

George,
Thank you
so much for
all your help &
love & advice

**AN ECOLOGICAL ASSESSMENT OF GREEN TURTLES
(*CHELONIA MYDAS*) IN COASTAL FORAGING AND RESTING
HABITATS OF HANAUMA BAY AND WAWAMALU, OAHU,
HAWAIIAN ISLANDS, USA.**

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ABSTRACT

Beach and snorkeling observations were conducted during three months in Hanauma Bay and Wawamalu, both located on the southeast coast of Oahu, in order to make an ecological assessment of the green turtle (*Chelonia mydas*). The ecological assessment had two main purposes. First, on Oahu, many of the areas inhabited by turtles have previously not been investigated. Second, Oahu is a very populated island, and turtles and humans interact every day. Some of these interactions are benign, others are not. To see what impact the presence of humans has on the turtles in Hanauma Bay (visited by an average of 3200 people a day), this area was compared to Wawamalu, a relatively deserted area. Also, Hanauma Bay was compared on open versus closed days. The results clearly indicate that the turtles in Hanauma Bay have a different behavior than the turtles in Wawamalu. Turtles in Wawamalu are more reclusive than most of the Hanauma Bay turtles. More turtles were spotted in Hanauma Bay on Tuesdays, when the park is closed, than on other days, and the turtles also swam around more freely. Hanauma Bay is clearly separated into feeding areas and resting areas, while in Wawamalu the same area is used for both feeding and resting. Waves, tides, and the time of the day did not have an observable impact on the behavior of the turtles. The turtles in the two areas are healthy and well fed. Few turtles were afflicted by fibropapillomatosis. Stranding data collected during the last 18 years shows that most stranded turtles in the area were entangled in nets or fishing lines, or had spear wounds. Few turtles that stranded had any tumors. This shows that the biggest threat to the turtles in the area is not fibropapillomatosis, but sport fishing.

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INTRODUCTION

The Hawaiian green turtle (*Chelonia mydas*) is a herbivore that spends most of its life foraging and resting in nearshore benthic habitats (Balazs *et. al.*, 1987). The turtles mainly eat benthic algae and sea grasses (Brill *et. al.*, 1995). At least 90 % of all reproduction by green turtles in Hawaii takes place at French Frigate Shoals, in the Northwestern Hawaiian Islands. Adult females migrate to breed every second year or more, while adult males often migrate once a year. The breeding season lasts from May until August. After the hatchlings leave the nest, they immediately swim out in the pelagic where they stay for at least 2 years. Not much is known about the green turtles stay in the pelagic zone, but they are thought to live at or near the ocean surface in convergent zones. In convergent zones various macroplankton concentrations are found that might serve as a food source for the green turtle.

When the turtles are about 35 cm, they return to nearshore habitats from the pelagic (Balazs *et. al.*, 1987).

The Hawaiian green turtles can be affected by fibropapillomatosis (FP), a neoplastic disease (Herbst, 1994 a), that was first documented in Hawaii in 1958 (Balazs, 1991).

Fibropapillomatosis has a global distribution and exists in the Atlantic Ocean, Indo-Pacific region, Pacific Ocean, and the Caribbean Sea (Balazs, 1991; Ehrhart, 1991; Herbst, 1994 b; Williams *et. al.* 1994; Work *et al.* 1999). The disease is characterized by epithelial fibropapillomas and internal fibromas (Lucke, 1938; Smith and Coates, 1938), and the tumors are found on the skin, eyes, oral cavity, carapace and in visceral organs (Harshbarger, 1991; Jacobson *et. al.*, 1989; Lucke, 1938; Norton *et.al.*, 1990). The tumors are benign, but the disease can still be life threatening since growth of tumors affect locomotion, vision, swallowing, and breathing. Visceral fibromas can also affect organ function (Herbst, 1994 b). The disease seems to be associated with near shore bays that are located in areas with agricultural and urban development (Balazs, 1991; Erhart, 1991). Since 1978, the Hawaiian green turtle has been listed and protected under the U.S. Endangered Species Act (Balazs, 1987).

Numerous sites on Oahu important for turtles have never been investigated before, and an ecological assessment of the turtles in those areas is needed. The objectives with this study were twofold. First, to make an ecological assessment of the turtles in two previously not investigated areas and second, to see how the presence of humans affects the turtles' behavior. The green turtle population in Hawaii has increased over the past 15-20 years. During the same period of time, the turtles' behavior has changed significantly. The turtles on Oahu accept the presence of humans in a way that is not documented anywhere else in the world. Oahu is very populated, and many tourists come to visit the island. An ecological assessment of areas used by both turtles and humans is therefore needed so that both parts can use the same areas without one species getting the worst of it.

For this study, two areas on the same coastline (and therefore with similar conditions) were chosen. Hanauma Bay, with many people visiting every day, was compared to Wawamalu, a fairly deserted area, to see if any differences in the turtles' behavior could be detected. Also, tides, waves, and the times of the day were investigated to determine their impact on the turtles' behavior. The two study sites are located in a fairly undeveloped part of Oahu. Since fibropapillomatosis seems to be associated with developed areas, stranding data from the study sites and the surrounding area was used to see if there were any correlations between the cause of the strandings and the nature of the area.

Hanauma Bay

Hanauma Bay is a nature preserve located at the southeast coast of Oahu, Hawaii, lat. 21° 16.391'N, long. 157°41.729'W (Figure 1 and Appendix IV). The bay is visited by an average of 3200 guests a day, and about 1 million guests a year. Every Tuesday the park is closed for maintenance (Hong, 2000, oral information). The inner area of the bay is protected by a shallow fringing reef that lies just offshore. The reef serves as a barrier for the waves and currents from the outer part of the bay, and makes the inner area very calm (Clark, 1977). The bay is a compound volcanic crater that erupted 30,000 to 40,000 years ago. In the precontact days, Hawaiians used Hanauma Bay as a launching and landing point for their interislands canoe trips. In the mid 1800s, the bay was also considered a favorite fishing place for King Kamehameha V (Hanauma Bay, Education Center, Hawaii Sea Grant Extension Service, 2000, oral information). The bay has also always been a popular area for divers, throw-netters and shore-casters. (Clark, 1977). In 1928, Hanauma Bay was given to the City and County of Honolulu by the Bishop Estate for use as a recreational park. In 1967, the bay became Hawaii's first Marine Life Conservation District. When that occurred, fishing and collecting were prohibited in Hanauma Bay. Until 1999, fish feeding was allowed in the park but after 1999, fish feeding was prohibited (Hanauma Bay, Education Center, Hawaii Sea Grant Extension Service, 2000, oral information).

Wawamalu

Wawamalu is a relatively deserted area, used by few people as a recreational area. Wawamalu is located on the southeast coast of Oahu, lat. 21° 17.625'N, long. 157° 39.647 W, about 2.5 miles away from Hanauma Bay (Figure 1 and Appendix V). The water is used by fishermen, and some surfers surf the break right outside the area, but other than that the water is undisturbed. The area is connected with the Kalama stream coming down through the nearby golf course. The stream is mostly dried out, and does not affect the salinity in the area except possibly during heavy rains. The study site is an partly enclosed pool, where only the outer part is affected by waves. The study site is easily recognised by the old abandoned bridge called Wawamalu, that overlies the Kalama stream. The area is also called Kaloko (personal observations).

Before 1800, there was an old farming village called Wawamalu in the area. By the beginning of the twentieth century, the village had dissapeared. In the 1930's there was a farm called Wawamalu Ranch in the area, but in 1946 the farm was destroyed by a tsunami (Clark, 1977).

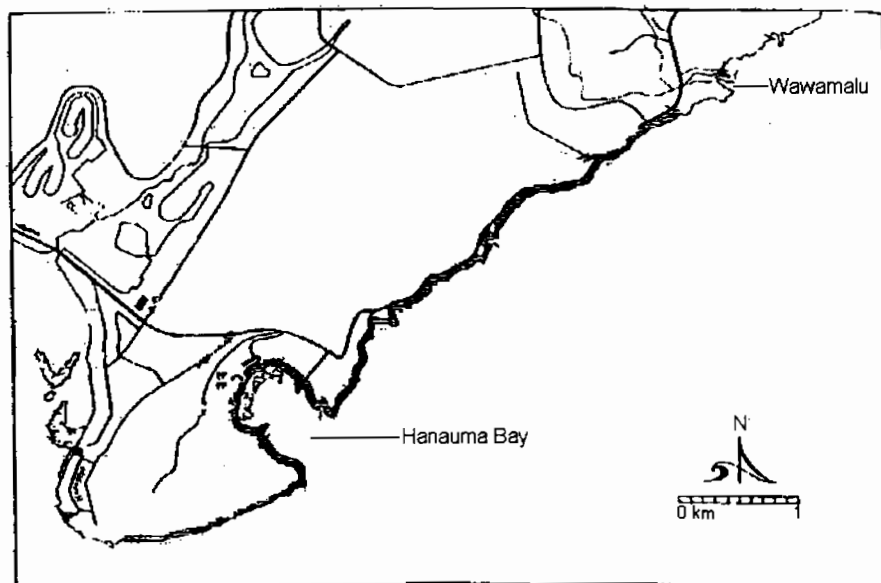
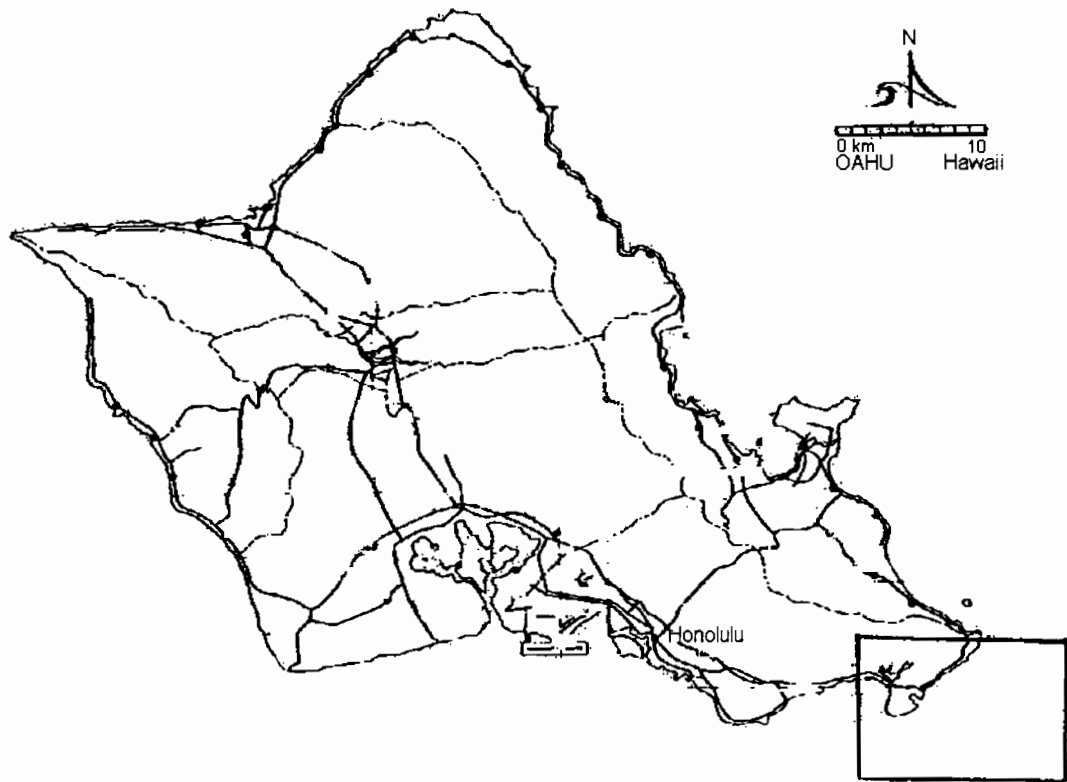


Figure 1. Map of Oahu, and the study area (Clark, 1977).

METHODS

Wawamalu

For the tagging of the turtles in Wawamalu, two nets were put up in the middle part of the area (figure 2). The nets were 100 X 8 m and 150 X 5 m long, and reached both shorelines and the bottom. Each net was observed all the time. If a turtle was caught in a net, it was retrieved immediately, placed on its back onto an inner tube and brought to shore where it was put under a tarp to make it calm.

One net was pulled from the oceanside towards net # 2. Then another net was pulled from the left side to net # 1. When possible turtles were also hand captured. After the pulling of the two nets, the captured turtles were tagged, measured, and blood samples were taken. Food samples were also taken when possible. The blood samples taken were not for this study, but are to be used in other studies. A speculum was used to open the mouth for oral examination to collect food samples and check for injuries, tumors, fish hooks and leeches. Tagging was done in two ways. Flippers were checked for pit tags with a pit tag reader (AVID Power Tracker II Reader). If no tags were found, pit tags (125 KHZ 11.5 mm presterilized pit tags) were placed in both hind flippers. Numbers were also harmlessly engraved (1-2 mm deep) into a carapace scute with a moto-tool (Dremel 58). White paint was applied in the inscription (Balazs, 1995). After all the data were collected, the turtles were released outside the enclosed area.

After release of the first captured turtles, net # 1 was pulled towards net # 2. People were spread out along the net to make sure that the net did not get stuck on the bottom and for a quick untangling of any captured turtles. Again, captured turtles were placed onto an inner tube and brought to shore where they were put under a tarp. The new turtles were also measured and tagged. Blood and food samples were also taken. Turtles were released after all necessary data were collected.

Tagging of the turtles in Wawamalu was conducted on 01-06-00, 03-14-00, and 04-21-00, all three times the same methodology was used. On 04-21-00, surfwax was applied on top of the engraved marks as an attempt to prevent algae growth within the inscription. All new captured turtles also got a mark in the front of the carapace for easier identification. Marks in the front of the carapace were also put on 5 of the turtles on 03-14-00. In total, 17 turtles were marked, from number 1-17.

Hanauma Bay

On 04-25-00 the turtles in Hanauma Bay were hand-captured through snorkeling. The water was searched from the left side to the right side of the bay by five snorkelers. When a turtle was spotted, it was captured by hand, placed on its back onto an inner tube and brought to shore by one or two of the snorkelers. Only the inner part of the bay (inside the reefbreak) was searched. When on shore, the turtles were put under a tarp in the shade. When the inner area was searched for turtles, one person went up on "the wall" and looked for more turtles. When a turtle was spotted, snorkelers went back in the water and caught them.

The captured turtles were tagged, and measurements were taken. Food samples were taken when possible. The turtles were tagged with pit tags, and numbers were engraved in the carapace scute. Again, an Avid Power Tracker II Reader was used to search the flippers for pit tags and 125 KHZ 11.5 mm presterilized pit tags were used if needed. When all the data were collected, the turtles were released.

On 05-16-00, another tagging was performed in Hanauma Bay. Again the inner area was searched by snorkelers and the turtles were hand-captured. The outer area (outside reef break) was searched by scubadivers. When a turtle was found it was hand-captured and brought up to the surface where snorkelers swam the turtles back to shore on tubes. In total 17 turtles were marked in Hanauma Bay, numbered 18-34.

Observational Methodology

The two observation areas, Wawamalu and Hanauma Bay, were divided into sub-areas in order to make the observations easier. Wawamalu was divided into five areas and Hanauma Bay into five areas (Figures 2,3). Hanauma Bay is a very large bay and it is almost impossible for one person to investigate the whole area. It is also hard to get access to parts of the bay because of currents and waves. Therefore the areas that were investigated in Hanauma Bay were chosen from where people said they mostly see turtles, personal observations, and from the accessibility and safety of the areas.

Both observation areas were visited at the same time on days following each other in order to get the environmental conditions as similar as possible. The observation areas were visited two to three times a week. Beach observations were made every time and snorkeling was only conducted if conditions allowed. Snorkeling was not possible in all sub-areas and were therefore only conducted where possible. The same days as the snorkeling were conducted, beach observations were also made. The day was divided into a morning, noon, and afternoon shift, where 8-11am = morning, 11-2pm = noon, and 2-5pm = afternoon. The observation sites were also visited at sunrise once.

Thirty minutes was spend at every sub-area with 10 minutes break in between every sub-area. The 30 minutes intervals were based on a study described in Brill et. al. 1995.

Turtles were counted, and size determined. If they had any tumors they were also recorded. The turtles behavior at the time of the spotting were also recorded, as was tide, winds, and waves.

After the marking of the turtles in Hanauma Bay the education center and the volunteers started to keep track of turtles spotted, marks, if any, location, and time of the observation. Observations were made by volunteers and employees of Hanauma Bay, and tourists visiting the bay.

Turtle feces collected were rinsed in fresh water through a 0.71 mm sieve and put in 10% formalin. Mouth samples were also put in 10% formalin. Feces and mouth samples were send to Dr. Dennis Russell at the American University of Sharjah, Sharjah, United Arab Emirates, for analysis.

Salinity was measured at both Wawamalu and Hanauma Bay.

When measured and size determined, the turtles were divided into different size ranges where turtles less than 61 cm were small, 61-83.8 cm medium and turtles larger than 84 cm were large.

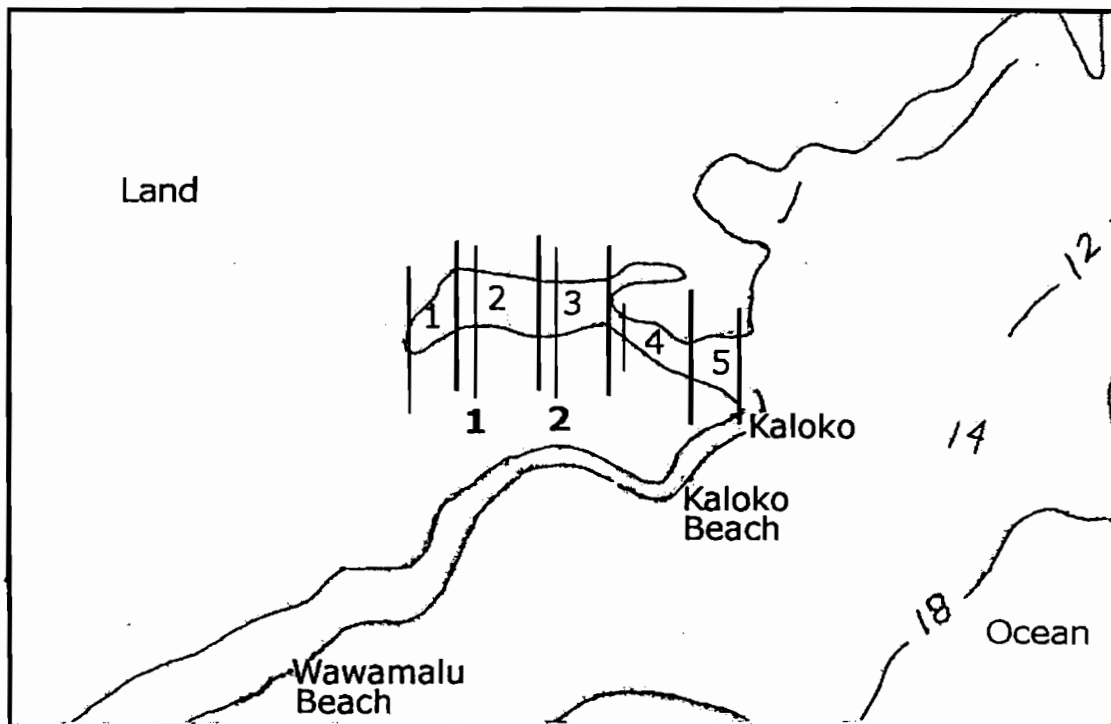


Figure 2. Map over Wawamalu (Clere, 1997).

——— Nets
 ——— Area sections

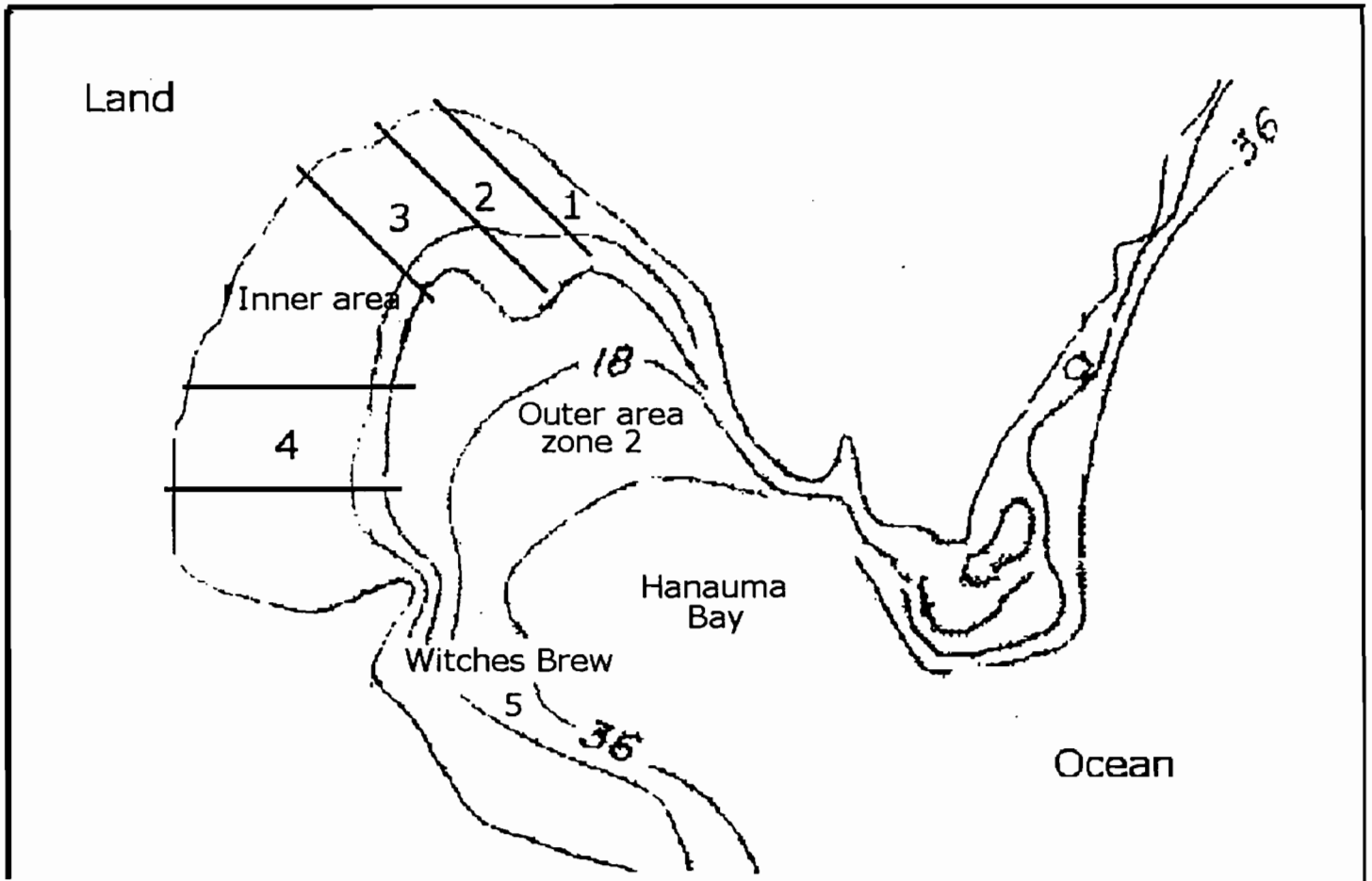


Figure 3. Map over Hanauma Bay (Clere, 1997).

- 1. Backdoor
- 3. Keyhole
- 4. Sandman's patch
- 5. Turtle beds

RESULTS

Turtles in Hanauma Bay normally ignored approaching or surrounding humans and kept feeding or swimming. However, if someone tried to grab the turtles, the turtles fled. A few turtles were observed swimming away when approached. In Wawamalu, the turtles immediately fled when approached.

In Wawamalu, none of the tagged turtles had any tumors. During the beach observations, no tumored turtles were spotted. In Hanauma Bay, one of the 17 tagged turtles was slightly afflicted with tumors. Also two tumored turtles were spotted during snorkel observations, both heavily afflicted with tumors.

Stranding data from 1982 until June 2000, collected by the National Marine Fisheries Service, Honolulu, showed that the largest threat to the turtles on the southeast shore of Oahu seems to come from getting entangled in nets or fishing lines, getting hooked on fishing hooks, or injured by spear fishers (Appendix II). In Hanauma Bay, Sandy Beach, Wawamalu, and Makapuu, all adjacent beaches, stranded turtles rarely had tumors and in most cases they were entangled in nets or fishing lines, or had spear holes. In Maunalua Bay, on the other hand, both tumors and nets/fishing-lines affected the turtles. Maunalua Bay is located immediately to the west of Hanauma Bay.

In Hanauma Bay, the majority of the turtles observed inside the reef were feeding. Only 3 turtles were observed resting inside the reef during the observation period. Swimming turtles were on their way in or out of the inner reef area, or swam in between different feeding areas (Figure 4). In Wawamalu, the behavior differed more, and the turtles seemed to use the area both for resting and feeding (Figure 5).

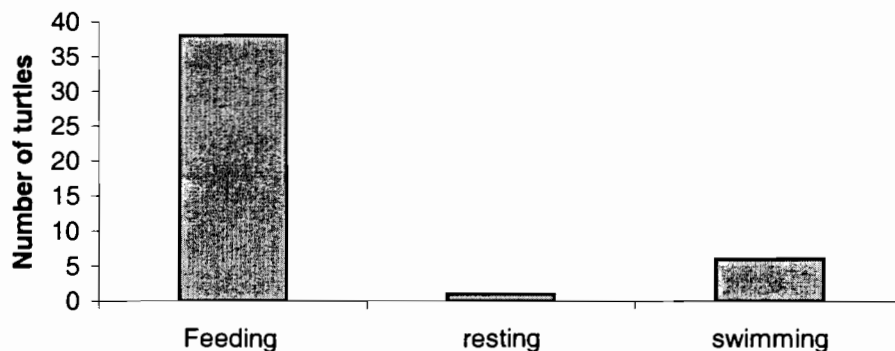


Figure 4. Behavior of the turtles in the inner part of Hanauma Bay.

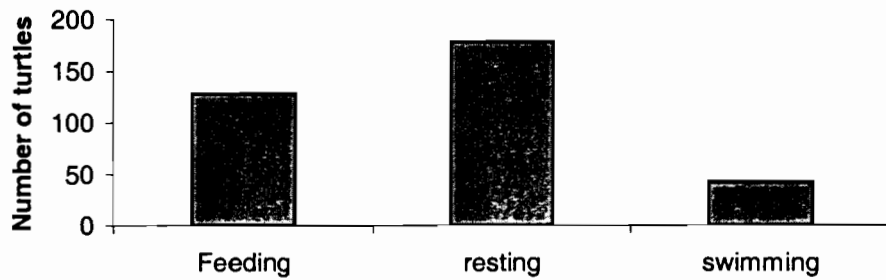


Figure 5. Behavior of the turtles in Wawamalu.

Mouth samples taken from turtles in Hanauma Bay all contained 100% *Melanamansia glomerata*. Feces samples taken from Wawamalu contained several different algae, where *Melanamansia glomerata*, *Cladophora sp.*, *Cladophora sericea*, *Codium edule*, *Sargassum sp.*, and an unidentified wiry gelid-like species dominated.

Seventeen turtles were caught and marked in Wawamalu (number 1-17). Resighting marked turtles in Wawamalu was hindered by low visibility in silty water.

Seventeen turtles were marked in Hanauma Bay (number 18-34), but at several occasions up to 7 unmarked turtles were spotted in the bay. Of all the turtles, only 7 seemed to visit the inner area on a regular basis (number 18,19,20,21,22,23,24). The turtles that visited the inner reef area preferred the deeper areas known as Backdoor, Keyhole, and Sandman's patch (Figure 3). A preference was also noted by the turtles for certain areas. The same turtles always fed in the same areas. Of the turtles captured by scuba diving outside the inner reef area only one (number 27) was spotted in the inner area although turtles caught inside the reef were often spotted in the outer area (Table 1).

Table 1. Total number of sightings in Hanauma Bay, 4/25-6/30/2000.

Number	Backdoor	Keyhole	Sandman's patch	Zone 2	Turtle beds	Witches Brew
18	4	12	7	3		
19	1	1		2	1	
20		1	3	2	1	3
21	1	14	7	7	1	1
22	3	4	4	9	1	4
23	2	7		1		
24	2	1	2	2	3	1
25	3			2	1	
26			1	8	2	2
27	2			1	1	3
28						
29				1	2	4
30						1
31						1
32				1	2	
33				6		4
34					5	3
not numbered	4		10	36	17	31

Statistical analyses used analysis of variance to determine the relationships between different environmental and physical factors recorded. PROC ANOVA was used for balanced data (SAS Institute, Inc., 1989a) and PROC GLM was used for unbalanced data (SAS Institute, Inc., 1989b). A Duncan-Waller multi-range test used in PROC ANOVA compared means in each group to determine which groups were significantly different at the alpha = 0.05 level. PROC GLM used least squares analysis with weighted means to determine significant difference between groups. Student's T-tests were also done for simple comparisons of means.

No interactions could be noted between tide, time, place, numbers, and size of the turtles ($p=0.1667$) (Appendix III, tables 6,7,8,9). Time and tide were not factors in the numbers and size of turtles spotted. More small turtles were seen than were others at both locations ($p = 0.0004$) (Appendix III, table 5). The small sized turtles dominated on the two observation sites, with 82.4% being small and 17.6% being medium sized in Hanauma Bay, and a 100% sample of small turtles being observed in Wawamalu. The winds and surfs effect on the turtles was also analyzed, but no interaction was noted (Appendix III, tables 3,4).

At sunrise a difference could be seen in the behavior of the turtles in Hanauma Bay. The turtles swam around for longer periods of time and also spent a longer time at the surface while breathing. In Wawamalu no difference could be detected.

The mean number of turtles observed was significantly greater when Hanauma Bay was closed versus when it was open, with a p value of 0.0019 (Appendix III, table 2). The turtles were also seen swimming around more in between feeding, and spent longer time at the surface on Tuesdays.

Salinity was measured in both Hanauma Bay and Wawamalu. Both areas had a salinity of 34 psu.

DISCUSSION

During the last 15-20 years the turtles on Oahu has become more and more tame. This is clearly observed in Hanauma Bay where the turtles feed unbothered by all the tourists surrounding them. Not all the turtles in the bay act tame though. It appears as if some of the turtles in the bay have made the inner part of the bay their feeding habitat and become accustomed to all the tourists. Those turtles spend a lot of time in the inner part of the bay and are spotted almost every day. Other turtles that come in only occasionally show another behavior. They are more reclusive, and swim away fast as soon as humans come close to them. The reclusive turtles were mostly ones that had not been captured during the study and were unmarked. In Wawamalu, where humans in the water is very rare the turtles show a more natural behavior. As soon as the turtles are approached by humans, the animals flee. It appears that some turtles have changed their behavior, becoming "tamer" or more tolerant to people, thorough repeated contact with humans.

At both study sites the turtles are healthy and well fed based on examination and observations of body condition. In Hanauma Bay, only three turtles were observed with tumors while none were observed with tumors in Wawamalu. This is a considerable difference from other parts of the island. In Maunalua Bay, located next to Hanauma Bay, many of the turtles are afflicted by tumors. Kaneohe Bay and the Kailua area turtles are also known for having a high frequency of fibropapillomatosis (Balazs, 1991, Borjesson, 2000, oral information). Earlier studies have shown that fibropapillomatosis appears to be common in areas with agricultural and urban development (Balazs, 1991). Maunalua Bay, Kaneohe Bay, and the Kailua area are all located in urban areas. Hanauma Bay and Wawamalu, on the other hand, are located on a part of the island that is fairly undeveloped.

Stranding data also support the fact that the turtles in the study areas are mostly unafflicted by fibropapillomatosis. Stranded turtles were in most cases entangled in fishing lines, nets or had spear wounds, and few had tumors. Turtle number 5 from Wawamalu was found dead in Wawamalu with a punctured neck, probably caused by a spear. This suggests that the biggest threat to the turtles on the southeast coast of Oahu comes from recreational fishing.

Of the 17 tagged turtles in Hanauma Bay only seven use the inner part of the bay on a regular basis. The turtles that were captured in the outer part of the bay have only been observed in that part of the bay. Only turtle number 27 was occasionally spotted inside the reef. In contrast, turtles that were caught and tagged in the inner area were also observed in the outer area. The turtles observed in the outer area were always resting, except for very close to the reef break where the turtles also feed. Since the turtles in the outer area do not feed in the inner area of the bay, there must be another feeding area. This feeding area is not known. Most likely it is inside the bay, or close to the bay, since resting habitats and feeding habitats tend to be close together. It would not be energetically efficient for the turtles to have feeding and resting areas far from each other.

In Hanauma Bay, the feeding and resting habitats are clearly distinguished. Feeding occurs inside the reef (and probably somewhere else too) while resting occurs in the so-called turtle beds located in the outer part of the bay. In Wawamalu, the turtles use the same area for both swimming and resting, with a preference for resting. One exception is the outer area, section number 5, where the turtles have only been observed foraging. The difference between the two areas is most likely because it is two different habitats with different environmental and physical characteristics. Why most turtles do not rest in the inner part of Hanauma Bay - even though the environment is suited for it - could be a result of the tourists. One of the turtles that was observed resting inside the reef was resting in a patch of reef close to the outside of the reef which was difficult to reach for snorkelers.

From mouth and fecal samples collected, it appears that the turtles in Hanauma Bay feed heavily on *Melamansia glomerata* while the turtles in Wawamalu have a more varied diet. The difference is probably due to the fact that very few algae grow in the inner part of Hanauma Bay, and that Wawamalu has a large variety of algae growing in the partly enclosed pool.

A total of 17 turtles were marked in Wawamalu. Several unmarked turtles were also spotted, but it is difficult to make an estimate of the total number of turtles in the area. The marks on the carapace of the turtles faded in a few weeks, and the numbers could therefore not be used in the study. Algae grew in the paint, and most turtles were covered with mud which made it impossible to read the numbers. Surf wax was applied on top of the marks in an attempt to prevent the algae from growing in the engravings, but the numbers were still covered after about two weeks. Also, the numbers were placed too far down on the carapace. The water in Wawamalu is very muddy and the numbers were therefore not readable from the surface.

In Hanauma Bay, there is an estimated total number of 25-30 turtles in the entire bay. This estimate is based on the 17 turtles that were marked, and the fact that up to seven unmarked turtles were spotted in the bay at least on three occasions. The number is very uncertain though, since few observations were done in the outer part of the bay.

In Hanauma Bay, the turtles in the inner part of the bay preferred the deeper areas. The deeper areas contain more food. The shallow areas are covered with reef and the top of the reef does not have much algae growing on it. Also, the deeper areas offer more protection. The same turtles were spotted in the same areas during the observation period, which indicates that the turtles have certain preferred feeding patches. This behavior was noted in both Wawamalu and in Hanauma Bay.

The interaction between tide, time, place, and the number of turtles spotted was investigated. The effect of waves and winds on the number of turtles was also examined. Statistical data show that no significant interaction could be found between tide, time, place, waves, winds, and the number of turtles. However, during the observation period, more turtles were usually spotted in Hanauma Bay early in the morning or late in the afternoon. Few, if any, turtles were spotted when extremely low tide occurred. The time did not allow for more observation days, but perhaps the statistics would show a different result if more data were available.

The two locations were also visited at sunrise once. In Hanauma Bay, six turtles were spotted. The turtles were swimming around much more freely in the open sandy areas than was observed later on in the day. The turtles also spent more time swimming in between their feeding, and spent more time up at the surface. In Wawamalu, no difference was noted compared to other times of the day.

The average number of turtles in Hanauma Bay was significantly greater on Tuesdays when the park was closed to the public than on other days. It is not known if the total number of turtles in the whole bay is larger on Tuesdays than compared to other days. The larger number of turtles was observed inside the inner reef, which is where most of the tourists are on days when the bay is open to the public. On Tuesdays, turtles were also observed swimming around more in between feeding, and staying up at the surface longer when breathing. Clearly the tourists' presence in the bay has an impact on the turtles' behavior.

The turtles were marked with number 1-34. 1-17 were used in Wawamalu, and numbers 18-34 in Hanauma Bay. Since the two areas are relatively close to each other (about 2.5 miles) the turtles were marked in a continuous order. It is not known how far the turtles migrate and a potential mixup was therefore avoided by not using the same numbers in the two different areas. No turtles from Wawamalu were ever spotted in Hanauma Bay, and the other way around during the observation period, and therefore turtles are not thought to move in between the two areas.

Both in Wawamalu and in Hanauma Bay, snorkel observations were difficult to perform. In Wawamalu, the water was too murky in three of the five sections, and the visibility non-existent. In the outer section (number 5) the conditions were too rough most of the time to go snorkeling. In Hanauma Bay, the inner area fine for snorkeling, while the outer area was difficult to access. Sometimes the lifeguards closed the outer area, and most of the time it was unsafe for one snorkeler to be out alone. Therefore data collected from the outer area of Hanauma Bay while snorkeling was limited to only a few visits. Also, shore surveys were not possible for the outer area of Hanauma Bay.

CONCLUSIONS

The presence of people in Hanauma Bay clearly affects the turtles' behavior. More turtles were spotted on days when the bay was closed than on other days. Also, the turtles swam around more freely, and spent long periods of time at the surface when the bay was closed. At sunrise, when few people visited the park the same behavior was observed.

Turtles that were observed in the inner part of the bay on days when the park was open displayed a very tame and unafraid behavior towards the people surrounding them. In Wawamalu the turtles fled as soon as they saw a human.

The turtles in both study areas are well fed and healthy, with few tumored individuals. The biggest threat to the turtles along the coastline between the two study sites appears to come from the recreational fishing.

In Hanauma Bay, the feeding and resting habitats are distinguished while in Wawamalu the same area is used for both feeding and resting with a preference for resting.

In Hanauma Bay, there is an estimated total numbers of 25-30 turtles.

In Wawamalu, the estimated total number of turtles could not be determined, but must exceed 17.

Tides, waves, and the time of the day have no effect of the number of turtles coming into the two areas.

Turtles are not thought to move between the two study sites.

Appendix I. Raw data collected at Hanauma Bay and Wawamalu, 2/28/00 - 6/10/00.

Place	Date	Status	Surveytype	Time	Tide	Hight(ft)	Waves(ft)	Winds(mph)	Size	Number	Behavior	Comments
Hanauma	3-1-00	open	shore	noon	low	0,3	2-4	10-20e	.	0	.	
Hanauma	3-2-00	open	shore	noon	low	0,2	2-4	10-20e	m	1	feeding	
Hanauma	3-2-00	open	shore	noon	low	0,2	2-4	10-20e	m	1	swimming	
Hanauma	3-7-00	closed	shore	noon	low	0	1-3	8-16se	s	2	feeding	
Hanauma	3-7-00	closed	shore	noon	low	0	1-3	8-16se	m	2	swimming	
Hanauma	3-7-00	closed	shore	noon	low	0	1-3	8-16se	m	1	feeding	
Hanauma	3-9-00	open	shore	morning	low	0,2	1-3	5-10se	s	2	swimming	Extr. low tide. Few people in the
Hanauma	3-9-00	open	shore	morning	low	0,2	1-3	5-10se	s	1	feeding	water.
Hanauma	3-13-00	open	shore	afternoon	low	0,1	1-3	5-10se	m	1	resting	Turtle got bothered by snorkelers
Hanauma	3-14-00	closed	shore	morning	low	0,2	1-3	5-10se	s	5	feeding	
Hanauma	3-14-00	closed	shore	morning	low	0,2	1-3	5-10se	m	1	feeding	
Hanauma	3-15-00	open	shore	afternoon	low	0	3-5	8-16e	m	3	feeding	
Hanauma	3-16-00	open	shore	afternoon	high	0,9	1-3	10-20e	s	1	feeding	Rough conditions,windy,big waves.
Hanauma	3-16-00	open	shore	afternoon	high	0,9	1-3	10-20e	m	1	feeding	
Hanauma	3-21-00	closed	shore	noon	low	-0,1	2-4	10-20e	s	4	feeding	Turtle out in sandy area. Also feeding
Hanauma	3-21-00	closed	shore	noon	low	-0,1	2-4	10-20e	m	1	feeding	on top of reef.Extr. Low tide.
Hanauma	3-23-00	open	shore	morning	high	1,1	2	15-30e	.	0	.	Rough conditions,section 2 closed.
Hanauma	3-24-00	open	shore	afternoon	high	1,5	2	12-22e	s	1	feeding	Feeding turtle got interrupted by
Hanauma	3-24-00	open	shore	afternoon	high	1,5	2	12-22e	m	1	feeding	snorkelers.
Hanauma	3-24-00	open	shore	afternoon	high	1,5	2	12-22e	s	1	swimming	Turtles moving in sandy areas.
Hanauma	3-27-00	open	shore	noon	high	0,5	3	10-25e	.	0	.	Choppy,windy,waves increasing.
Hanauma	3-29-00	open	shore	morning	low	0,2	4-8	12-22s	s	2	swimming	Rough conditions, south winds,
Hanauma	3-29-00	open	shore	morning	low	0,2	4-8	12-22 s	s	1	feeding	yellyfish warning,few people.
Hanauma	4-6-00	open	shore	afternoon	high	1,8	1-3	10-20e	s	1	resting	Calm,few people in water.
Hanauma	4-11-00	closed	shore	noon	low	0,2	1-3	10-25e	s	7	feeding	
Hanauma	4-12-00	open	shore	afternoon	low	0,2	4	18-20e	s	1	swimming	
Hanauma	4-12-00	open	shore	afternoon	low	0,2	4	18-21e	m	2	feeding	

Appendix I. Raw data collected at Hanauma Bay and Wawamalu, 2/28/00 - 6/10/00.

Place	Date	Status	Surveytype	Time	Tide	Hight(ft)	Waves(ft)	Winds(mph)	Size	Number	Behavior	Comments
Hanauma	4-18-00	closed	shore	noon	low	-0,2	1-3	10-25e	s	1	feeding	3 turtles right outside reef,resting.
Hanauma	4-20-00	open	shore	afternoon	high	1,8	1-3	10-25e	s	8	feeding	Turtle harrassed by tourist
Hanauma	4-26-00	open	shore	noon	low	0,4	1-3	15-25e	.	0	.	
Hanauma	4-27-00	open	shore	afternoon	low	0,4	1-3	15-30e	s	1	feeding	
Hanauma	5-1-00	open	shore	morning	low	-0,2	1-3	10-20e	.	0	.	Number 22,24 spotted at 7am.
Hanauma	5-2-00	closed	shore	afternoon	high	1,7	1-3	10-20e	s	4	feeding	2 marked, but numbers not readable.
Hanauma	5-3-00	open	shore	afternoon	high	1,7	1-3	10-25e	s	4	feeding	Number 18 and 3 marked, but
Hanauma	5-3-00	open	shore	afternoon	high	1,7	1-3	10-25e	s	1	resting	with no readable numbers.All feeding.
Hanauma	5-10-00	open	shore	morning	high	0,6	2-3	10-25e	s	4	feeding	
Hanauma	5-10-00	open	shore	morning	high	0,6	2-3	10-25e	s	1	swimming	
Hanauma	5-17-00	open	shore	afternoon	high	1,9	1-3	8-16e	s	1	feeding	Marked,number not readable.
Hanauma	5-30-00	closed	shore	afternoon	high	1,8	1-3	10-20e	s	3	feeding	
Hanauma	6-3-00	open	shore	morning	low	-0,4	3-4	8-16e	.	0	.	Extr. low tide.
Hanauma	6-5-00	open	shore	morning	low	-0,1	2-4	10-25e	.	0	.	Extr. low tide.
Hanauma	6-6-00	closed	shore	morning	low	0,5	2-4	10-25e	s	6	feeding	
Hanauma	6-10-00	open	shore	morning	low	-0,2	1-3	10-20e	.	0	.	
Wawamalu	2-28-00	.	shore	noon	high	0,6	2-4	10-20e	s	3	swimming	
Wawamalu	2-28-00	.	shore	noon	high	0,6	2-4	10-20e	s	4	resting	
Wawamalu	2-28-00	.	shore	noon	high	0,6	2-4	10-20e	s	10	feeding	
Wawamalu	2-28-00	.	shore	noon	high	0,6	2-4	10-20e	m	1	feeding	
Wawamalu	2-28-00	.	shore	noon	high	0,6	2-4	10-20e	m	1	swimming	
Wawamalu	2-28-00	.	shore	noon	high	0,6	2-4	10-20e	m	4	resting	
Wawamalu	2-28-00	.	shore	noon	high	0,6	2-4	10-20e	l	1	feeding	
Wawamalu	2-29-00	.	shore	noon	high	0,6	2-4	10-20e	s	3	feeding	
Wawamalu	2-29-00	.	shore	noon	high	0,6	2-4	10-20e	s	11	resting	
Wawamalu	2-29-00	.	shore	noon	high	0,6	2-4	10-20e	m	3	resting	
Wawamalu	2-29-00	.	shore	noon	high	0,6	2-4	10-20e	s	1	swimming	

Appendix I. Raw data collected at Hanauma Bay and Wawamalu, 2/28/00 - 6/10/00.

Place	Date	Status	Surveytype	Time	Tide	Hight(ft)	Waves(ft)	Winds(mph)	Size	Number	Behavior	Comments
Wawamalu	3-8-00	.	shore	noon	low	-0,1	1-2	5-10se	s	6	feeding	Extr. low tide. Dog in the water
Wawamalu	3-8-00	.	shore	noon	low	-0,1	1-2	5-10se	m	3	swimming	
Wawamalu	3-8-00	.	shore	noon	low	-0,1	1-2	5-10se	s	5	resting	
Wawamalu	3-8-00	.	shore	noon	low	-0,1	1-2	5-10se	m	3	resting	
Wawamalu	3-8-00	.	shore	noon	low	-0,1	1-2	5-10se	m	1	feeding	
Wawamalu	3-10-00	.	shore	morning	low	0	1-3	5-10se	s	10	resting	
Wawamalu	3-10-00	.	shore	morning	low	0	1-3	5-10se	s	3	swimming	
Wawamalu	3-10-00	.	shore	morning	low	0	1-3	5-10se	s	3	feeding	
Wawamalu	3-20-00	.	shore	morning	high	1,7	2-4	10-20e	s	8	resting	Number 13,small,resting. Number 10, small, feeding.
Wawamalu	3-20-00	.	shore	morning	high	1,7	2-4	10-20e	s	2	feeding	
Wawamalu	3-20-00	.	shore	morning	high	1,7	2-4	10-20e	m	1	feeding	
Wawamalu	3-20-00	.	shore	morning	high	1,7	2-4	10-20e	m	1	swimming	
Wawamalu	3-22-00	.	shore	afternoon	high	1,5	2-4	20-25e	s	2	resting	Rough conditions.Fishermen with nets in inner area.# 10,12,feeding.
Wawamalu	3-22-00	.	shore	afternoon	high	1,5	2-4	20-25e	s	6	feeding	
Wawamalu	3-28-00	.	shore	noon	low	0,5	2-4	12-22e	s	6	feeding	Rough conditions.
Wawamalu	3-28-00	.	shore	noon	low	0,5	2-4	12-22e	s	8	resting	
Wawamalu	3-28-00	.	shore	noon	low	0,5	2-4	12-22e	s	2	swimming	Number 10,small, feeding.One marked small, resting.Number not readable.
Wawamalu	3-28-00	.	shore	noon	low	0,5	2-4	12-22e	m	1	swimming	
Wawamalu	3-28-00	.	shore	noon	low	0,5	2-4	12-22e	m	1	resting	
Wawamalu	3-30-00	.	shore	morning	low	0,1	1-2	12-22 s	s	4	resting	
Wawamalu	3-30-00	.	shore	morning	low	0,1	1-2	12-22 s	s	3	feeding	Dog in water 15 min before counting. Number 1, small,resting.
Wawamalu	3-30-00	.	shore	morning	low	0,1	1-2	12-22 s	s	3	swimming	
Wawamalu	4-5-00	.	shore	morning	low	-0,2	1-2	15-30e	s	6	resting	Extr. low tide. Number 12,5,small, resting. Number 10, small feeding.
Wawamalu	4-5-00	.	shore	morning	low	-0,2	1-2	15-30e	s	4	feeding	
Wawamalu	4-5-00	.	shore	morning	low	-0,2	1-2	15-30e	m	1	resting	8 turtles feeding in outer area. Number 10,1,1,3,/,feeding.
Wawamalu	4-7-00	.	shore	afternoon	high	1,8	1-2	5-15e	s	10	feeding	
Wawamalu	4-7-00	.	shore	afternoon	high	1,8	1-2	5-15e	m	1	feeding	Number 10.Feeding.
Wawamalu	4-10-00	.	shore	noon	low	0,1	1-2	10-25e	s	4	resting	
Wawamalu	4-10-00	.	shore	noon	low	0,1	1-2	10-25e	s	1	swimming	
Wawamalu	4-10-00	.	shore	noon	low	0,1	1-2	10-25e	m	1	swimming	
Wawamalu	4-10-00	.	shore	noon	low	0,1	1-2	10-25e	m	2	resting	
Wawamalu	4-10-00	.	shore	noon	low	0,1	1-2	10-25e	s	4	feeding	

Appendix I. Raw data collected at Hanauma Bay and Wawamalu, 2/28/00 - 6/10/00.

Place	Date	Status	Surveytype	Time	Tide	Height(ft)	Waves(ft)	Winds(mph)	Size	Number	Behavior	Comments
Wawamalu	4-13-00	.	shore	afternoon	high	0,8	3	10-25e	s	4	feeding	Number 10 and one small unmarked.
Wawamalu	4-13-00	.	shore	afternoon	high	0,8	3	10-25e	s	2	swimming	Both feeding.
Wawamalu	4-13-00	.	shore	afternoon	high	0,8	3	10-25e	s	1	resting	
Wawamalu	4-13-00	.	shore	afternoon	high	0,8	3	10-25e	m	1	feeding	
Wawamalu	4-13-00	.	shore	afternoon	high	0,8	3	10-25e	m	5	resting	
Wawamalu	4-13-00	.	shore	afternoon	high	0,8	3	10-25e	l	1	resting	
Wawamalu	4-17-00	.	shore	morning	low	-0,2	1-3	10-20e	s	13	resting	Number 10, feeding. One marked w./
Wawamalu	4-17-00	.	shore	morning	low	-0,2	1-3	10-20e	s	2	feeding	no readable number, swimming.
Wawamalu	4-17-00	.	shore	morning	low	-0,2	1-3	10-20e	s	2	swimming	
Wawamalu	4-19-00	.	shore	afternoon	high	1,7	1-3	10-25e	s	17	resting	
Wawamalu	4-19-00	.	shore	afternoon	high	1,7	1-3	10-25e	s	2	swimming	
Wawamalu	4-19-00	.	shore	afternoon	high	1,7	1-3	10-25e	s	2	feeding	
Wawamalu	4-27-00	.	shore	morning	high	1,5	1-3	15-30e	s	7	resting	One marked but number not readable.
Wawamalu	4-27-00	.	shore	morning	high	1,5	1-3	15-30e	s	2	swimming	
Wawamalu	5-1-00	.	shore	afternoon	high	1,5	1-3	10-20e	s	8	feeding	One turtle under the bridge, one feed
Wawamalu	5-1-00	.	shore	afternoon	high	1,5	1-3	10-20e	s	1	resting	by mangrove trees.
Wawamalu	5-1-00	.	shore	afternoon	high	1,5	1-3	10-20e	s	1	swimming	
Wawamalu	5-4-00	.	shore	noon	low	-0,4	2-4	10-25e	s	12	resting	Rough conditions.
Wawamalu	5-4-00	.	shore	noon	low	-0,4	2-4	10-25e	s	7	feeding	
Wawamalu	5-4-00	.	shore	noon	low	-0,4	2-4	10-25e	s	3	swimming	
Wawamalu	5-11-00	.	shore	morning	high	1,6	3-4(5)	15-30e	s	8	resting	Very rough conditions. Raining,
Wawamalu	5-11-00	.	shore	morning	high	1,6	3-4(5)	15-30e	m	1	swimming	poor visibility.
Wawamalu	5-11-00	.	shore	morning	high	1,6	3-4(5)	15-30e	s	2	swimming	
Wawamalu	5-11-00	.	shore	morning	high	1,6	3-4(5)	15-30e	s	2	feeding	

Appendix I. Raw data collected at Hanauma Bay and Wawamalu, 2/28/00 - 6/10/00.

Place	Date	Status	Surveytype	Time	Tide	Height(ft)	Waves(ft)	Winds(mph)	Size	Number	Behavior	Comments
Wawamalu	5-15-00	.	shore	afternoon	high	1,7	1-3	10-20e	s	15	feeding	Very big waves and strong current.
Wawamalu	5-15-00	.	shore	afternoon	high	1,7	1-3	10-20e	s	3	resting	
Wawamalu	5-15-00	.	shore	afternoon	high	1,7	1-3	10-20e	s	2	swimming	
Wawamalu	5-18-00	.	shore	morning	low	-0,2	2-4	8-16e	s	9	resting	1 marked small resting. Number not readable.
Wawamalu	5-18-00	.	shore	morning	low	-0,2	2-4	8-16e	s	4	feeding	
Wawamalu	5-25-00	.	shore	afternoon	low	0,5	1-3	10-20e	s	6	resting	1 marked small swimming, 1 marked small feeding. Numbers not readable.
Wawamalu	5-25-00	.	shore	afternoon	low	0,5	1-3	10-20e	s	5	feeding	
Wawamalu	5-25-00	.	shore	afternoon	low	0,5	1-3	10-20e	s	1	swimming	
Wawamalu	5-31-00	.	shore	afternoon	high	2,1	1-3	5-15e	s	10	feeding	Extr. High tide.
Wawamalu	5-31-00	.	shore	afternoon	high	2,1	1-3	5-15e	s	1	resting	
Wawamalu	5-31-00	.	shore	afternoon	high	2,1	1-3	5-15e	s	1	swimming	
Wawamalu	6-8-00	.	shore	morning	low	-0,1	1-3	10-20e	s	9	resting	
Wawamalu	6-8-00	.	shore	morning	low	-0,1	1-3	10-20e	s	1	swimming	
Wawamalu	6-8-00	.	shore	morning	low	-0,1	1-3	10-20e	s	3	feeding	
Wawamalu	6-8-00	.	shore	noon	low	-0,1	1-3	10-20e	s	10	resting	
Wawamalu	6-8-00	.	shore	noon	low	-0,1	1-3	10-20e	s	2	swimming	
Wawamalu	6-8-00	.	shore	noon	low	-0,1	1-3	10-20e	s	4	feeding	
Wawamalu	6-8-00	.	shore	noon	low	-0,1	1-3	10-20e	m	1	feeding	

morning = 8-11am
noon = 11-2pm
afternoon = 2-5pm

s = small (<61cm)
m = medium (61-83.8cm)
l = large (>84cm)

winds mph
e = east
s = south
se = southeast

Appendix II.

Stranding data for Hanauma Bay, Wawamalu and adjacent areas 1982-2000.

Compiled from records on file at the National Marine Fisheries Service, Honolulu.

4-25-84	Sandy Beach	Dead, washed ashore in an advanced and bloated state of decomposition.
6-10-84	Sandy Beach	Accidentally hooked in the neck while fishing from shore. Released unharmed.
10-30-84	Sandy Beach	Found alive w. fishhook in mouth and trailing 5' of line.
4-28-85	Hanauma Bay	Dead, floating w. a small spear hole in ventral neck.
7-15-85	Hanauma Bay	Reported seeing a turtle w. a hook in it's front flipper trailing a wire leader.
7-30-85	Hanauma Bay	Turtle w. fish hook and piece of wire leader stuck in FF.
9-17-85	Sandy Beach	Gill net entangled tightly around right front flipper. Released.
1-8-86	Sandy Beach	Found alive floating in a weakend condition. RFF dislocated and paralyzed from possible entanglement in piece of gill net. Released.
3-2-86	Sandy Beach	Dead. In advanced decomposition.
8-6-86	Makapuu	Butchered remains of two small turtles found along the shoreline.
1-16-87	Portlock	Seen resting in an underwater cave w. a large rusted fish hook in front flipper.
3-2-87	Maunalua Bay	Dead, floating at the surface. Large split trough top of head. Tumors on most soft parts.
3-5 -87	Maunalua Bay	Found dead floating in advanced decomposition.
4-11-87	Queen's Surf Beach	Decomposing remains seen along shoreline.

Appendix II.

Stranding data for Hanauma Bay, Wawamalu and adjacent areas 1982-2000.

5-2-87	Maunalua Bay	Found alive in a lethargic and emaciated state lying in shallow water close to shore. Numerous tumors present. Uthenized.
10-17-87	Hanauma Bay	Found dead, floating. Numerous small tumors on soft parts. Piece of small fishing line entangled around RFF.
3-27-88	Maunalua Bay	Found dead floating off shore. Tumors present on FF.
5-16-88	Maunalua Bay	Found dead floating. Massive tumors on all soft parts including eyes and tail.
4-7-89	Makapuu	found alive w. monofilament entangling neck, FF deep in one, and swollen head. Released.
4-23-89	Maunalua Bay	Found dead in a cave w. monofilament and a rusted hook.
5-22-89	Hanauma Bay	Dead w. 3 large ulua hooks, and heavy monofilament.
7-18-89	Blowhole	Found dead, washed ashore.
6-4-90	Maunalua Bay	Found dead. Tumors present.
2-12-91	Maunalua Bay	Found dead floating in adv.decomp.Tumors present on mouth,neck,FF,LHF.
2-27-91	Sandy Beach	Found alive.Speard.Released.
4-1-91	Portlock	Found dead very bloated in adv. decomposition.
4-29-91	Sandy Beach	Found dead washed ashore. Monofilament line wrapped tightly around neck and RFF.
6-9-91	Sea Life Park	Found alive w. a spear hole in it's head,beak/nostril and neck.Died later.
6-24-91	Hanauma Bay	Found alive on ledge.Released.Prob.dragged up by someone.
8-12-91	Hawaii Kai	Dead report. No confirmation.

Appendix II.

Stranding data for Hanauma Bay, Wawamalu and adjacent areas 1982-2000.

9-26-91	Hanauma Bay	Found beached at night w. moderate emaciation.
2-29-92	Hanauma Bay	Dead in a trash can. Decomposing.
4-3-92	Hanauma Bay	Dead, severely bloated. Probably shark attack.
6-2-92	Sandy Beach	Live turtle. Hook in right front mouth w. fishing line wrapped around RFF.
7-15-92	Sandy Beach	Live injured turtle. Fishing line in mouth and around flipper with it nearly falling off.
8-30-92	Sandy Beach	Found alive, washed ashore. Released.
1-7-93	Hanauma Bay	Found alive, beached w. moderate emaciation. Released.
3-10-93	Maunalua Bay	Found dead, floating. Bloated.
3-10-93	Makapuu	Found dead washed ashore. Monofilament entangled.
5-16-93	Maunalua Bay	Found dead. Net entangled.
6-7-93	Sandy Beach	Live turtle w. a hook and wire leader attached to it.
6-15-93	Blowhole	Alive entangled in fishingline.
1-8-94	Hanauma Bay	Live turtle w. hook and line and plastic bag.
5-12-94	Makapuu	Alive, very weak. Euthenized.
7-11-94	Portlock	Alive, lethargic. Tumors. Euthenized.
10-1-94	Hanauma Bay	Dead, floating.
7-21-95	Hanauma Bay	Found alive entangled w. monofilament line, wire leader and hook. Released.
10-27-95	Hanauma Bay	Dead. adv. decomposition. Hook in RFF. Monofilament.

Appendix II.

Stranding data for Hanauma Bay, Wawamalu and adjacent areas 1982-2000.

2-5-96	Betw. Portlock and Hanauma Bay	Dead. Mild emaciation.
2-6-96	Maunalua Bay	Dead. Tumors.
3-3-96	Hanauma Bay	Dead. Advanced decomposition.
6-18-96	Hanauma Bay	Dead. Mild decomposition.
6-20-96	Hanauma Bay	Dead.
7-28-96	Sandy Beach	Dead. Fishingline entangling neck and FF.
10-20-96	Hanauma Bay	Dead. Shark attack?
2-12-97	Maunalua Bay	Dead.
3-7-97	Hanauma Bay	Dead. Possible propeller slash.
4-3-97	Maunalua Bay	Live entangled in net. Released.
4-4 -97	Maunalua Bay	3 live turtles entangled in net. Released.
4-14-97	Maunalua Bay	Dead. Net entangled in neck and FF.
4-17-97	Maunalua Bay	Dead.
4-22-97	Blowhole	Live w. hook and weights. Released.
5-4-97	Maunalua Bay	Dead. Entangled in net.
6-16-97	Hanauma Bay	Live large turtle w. fish hook. Got cut loose.
1-2-98	Maunalua Bay	Dead. Possible net entanglement.
2-13-98	Maunalua Bay	Dead. Tumors.
4-17-98	Sandy Beach	Dead.
5-13-98	Hanauma Bay	Dead. Tumors.

Appendix II.

Stranding data for Hanauma Bay, Wawamalu and adjacent areas 1982-2000.

7-15-98	Hanauma Bay	Dead. Adv. decomposition.
10-12-98	Hawaii Kai	Barely alive, entangled in gillnet. Died.
6-25-99	Sandy Beach	Live beached turtle. Reports of several turtles basking.
7-3-99	Hanauma Bay	Dead, floating offshore. Hook, wire leader and monofilament.
8-5-99	Sandy beach	Dead. Fish hook in lower jaw.
9-25-99	Sandy beach	Live tumored turtle beached.
10-24-99	Makapuu	Alive, with fishingline entangled in RFF.
3-25-00	Makapuu	Several live turtles entangled in a fishermans net. Got cut free.
4-5-00	Hanauma Bay	Found dead, washed ashore. Adv. decomposition.
5-16-00	Hanauma Bay	Alive, w. fish hook in front flipper. Released with fish hook taken away.
7-3-00	Wawamalu	Found dead in the inner of the enclosed pool. Spear wounds.

FF = front flipper

HF = hind flipper

RFF = right front flipper

LHF = left hind flipper

Appendix III. Statistical data.

Table 2. The mean number of turtles in Hanauma Bay when closed versus open.

Duncan Grouping	Mean	N	Status
A	1.4583	24	closed
B	0.7067	75	open

P value = 0.0019

Tables 3 and 4. Surf and winds effect on number of seen turtles.

Duncan Grouping	Mean	N	Waves
A	4.000	32	2-4 ft
A	3.900	50	1-3 ft
A	3.444	18	1-2 ft
A	3.250	4	3-4(5) ft
A	3.000	1	3-5 ft
A	2.500	2	2-3 ft
A	2.333	6	3 ft
A	1.500	2	4-8 ft
A	1.500	2	4 ft
A	1.000	3	2 ft

Duncan Grouping	Mean	N	Wind
A	4.600	5	5-15 e
A	4.250	4	8-16 e
A	4.040	25	10-25 e
A	4.000	2	20-25 e
A	3.721	43	10-20 e
A	3.400	10	15-30 e
A	3.385	13	5-10 se
A	2.625	8	12-22 e
A	2.600	5	12-22 s
A	2.000	1	18-21 e
A	1.667	3	8-16 se
A	1.000	1	18-20 e

P value = 0.8066

Appendix III. Statistical data.

Table 5.

Size difference in Hanauma Bay and Wawamalu.

Duncan Grouping	Mean	N	Size
A	4.307	88	s
B	1.600	30	m
B	1.000	2	l

P value = 0.0004

Table 6, 7, 8 and 9. Difference in numbers by place, tide, time and size for Hanauma Bay and Wawamalu.

Duncan Grouping	Mean	N	Tide
A	3.5789	57	high
A	3.5714	63	low

Duncan Grouping	Mean	N	Time
A	3.8056	36	morning
A	3.5476	42	noon
A	3.4048	42	afternoon

Duncan Grouping	Mean	N	Place
A	4.1294	85	Wawamalu
B	2.2286	35	Hanauma Bay

Duncan Grouping	Mean	N	Size
A	4.307	88	s
B	1.600	30	m
B	1.000	2	l

P value = 0.1667

Appendix IV. Study area Hanauma Bay.



Figure 6. Hanauma Bay.

Appendix V. Study area Wawamalu.



Figure 7. Wawamalu.

Appendix V. Study area Wawamalu.

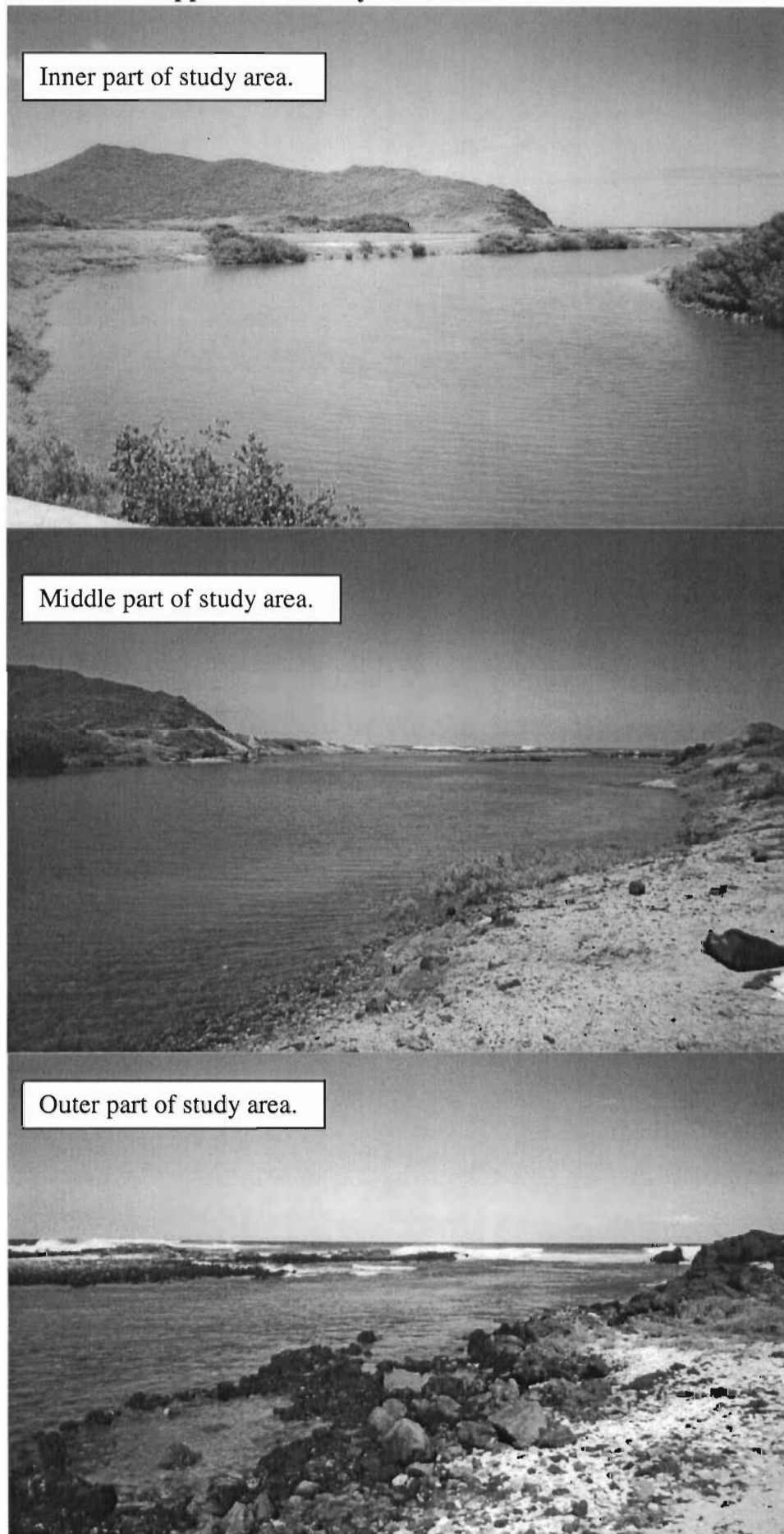


Figure 8. Wawamalu.

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