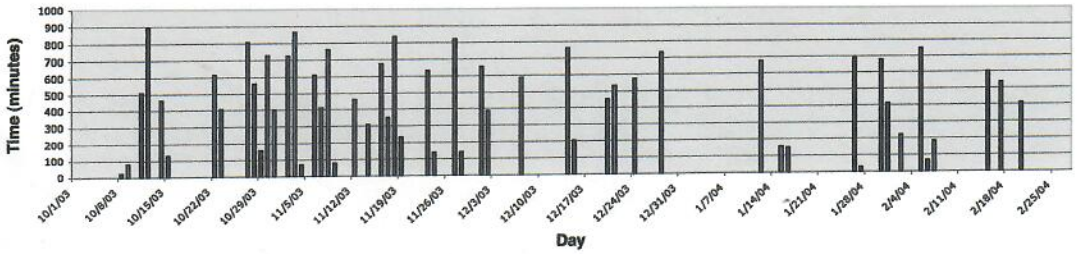


Basking behavior could result in a decrease in temperature if the animal hauled out in the evening, night or when there were high winds. Normally once the turtle's temperature was below ocean temperature it would shortly return to the water.

RESULTS

Out of 155 days L7 spent a total of 55% resting, 11% basking and 32% doing other behaviors. On 53 of those 155 days L7 hauled out to bask during some part of the day to bask, the maximum duration was 15 hours during 3 episodes in the same day. Figures 5 and 6 show the frequency of basking days.

Figure 5. L7 Basking Frequency over 155 days



Out of 70 days L1 spent a total of 11% of the time resting, 17% basking and 72% doing "other" behaviors. On 38 of those 70 days he hauled out during some part of the day to bask, the maximum duration per day was 13.5 hours during one episode (fig 6).

Figure 6. L1 Basking Frequency over 70 days

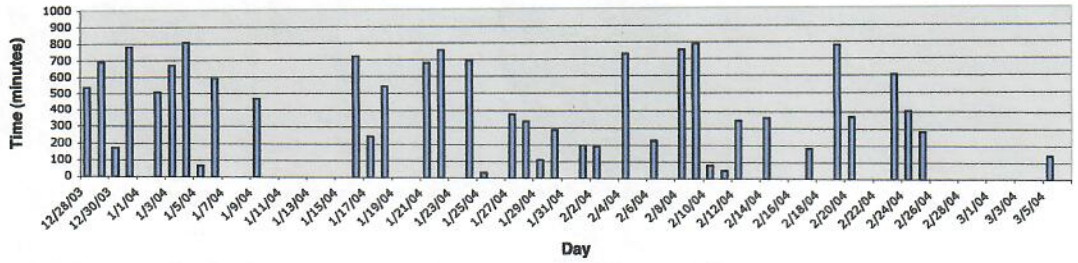
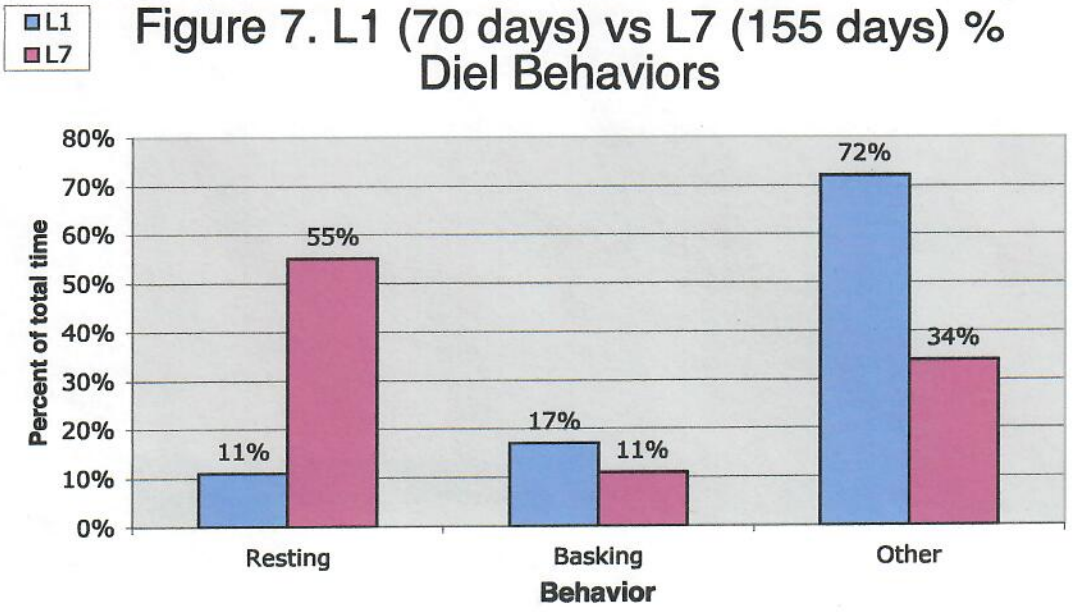


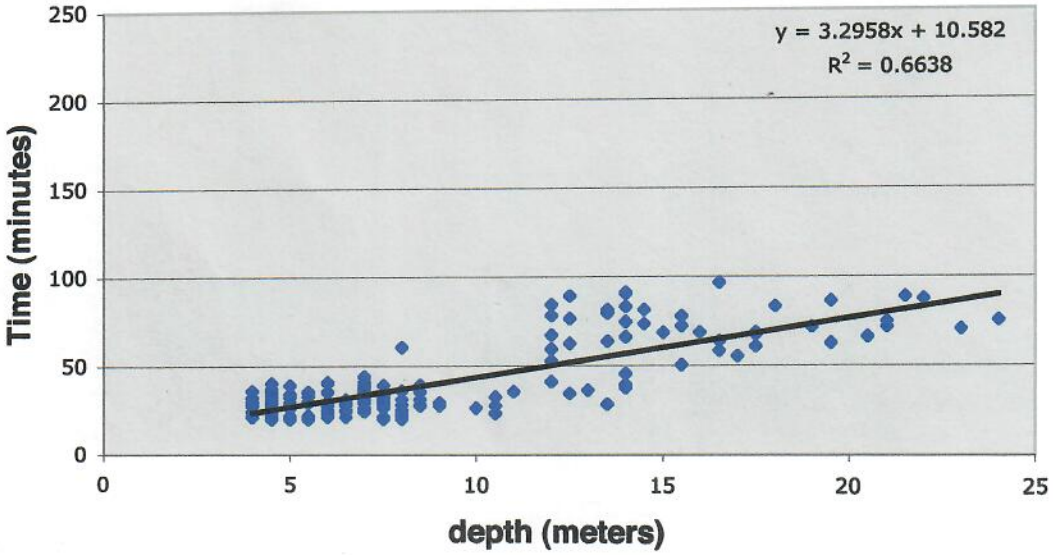
Figure 7 compares the amount of time each turtle spent doing "resting", "basking" and "other" behaviors. Resting dive duration was compared with the dive depth.



L7 made 1,652 resting dives with a maximum duration of 202 minutes, and L1 made 225 resting dives with a maximum duration of 96 minutes. 97% and 99% of resting dives for L7 and L1 respectively were above 20 meters.

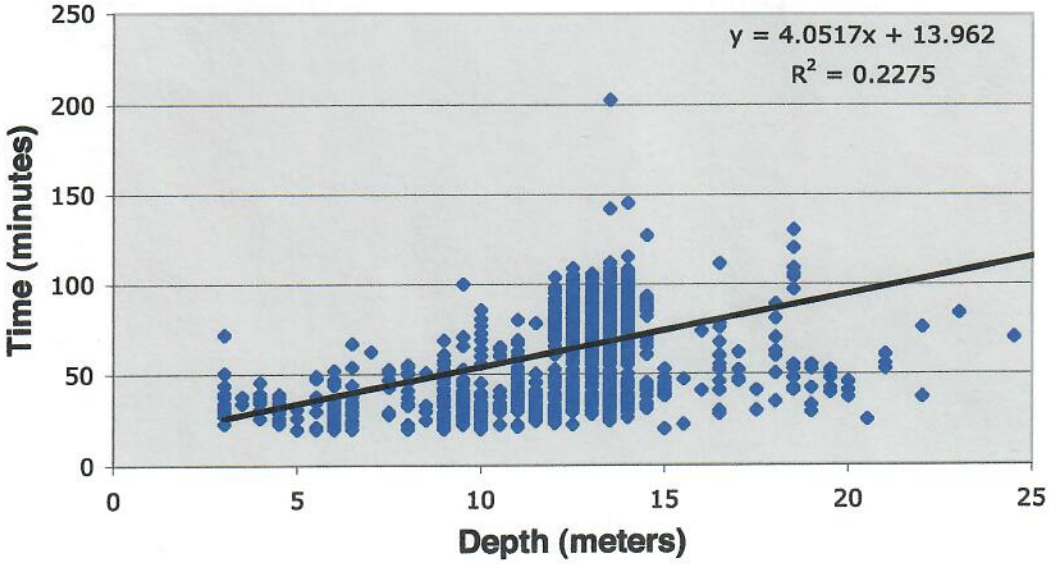
Figures 8 & 9 show the relationship for L1 and L7 respectively between the average depth of each resting dive and duration of the dive.

Figure 8. L1 Depth vs Time, 70 days



L1 shows a high correlation because r=0.814 or depth correctly predicts duration 81% of the time.

Figure 9. L7 Depth vs Time, 155 days



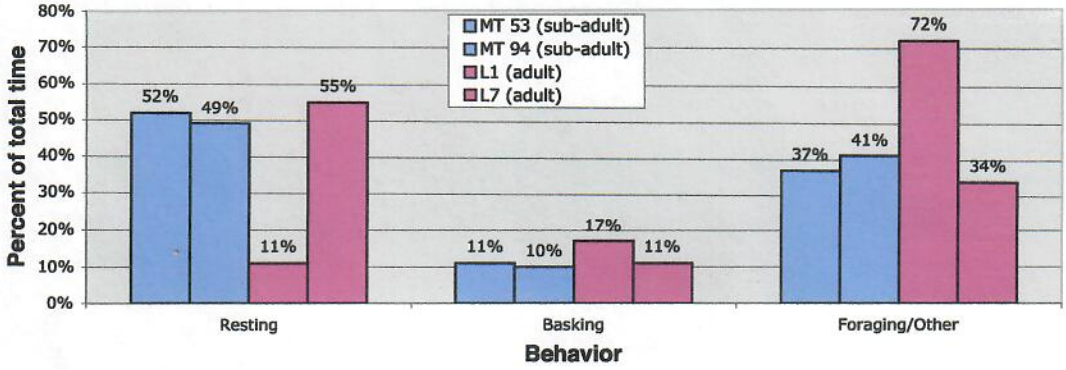
L7 does not show a good correlation with r=0.5 depth predicts duration only half of the time.

DISCUSSION

L1 had a very strong, positive correlation between resting dive duration and depth, r=0.81. The deeper his resting dives got the longer he rested. However, it is important to note that there is a cluster of points from 4-6 meters that could be acting as one point and throwing the r-value off. Though, this positive correlation has been found by other studies (Hays et al. 2001). Hays also argued that with a full breath of air a turtle would become negatively buoyant deeper than 20 meters. The data from these turtles supports that thought since 97% of the time, the turtles were above 20 meters. The few times that L1 and L7 did rest deeper than 20 meters can be explained by resting on a shelf at that depth.

Figure 10 compares two sub-adult green turtles from Kiholo Bay Lagoon (Quaintance et al. 2002) and the two adult turtles from this study.

Figure 10. Kiholo Sub-adults vs Laniakea Adults Diel Behavior



There are no distinct differences besides L1's resting and other behaviors. It is most likely that much of L1's resting behavior was somehow masked by what seemed to be other behavior.

Figures 5 and 6 show that basking was slightly clumped in groups of several days of basking followed by several days of other activities. This would suggest a multiple day cycle of resting and basking or other active behavior. These cycles could be driven by environmental influences such as tides, surf, clouds and/or human impact. All basking episodes were initiated during the day and often extended into the night. This would suggest that thermoregulation and the warming effect of basking is a crucial benefit of basking.

It would be interesting to gather resting dive depth and duration data to more strongly support the correlation. There were also deeper migration dives during each turtle's migration that would make a fascinating comparison. Also, it might be good to look at basking initiation times and durations to see if there are any patterns.

There were no significant differences between the sub-adult turtles of Kiholo and adult turtles of Laniakea. This suggests that reasons for basking are similar to green turtles of all stages of development. This is interesting because the biggest difference between sub-adult and adult turtles is size, in fact that is what it is defined by, and it would seem that basking would affect different sized turtles in different ways. For example, it would take longer for the internal body temperature of a large adult turtle to heat up than it would for a small sub-adult. Because this size difference doesn't seem to make a difference, it would seem that there is another simpler reason of basking common to both stages of development.

AKNOWLEDGEMENTS

I would like to thank George Balazs from the National Marine Fisheries Service for providing data used for the Laniakea turtles as well as his mentoring throughout the project. I would also like to thank Marc Rice from the Hawaii Preparatory Academy for providing most of the pictures seen in this paper as well as his continued guidance and mentoring throughout the project. Lastly, I would like to thank David Booth and the University of Queensland for allowing me to do this summer project.

REFERENCES

Balazs, GH & M Chaloukpa 2004, "Thirty-year recovery trend in the once depleted Hawaiian green sea turtle stock," *Biological Conservation*, 117:491-498.

Glen, F, AC Broderick, BJ Godley & JD Metcalfe 2001, " Dive angles for a green turtle (*Chelonia mydas*)," Marine Biology Association UK, 18:683-686.

Green, D 1998. "Basking in Galapagos green turtles," In: SP Epperly & J Braun, comps, *Proceedings of the 17th Annual Symposium on Sea Turtle Biology and Conservation,* NOAA Tech, Memo, NMFS-SEFSC-415, pp. 60-62.

Hays, GC, S Akesson, AC Broderick, F Glen, BJ Gogley, P Luschi, C Martin, JD Metcalfe & F Papi 2001, "The diving behaviour of green turtles undertaking oceanic migration to and from Asention Island: dive durations, dive profiles and depth distribution," *The Journal of Experimental Biology*, 204:4093-4098.

Hays, GC, JD Metcalfe, AW Walne & RP Wilson 2004, "First records of flipper beat frequency during sea turtle diving," *Journal of Experimental Marine Biology and Ecology,* 303:243-260.

Quaintance, JK, M Rice & GH Balazs In Press, "Monitoring turtle basking behavior with remote cameras," In: M Coyne, comp, *Proceedings of the 21st*

Annual Symposium on Sea Turtle Biology and Conservation," Philadelphia PA, USA.

Quaintance, JK, MR Rice & GH Balazs 2002, "Basking, foraging, and resting behavior of two sub-adult green turtles in Kiholo Bay Lagoon, Hawaii," *Proceeding of the 22nd Annual Symposium on Sea Turtle Biology and Conservation*, NOAA Tech, Miami Florida USA, pp. 225-226.

Rice, M, GH Balazs, D Kopera & C Whittow 2002, "Ecology and behavior of green turtles basking at Kiholo Bay, Hawaii," In: A Mosier, A Foley & B Brost, comps. *Proceedings of the 20th Annual Symposium on Sea Turtle Biology and Conservation*. NOAA Tech. Memo. NMFS-SEFSC-477.

Spotila, JR & EA Standora 1985, "Environmental constraints on the thermal energetics of sea turtles," *Copeia*, pp. 694-702.

Swimmer, JY & GH Balazs 2000, "The biology of basking in the green turtle *(Chelonia mydas)*. In: FA Abreu-Grobois, R Briseño-Duenas, R Márquez-Millán & AL Sarti-Martínez, comps. *Proceedings of the 18th Annual Symposium on Sea Turtle Biology and Conservation*, NOAA Tech, Memo NMFS-SEFSC-436, pp. 233-234.

Whittow, GC & GH Balazs 1985, "Basking behavior of the Hawaiian green turtle *(Chelonia mydas)*," *Pacific Science*, 36:129-139.