Nesting Site Disbursement for the Green Sea Turtle (*Chelonia mydas*) in Kaneohe Bay

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Abstract

Assays of patch reefs located in various parts of Kaneohe Bay, Hawaii were performed to determine the distribution of green turtle (*Chelonia mydas*) nests within the bay. In this instance, a nest is defined as an underwater site where turtles retreat to rest. While only 28 of the 57 reefs within the bay were studied we found a concentration of nests in the northern end of the bay and in the Mark's bay vicinity. Also reef 42, due to large numbers of turtles associated with the reef, was chosen for studies of nest site fidelity, time of day and frequency of usage. It was determined that % occupation of the nests on 42 ranged from 0% to 25% with the highest rates just before midnight and the lowest around sunrise. In addition, daytime occupation was concentrated to the northern end of the reef where we discovered a wrasse/turtle cleaning station. A list of turtles with distinct malformations is included for future use.

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Introduction

Over a hundred million years ago 15 genera of marine turtles thrived on Earth (Alderton, 1988). Today there are five (Mortimer, 1982). As recently as 1947, it is estimated that over 40,000 female Kemp's ridleys (*Lepidochelys kempii*) nested at Rancho Nuevo, Mexico in a single day. By the 1980's the ridleys were only laying 800 nests a year at Rancho Nuevo, less than 1% of the number produced 40 years prior (National Research Council, 1990). This decline in numbers is not reserved to the Kemp's ridleys. Similar declines were seen in the green turtle (*Chelonia mydas*). A plummet in the number of green sea turtle eggs that were harvested in Sarawak between 1935 and 1975, from 3.1 to 0.3 million, corresponds to a decrease in the number of eggs that were laid (King, 1982) on nesting beaches everywhere, and symbolizes a dramatic reduction in population size. A decrease that proved so severe that on July 28, 1978 greens became the fourth species of sea turtle to be elevated to endangered status (National Research Council, 1990).

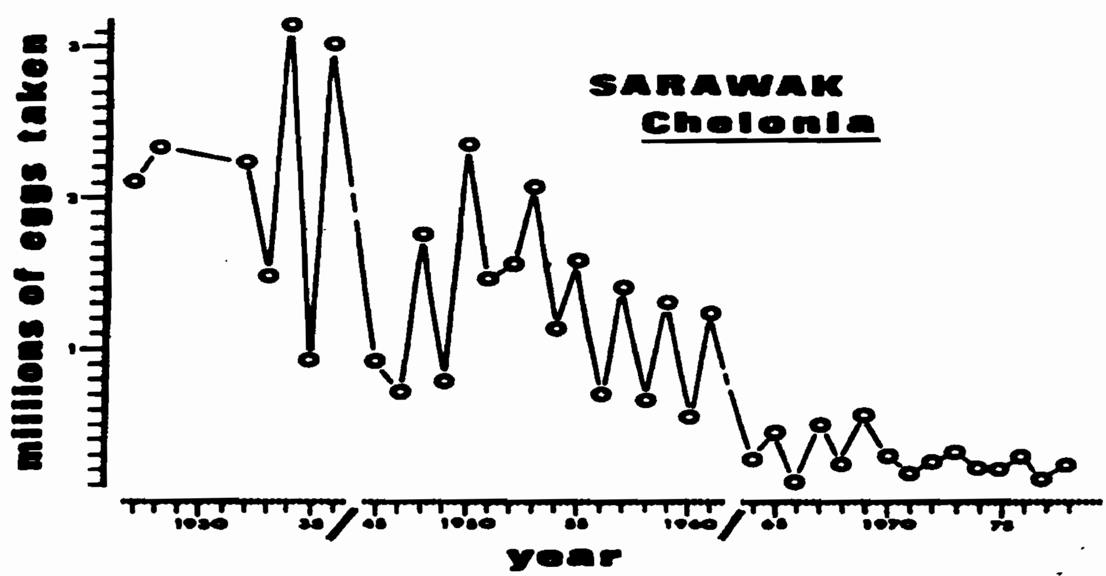


Figure 1: Decline in Sarawak *Chelonia mydas* population as reflected by decreased numbers of eggs available for collection and sale between 1935 and 1975 (King, 1982).
(Figure from King, 1982)

Today, all seven surviving species of sea turtles have experienced sufficient declines from traditional numbers to be listed as either endangered or threatened throughout their ranges. These are not highly sought after titles considering a listing of endangered means the bearer is in immediate danger of becoming extinct. A listing of threatened is only slightly better with the bearer not in immediate danger of extinction but likely to enter that stage in the near future (Thomas et. al., 1989).

Six of the species can be found roaming the waters of the Pacific Ocean (South Pacific Regional Environment Programme and Queensland, 1995), with the green turtle and the hawksbill (*Eretmochelys imbricata*) calling the Hawaiian waters their home. Leatherbacks (*Dermochelys coriacea*) are also seen in Hawaiian waters but do not nest on Hawaiian beaches (Balazs, 1982b). The largest of the hard-shelled turtles living (National Research Council, 1990), the green turtle or honu (Balazs, 1995), is the principle turtle of the Hawaiian chain, with individuals ranging in size from 35 cm to adult (>82 cm) residing in island coastal waters (Balazs and Forsyth, 1986; Balazs et al., 1994b). These coastal waters and the beaches associated with them are considered by the National Research Council (1990) to be the two main areas of human interference with sea turtles. For this reason, the National Marine Fisheries Service have divided Hawaiian waters into 7 representative study sites plus 9 study sites where periodic tagging is done (Balazs, 1982a) for a total of 16 study areas in the Hawaiian archipelago (Balazs et al., 1996).

The seven representative study sites are located at: Kure, Midway, Lisanski, French Frigate Shoals, Necker, the Bellows Air Force Base area of Oahu, and the Kau district on the big island of Hawaii (Balazs, 1982a). Figure 2 on the proceeding page shows the placement of these islands throughout the archipelago. These locations were chosen due to high numbers of turtles residing in the area and safe access to the area for the gathering of data on the growth rate, habitat usage, migration patterns and health status of the animals (Balazs 1980b; Balazs et al. 1994b; Russell and Balazs, 1994) as well as to monitor population trends.

French Frigate Shoals, 23°45'N; 166°10'W, is located midway in the Hawaiian chain and is a primary study site because over 90% of the Hawaiian greens, from both ends of the archipelago, migrate there to nest (Balazs, 1980a).

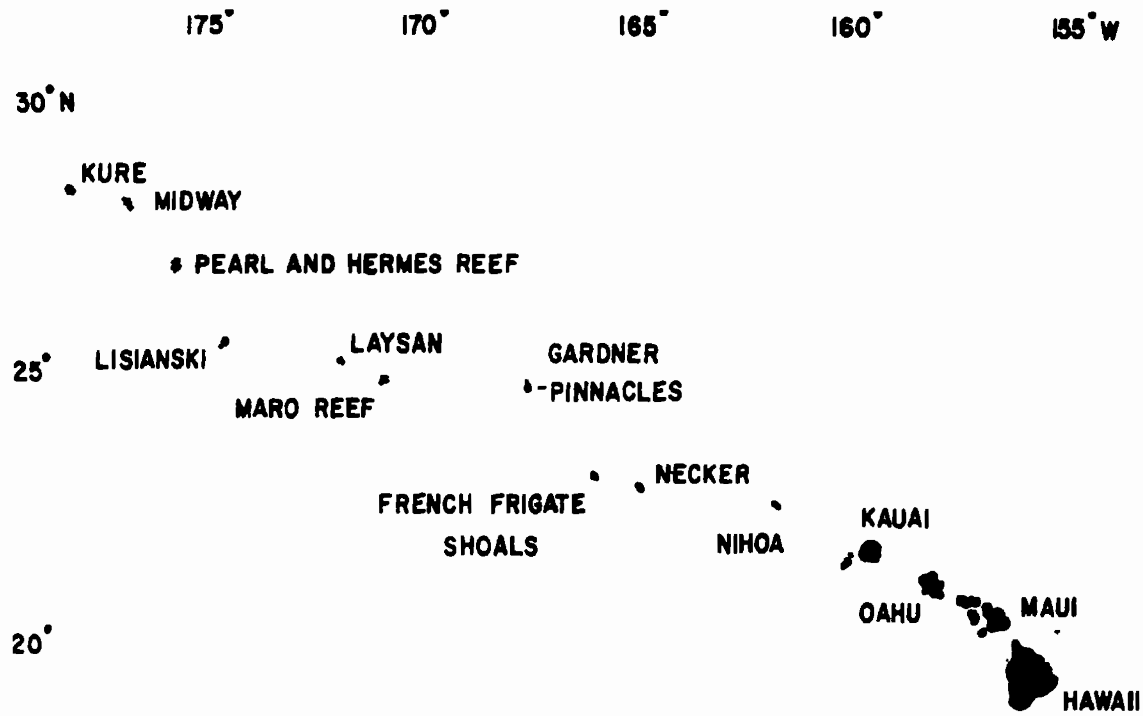


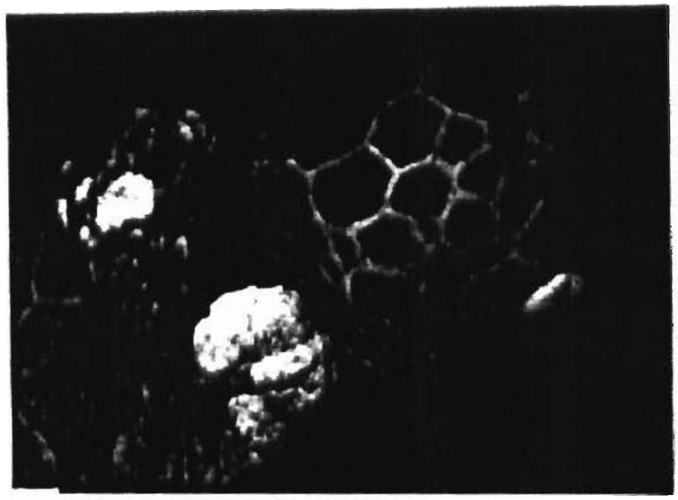
Figure 2: The Hawaiian Archipelago.
(Figure from Balazs, 1977)

Females are known to nest only 1 in every 4-6 years (Gyuris, 1994) and estimations based on recent nesting numbers suggest there are roughly 1,800 adult females in the population that breeds at the Shoals. Since, monitoring of the French Frigate Shoals breeding grounds began in 1973 the National Marine Fisheries Service Honolulu Laboratory has noted a slight but steady increase in the number of nesting females (Balazs et. al., 1994b, 1996). In addition, an increase in the juvenile and sub-adult population has been noted but not studied thoroughly (NMFS).

One of the periodic study sites is Kaneohe Bay, Oahu. Up to 90% of the breeding members of the Kaneohe Bay population make the approximately 26 day migration (Balazs et al. 1994a) to French Frigate Shoals to breed and nest from May until August (Balazs 1980b; Balazs and Forsyth 1986). Increased numbers of nesting females at French Frigate indirectly suggests an increase in the number of turtles residing at foraging areas all along the Hawaiian Archipelago, including those in the Kaneohe Bay population. Further support is found in the Balazs et al. (1993) estimation of green turtle population size in Kaneohe Bay in 1979 and 1989. In 1989 an estimated 500 individuals were residing in the bay as compared to 50 in 1979. This is not an isolated event as both the Atlantic and Pacific populations of *C. mydas,* while still endangered or threatened throughout their ranges, are thought to be increasing (Mosbacher et al., 1991).

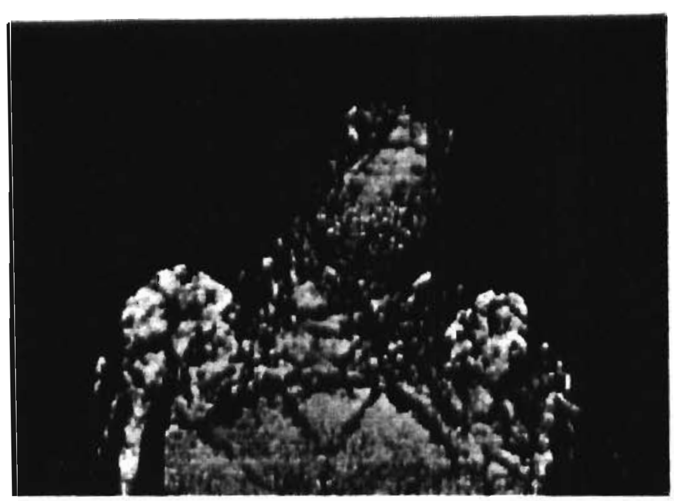
Increasing numbers are a testament to the positive effects of research and conservation efforts over the past 20 years. One might go so far as to say the battle to save green turtles has been won, but being listed on the U.S. Endangered Species Act and by the Convention on International Trade in Endangered Species has brought attention to the problem, it has not remedied the situation (Alderton, 1988). In order, to secure the future of these air-breathing reptiles it is essential that we learn more about their life cycles and natural habitats. This is so we can protect them not only from exploitation but also from unintentional human interference. Interference that takes the form of recreational boat traffic in coastal waters, dredging of the reefs that make up their preferred habitat, commercialization of nesting beaches, accidental kills in shrimp nets and the damage done to their waters by runoff of sewage and chemicals (Greenpeace Wildlife, 1988).

Immediate danger is found in the unfortunate occurrence that at a time when the populations are once again stabilizing they are being affected by an infectious (Herbst, 1994) virus of unknown etiology. Fibropapillomatosis is a tumor causing virus that was first described in Florida in the 1930's but is now present in green turtle populations worldwide (Jacobson, 1996) and comparable tumor causing diseases have been discovered in other species of sea turtles (Herbst, 1994). Pictures 1a and b, on page 5, effectively illustrate that tumors can grow on any of the soft tissues of the turtle including the flippers, eyes, mouth, (Jacobson, 1996) and in advanced cases the lungs, kidneys, heart, gastrointestinal tract and the liver (Herbst, 1994).



Picture 1a (above) and 1b (below): Green sea turtles (*Chelonia mydas)* with fibrous tumors on the soft tissues of their bodies. Fibro-papilloma, which causes the tumors, is a disease is of unknown etiology that results in various clinical courses (Herbst, 1994). The most common course is severe emaciation followed by death (http, 1997).

(Pictures from http, 1997)



With the increasing turtle numbers in Kaneohe Bay it would now be difficult to spend a day partaking of recreational activities in the bay without seeing at least one of the amazing reptiles. Unfortunately, if you saw two turtles in your day in the bay it is likely that at least one if not both of them would be afflicted with Fibropapilloma. Between 49 and 92% of the individuals, in the Kaneohe Bay population, are infected and symptomatic (Balazs, 1991). In fact, the first case ever confirmed in Hawaii was in Kaneohe Bay in 1958 (Aguirre, 1992). Diseases such as Fibropapillomatosis as well as continued intentional and unintentional interference are advocates for continued research on green turtles even though numbers in some populations are on the increase. In fact, increased population size is itself a cause for research.

Due to the need for data associated with the increasing Kaneohe Bay population and the location of the Hawaii Institute of Marine Biology (HIMB) on Coconut Island, in the south end of the bay, Kaneohe Bay was a chosen for this study. Questions regarding sufficient foraging and nesting sites, defined as underwater sites were juvenile, sub-adults, and adults retreat for periods of quiescence (Balazs, 1980b), for the turtles merge with questions about what effects turtle nesting will have on coral, what turtle grazing will do to alga distributions, and what behavioral changes may be seen in animal species throughout the bay.

These questions are to complex to be answered in a single four-month study so our main objective for this study became to gather data that could be used as a basis for future research. Specifically we set out to determine which regions of the bay and regions of specific reefs were receiving the most usę by turtles and if possible to relate the amount of use to some ecological variation between the regions. In addition, we wished to establish an idea of the morphological characteristics of an active turtle nest. Finally, we wished to try an answer some of the questions associated with nesting site usage and fidelity. Our main questions were: 1) what are common morphological characteristics of nests, 2) where are nests located and why, 3) how often is a nest used, 4) for what period of a time does a turtle stay in a nest, 5) do turtles always use the same nest, 6) will more than one turtle rest at a single nest?

Material and Methods

Study Area

Kaneohe Bay, Oahu (Hawaii, USA) is located at 21°, 30' N; 157°, 50' W (Aguirre 1992) and has a semi-tropical climate. Figure 3 shows the placement of Kaneohe Bay on the east side of Oahu.

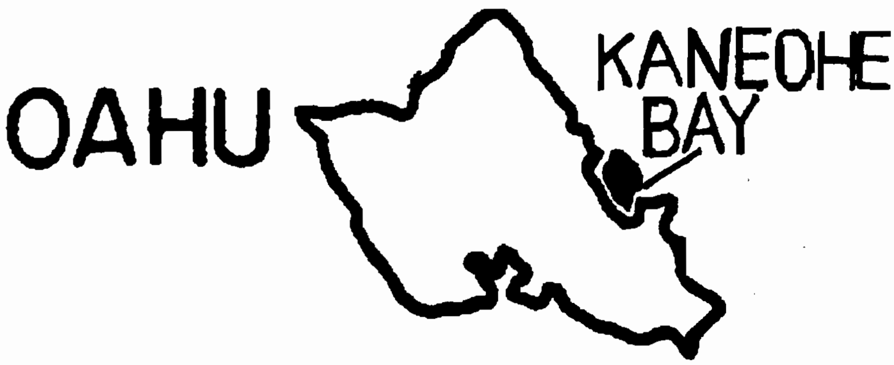


Figure 3: Oahu, Hawaii. Green turtle nesting site distribution was studied in Kaneohe Bay between February and May of 1997.

(Figure modified from Balazs, 1980b)

As the largest sheltered body of water found in Hawaii the bay is approximately 12.8 km long and 4.3 km broad with depths of up to 16m. Water temperature ranges between 19.5 and 27.8 °C. There are patch reefs located throughout the northern and mid sections of the bay (reefs previously located in the southern end have been dredged out), fringe reefs extending out from Oahu and Coconut Island, also known as Moku o Loe (Smith et al. 1973), as well as a barrier reef across the mouth of the bay, Figure 4. Coconut is a 29 acre island located in the southern region of the Bay with approximately 0.4 miles between its northeast coast and the coast of Oahu (Final Environmental Impact Statement, 1996).

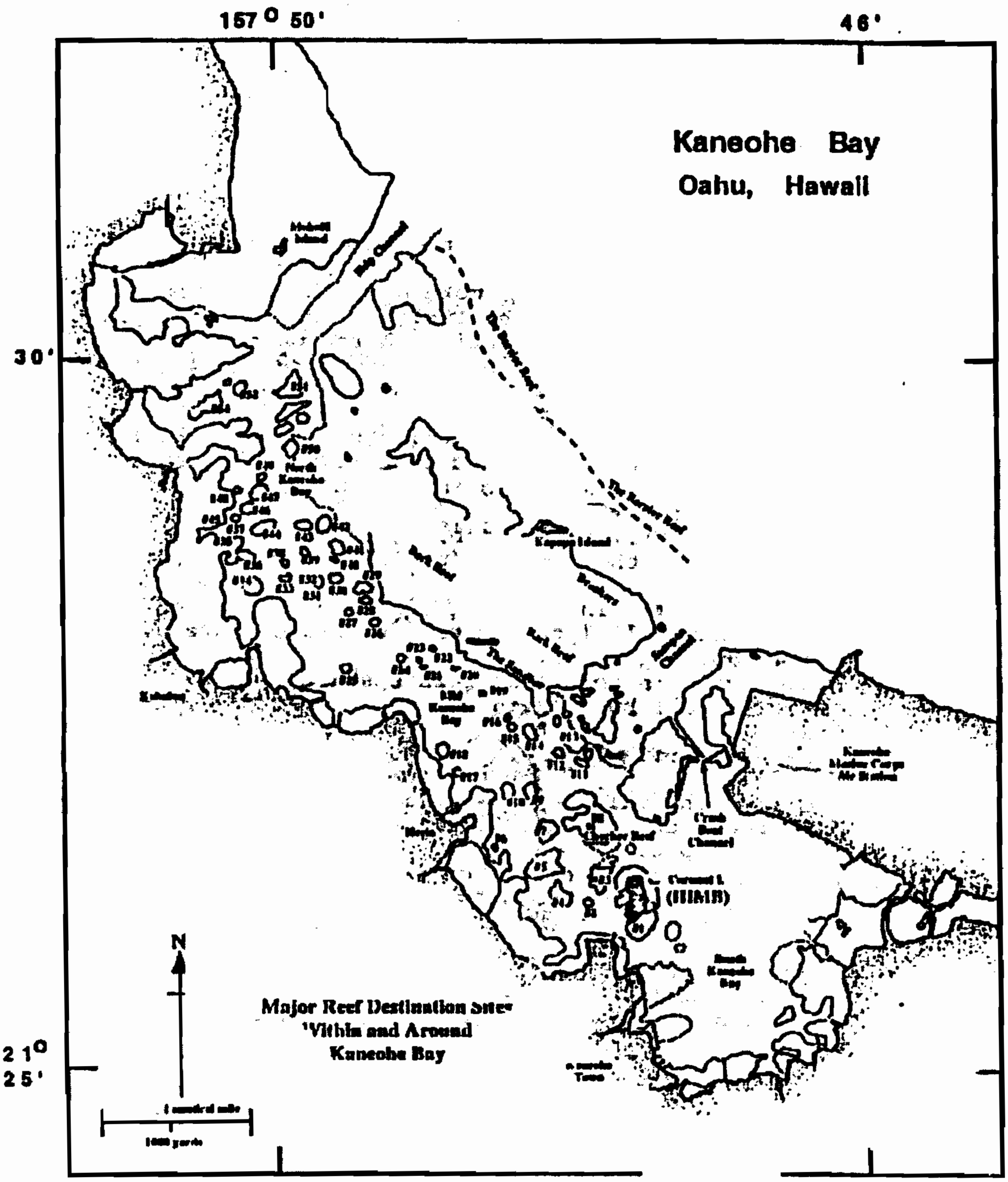
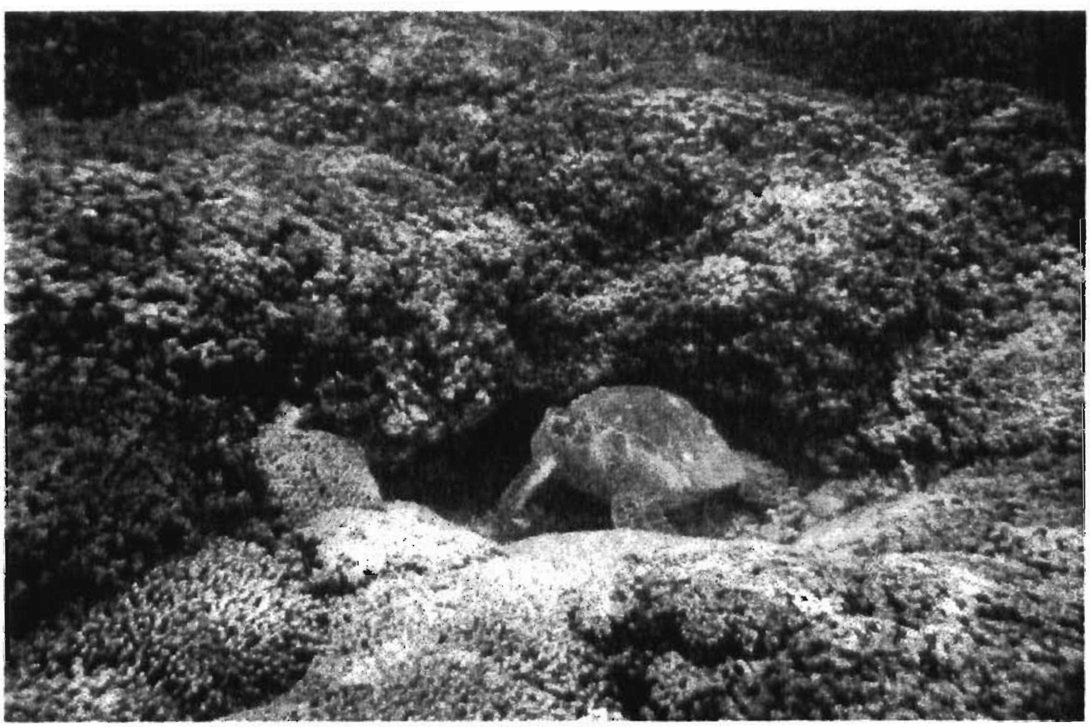


Figure 4: Map of Kaneohe Bay, Hawaii showing placement of all fringe, patch, and barrier reefs associated with the bay as well as the location of the Hawaii Institute of Marine Biology (HIMB).
(Map from flyer on HIMB boat use procedures.)

Home to the Hawaii Institute of Marine Biology (HIMB) Coconut was the base for all of our research.

With aid from the Zoology Department at the University of Hawaii's Manoa campus and HIMB personnel surveys of individual patch reefs, to identify green turtle nests, were performed between early February and late May of 1997. Well-developed sites were defined as those that showed signs of alteration from normal coral morphology. Examples of this included indented or overhanging nests with floor substrates consisting of either live but flattened coral branches, rubble of broken coral branches, or sand. Pictures 2a-d clearly show these common alterations associated with nests. Picture 2a was taken on the flat of patch 42 and shows an overhanging nest with distinct flattening of the coral branches located in the floor of the nest and just anterior of the turtle.



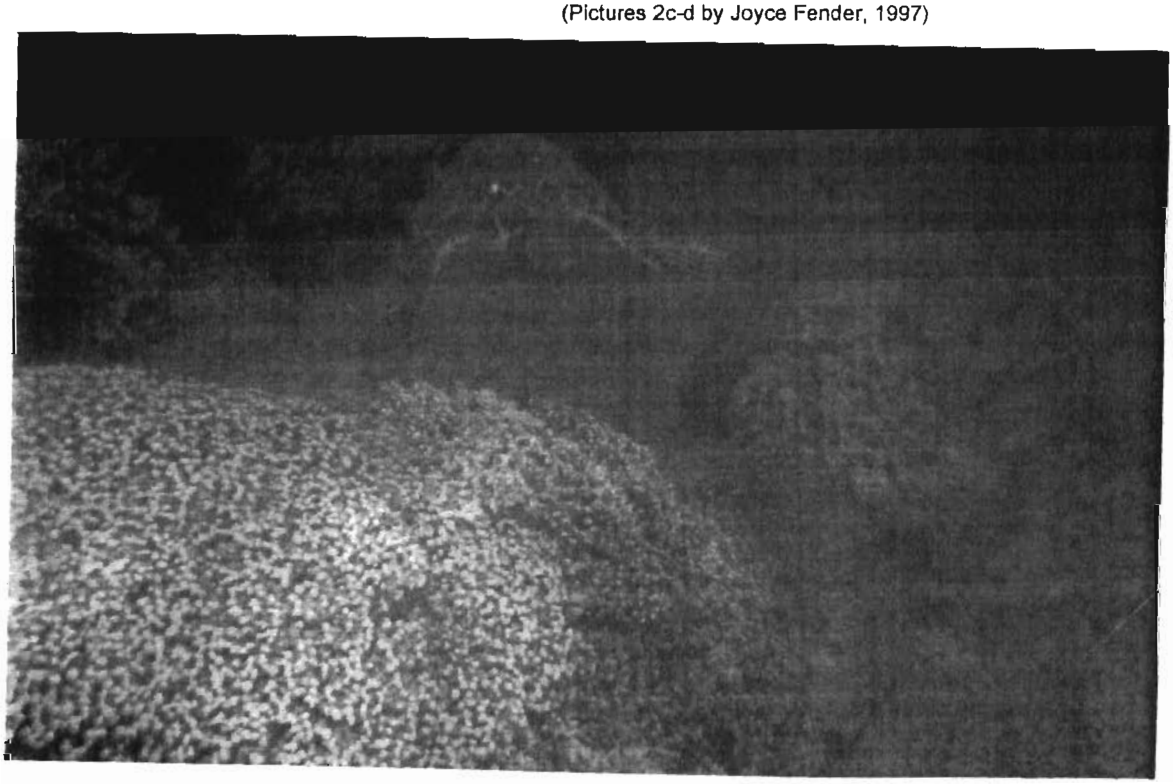
Picture 2a: Turtle nest located on flat of reef number 42. The flattening of coral branches seen at the anterior end of the turtle is a characteristic of many sites.
(Picture by Joyce Fender, 1997)

Picture 2b illustrates the appearance of an indented nest. Unfortunately, the angle of the picture does not show any alteration in the morphology of the coral around the nest but the coral on the inside walls of the site are smooth from being brushed repeatedly with flippers, rostrum and carapace. Depth of the site seems to determine the substrate of the floor with those that indent further than a foot into the coral having sand bottoms and those whose floors are closer to the level of the flat having coral, with the characteristic flattened morphology.

Picture 2b: Opening of a nest that is an indented area in on the flat of reef 42. This view does not show coral branch flattening but the inside walls of the site do have this characteristic. Floors of sites such as these are usually either sand or flattened coral depending on the depth of the indent.
(Picture by Joyce Fender, 1997)

Picture 2c resembles Picture 2a in that it is an overhanging nest on the flat but it does not show the flattening of branches seen in 2a. This is due to the size of the sandy area adjacent to the nest allowing ample space for entrance and exit of the site without consistent impact with the surrounding coral. Finally, Picture 2d shows an overhanging site on the perimeter of a patch reef. The floor consists of

Picture 2c: Green turtle nest or testing site located on the flat of patch reef 42 in Kaneohe Bay.
(Pictures 2c-d by Joyce Fender, 1997)

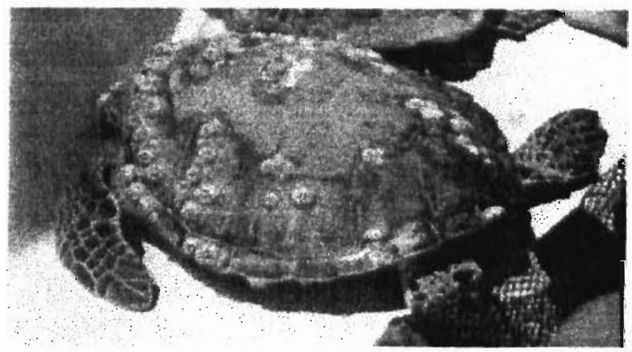


Picture 2d: Sea turtle resting site located on the perimeter of patch reef 42. This site shows a characteristic coral rubble floor but the height and width of the opening make it difficult to monitor, for occupation rates, without scuba gear and/or video equipment.

coral fragments that have broken off of the patch during coral falls. This picture illustrates just a few of the problems encountered when surveying perimeter nests. The width of openings and the way they run together on the perimeter makes accurate counts of nests difficult while the depth of the entrance make the nail technique we used on the flat, to check for occupation, inadequate. It is for these reasons that the flat was chosen as the site for a more in-depth study of occupation rates.

Patch reef 42 (due to the abundance of sites and turtles associated with the patch) was chosen for surveys in which the density and position of the sites on the flat were determined in order to learn more about frequency of use, time of day usage and fidelity of sites. Since, individual identification is difficult turtles were identified when possible by the presence of the tumors (Picture 1a-b on page 4) as well as by placement of the barnacles, from the species (*Chelonibia testudinaria*) (Picture 3a – below left), on the carapace, flippers or head, see Picture 3b (below right).

(Picture from Chaung, 1961)



(Picture by Joyce Fender, 1997)

Picture 3a (above right): *Chelonibia testudinaria* lives attached to the shells of marine turtles (Chaung, 1961). Barnacle spatial distributions, on green turtle carapaces (Picture 3b – above left), were used in short-term identification of individual turtles.

At all times during the surveys interference was kept to a minimum and no handling of the turtles was done at any time.

Field Techniques

Kaneohe Bay

During the bay wide study assays, for the abundance of nesting sites on the perimeters of patch reefs throughout various sections of the bay, were performed in one of two ways. One method was to tow a person behind a 13 foot long Boston Whaler at low speeds so that a count of the perimeter sites could be accomplished. This had the benefit of being time conserving but may also have been cause for slightly lower estimations on the number of sites due to missed sites under multiple sets of overhangs or across wide reef crests. It was considered appropriate for this survey since no nests located below 4 meters was recorded by use of Methods 1 or 2.

Survey Method 2 was for one or two snorkelers to circuit the entire perimeter of the patch reef, keeping a count of nests as well as turtles seen in nesting sites. When two snorkelers were present individual counts were kept and later compared. It quickly became apparent that, even with set standards about the appearance of a nest, counts could be quit different in magnitude, due to different perspectives as to what constituted a site and what normal coral morphology. For this reason a single surveyor performed all counts used in the Results section of this paper. This is sure to have cut down on the variation in counting technique, but did not completely eliminate it since the earlier surveys served as lessons in observation to reef alteration and nest identification undoubtedly required less alteration in the later surveys. In instances were the reef depth was considered adequate, for turtle resting on the flat, snorkeling across the flat was also done and counts taken. The size of the individual reefs as well as the abundance of sites present determined time spent on each reef.

Patch 42 of Kaneohe Bay

On patch 42 reef flat sites were first identified and then numbered. Numbering was accomplished by etching on stakes, elongated triangular pieces of hard gray plastic, 6 inches long and with a base of 2 1/2 inches. Placement of the stakes in between branches of coral located in close proximity to the site (visible in upper left hand corner of Picture 2b on page 10) enabled us to designate individual sites without interfering with turtles or causing any alteration of behavior. Exact location of sites on the flat was not determined but proximity to other sites and the crest as well as general location on the reef was mapped to determine if any section of reef received excessive usage.

Determination of the amount of use each nest received was accomplished by the employment of several different techniques. Technique 1 was to hammer nails into the coral at a position in the site or at the face of the site. Exact placement and number of nails per site was determined by the features of the site with small sites having one nail and large sites having up to three nails. If the site was an overhang the nails were placed in the open area at the mouth of the overhang. In Picture 2a on page 9 a nail would have been placed approximately where the turtle's left fore flipper is seen touching the coral. Indented nests with coral bottoms had nails placed in the indent. If overhangs had sand or coral rubble floors the hole was either numbered but not nailed or a large piece of coral rubble was nailed and placed upright in the mouth of the opening. Indents with sand bottoms tended not to be very common or to have large circumferences so nails were placed at an angle in the coral on the inside of the site. Indents with rubble floors were treated the same as overhangs with sand or rubble floors. With 3-inch long nails hammered approximately 1/4 of an inch into the dead coral we created a barrier that was unobtrusive and easily dislodged.

Technique 1 was determined effective by control nails placed on coral and rubble in or near the sand patch located near the southern corner of the reef. Control and test nails were set, checked, and reset at the same time, but those in the nests had an average knock down rate of 49.1% while control nails had an average rate of 8.5%. This was seen as sufficient difference to deduct that the turtles entering and exiting the sites were the cause of the high rate of knock down at the sites instead of the rate being due to factors such as currents which nests and adjacent control areas had in common.

Nails were run in two ways. For one trial the nails were set and then checked every 24 hours for 5 consecutive days, and for one trial they were set and run every 6 hours for 24 hours. During the five-day run, from 4/20/97 to 4/24/97, only the nails that had been dislodged were reset. This raised several questions about whether some nails were harder to dislodge than others and whether the data was skewed by them staying that way during the entire 5 day period. To atone for this problem in the 24-hour run, from noon on 5/21/97 to noon on 5/22/97, all nails were reset at each checking. This included the lodged and dislodged control nails as well as the lodged and dislodged nest site nails. In both runs leaning nails were considered to be standing while nails shoved down into the coral were considered as knocked down. In sites were multiple nails were used one nail down was considered a knock down. This did not prove to be a very important factor since, with the exception of a few holes that had two openings nailed, if one was down than the others were a well. On the sites with more than one opening it was recorded as to which nail was being dislodged in the hope of determining if one was the preferred entrance/exit.

Running the nails required at least on night visit to the patch but in order to determine whether nest occupation numbers increase at night as was determined by Brill et. al. (1995) we added three additional visits to reef 42 between the hours of 9 p.m. and 6 a.m. Finally, two 24-hour observation sessions were undertaken with the use of a fixed position underwater video system. These sessions were used to acquire data about nest fidelity, duration of visits, and frequency of visits as well as to observe the symbiotic cleaning behavior of the wrasse (*Thalassoma duperry*) (Losey et. al., 1994). One camera visit was made at Mark's Reef (Figure 5 on page 16) and the other at nest site 82 of reef 42 (Figure 6 on page 19). Unfortunately, the camera that we planned to used became flooded and the alternate was only able to record during daylight hours so that each 24 hour survey became two surveys shorter surveys, one 6 hours in duration and one 9 hours, broken by an approximately 9 hour night.

Results

Kaneohe Bay

In the bay wide surveys we recorded the reefs on which turtles and turtle nests were located. The numbers in Figure 5 represent the placement and reef

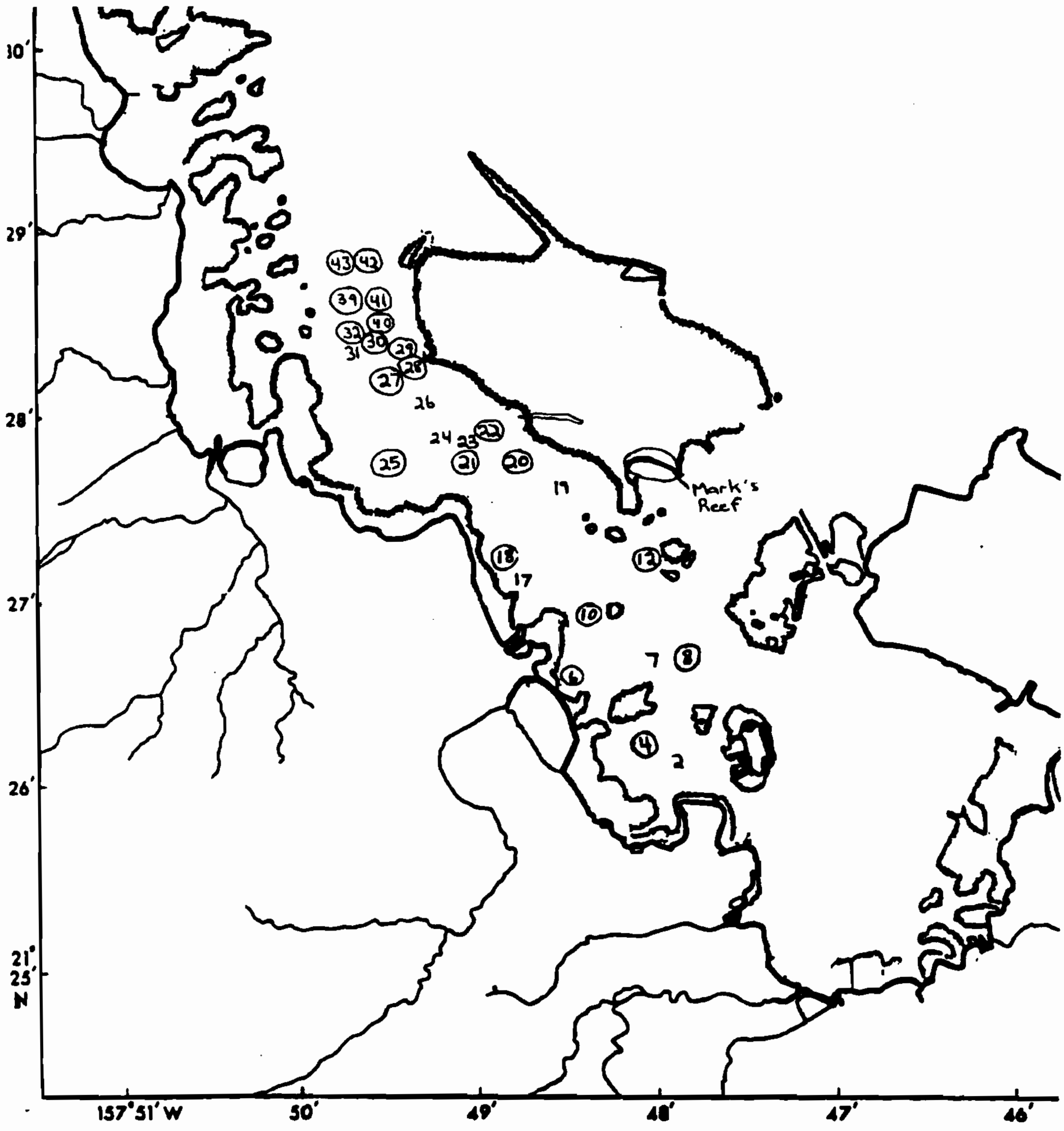


Figure 5: Numbers represent patch reefs that were surveyed for the presence of turtle nests. The number shown corresponds to the accepted number of the reefs and a circle around the number means nests were present.
(Figure modified from Balazs, 1980b)

number of the patches surveyed. Circles around the numbers signify that nests showing clear deviations from normal coral morphology where observed on the patch while no circles means that no sites were seen. Sighting of turtles in the water near the patch or resting at a place that did not resemble a nest is not shown on Figure 5 but is recorded in Table 1. This table lists the reefs surveyed

Patch # Surveyed	Region of Bay	Flat Surveyed	# of nests	# turtles resting	# turtles swimming
2	South	no	0	0	0
4	South	no	15	0	1
6	South	no	35	5 & 0	0 & 2
7	South	no	0	3	0
8	South	yes (sections)	? > 5	0	0 to 2
10	South	no	1	0	0
12	Mid	no	120	2	0
17	Mid	no	0	0	0
18	Mid	no	18	1	0
19	Mid	yes	0	0 & 0	0 & 2
20	Mid	yes	15	0 & 0	3 & 0
21	Mid	no	?	3	1
22	Mid	yes	0	0	1
23	Mid	no	0	0	0
24	Mid	no	0	1	0
25	Mid	no	? many large overhangs	1	0
Mark's Reef	Mid	yes	> 100	0 to 10	0 to 5
26	North	no	0	0	0
27	North	no	8	1	0
28	North	no	12	1	0
29	North	no	? > 30	7	3
30	North	no	120	4	0
31	North	no	0	0	1
32	North	no flat present	89	6 & 1	0 & 1
39	North	no	?	0	2
40	North	no	? > 10	1	0
41	North	yes	? > 10	2	1
42	North	yes	? > 100	0 to 11	0 to 8
43	North	yes	? > 100	0 to 5	2 to 6

Table 1: Listing of patch reefs within Kaneohe Bay that were surveyed for the presence of green turtle nest sites. Also listed is the section of bay in which the reef is located, whether the flat as well as the perimeter was surveyed, and the number of sites, occupied sites, and swimming turtles observed.

along with the section of bay in which it is found, whether or not the flat was surveyed, the number of nests found and the number of turtles seen resting/swimming. Section of bay was related to latitude with reefs located to the north of 21°28'N classifying as North bay, reefs between 21°28'N and 21°27'N counting as Mid bay, and reefs south of 21°27' classifying as South bay. Reefs found having a large number of nests (>100) were often not surveyed in there entirety and therefore are listed as ? > 100 in the # of nests column. Such reefs include Patches 42-43 and Mark's Reef. Other reefs that were only partially surveyed are also listed as ? > and a number. The number in this case represents the cumulative number of nests for all sections of the reef that were surveyed. Similarly, the columns # turtles resting and # turtles swimming have various listing relative to the number of visit to each reef. Those surveyed once list only one number, those visited twice have two number separated by a & symbol and with reefs that were visited three or more times listed with 2 numbers separated by the word (to), meaning the minimum and maximum numbers observed.

Patch 42 in Kaneohe Bay

Figure 6, on the next page, shows the general placement of most of the nests, that were surveyed for occupation rates, on the flat of reef 42. The outlined areas within the area designated as the reef are sand patches located on the flat. The patch was visited 27 times for periods of time ranging from 30 minutes to 2 ½ hours. Visits to nests were variable since some outlying holes were overlooked on occasion. This make determination of which site received the most absolute usage impossible. The site with the most visually observed occupations was nest 33 with turtles being present 48% of the time or 10 out of the 21 times the site was visited. In addition, on one visit we recorded two turtles in the hole and on 4 of other visits from 2 to 4 additional turtles were posing for cleaning, by wrasse's, in the water directly above the nest. Temperature readings were not made but the water in the site felt cooler than the surrounding seawater and a shimmer that may have been a fresh water seep was seen emerging from the nest.

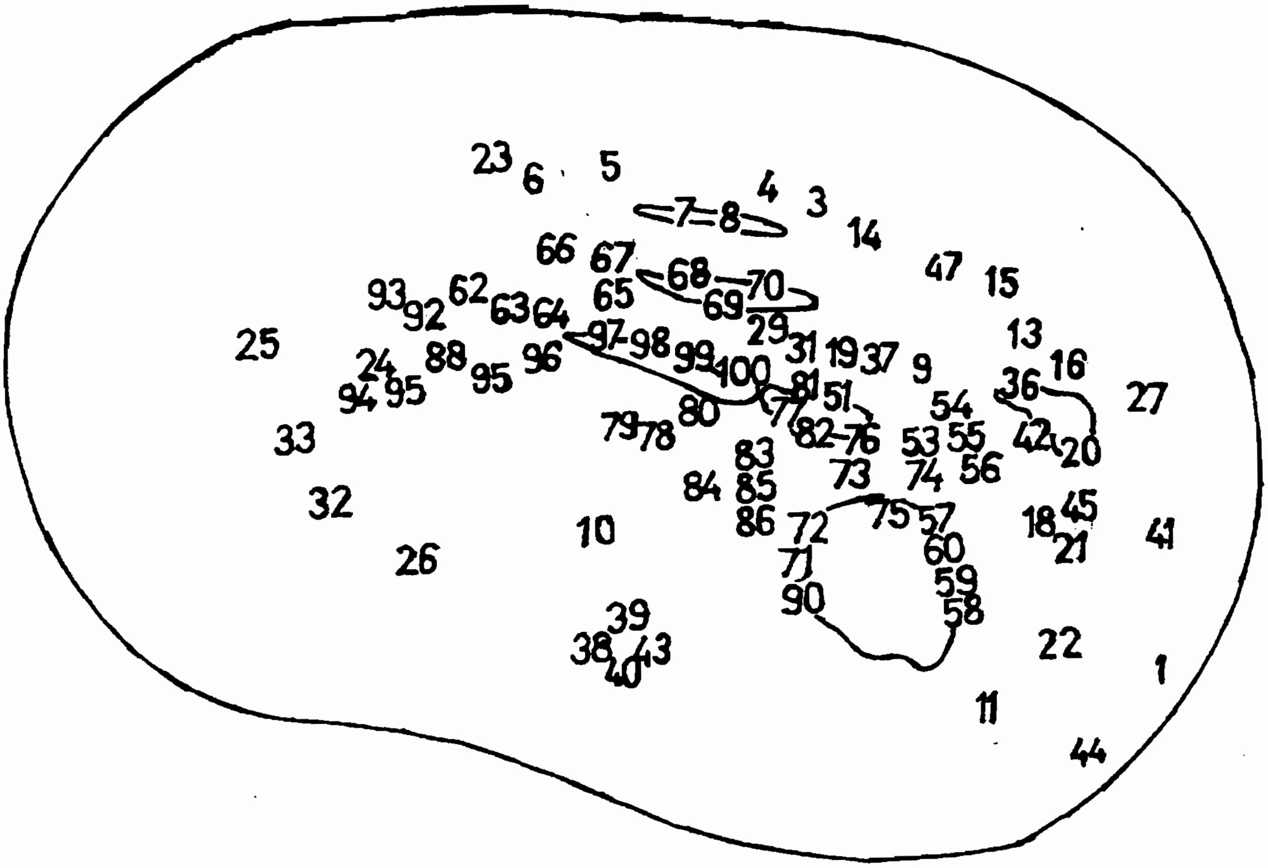


Figure 6: Outline of the flat of reef 42 showing approximate placement of nests in relation to the crest and to each other. The numbers are arbitrary other than being the numbers used to designate one site from another. Nest 33 on the northwest portion of the reef had the highest visual occupation rates with turtles present 48% of the time.

Figure 7 charts the number of times turtles were visually observed occupying nests. A total of 96 nests were checked between 1 and 24 times each and 101 times a turtle was observed resting. The majority, 52, of the holes we never saw a turtle in while the other 44 were occupied at least once and one hole was occupied 10 times.

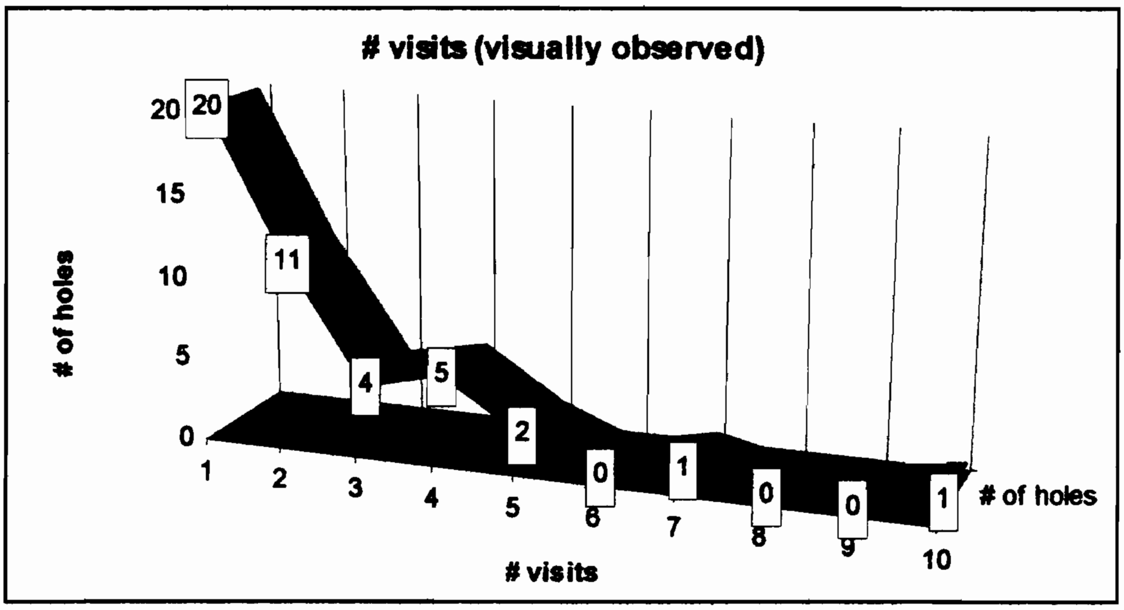


Figure 7: Graph of the number of visually observed visits to the 96 test nest sites on the flat of reef 42. A total of 101 occupations were recorded in 44 of the nests while 52 nests we never saw a turtle in.

In figure 8 the number of occupied nests, visually observed, as a ratio of the number of sites checked was plotted against time of day to determine if there is a change in occupation rate due to time of day.

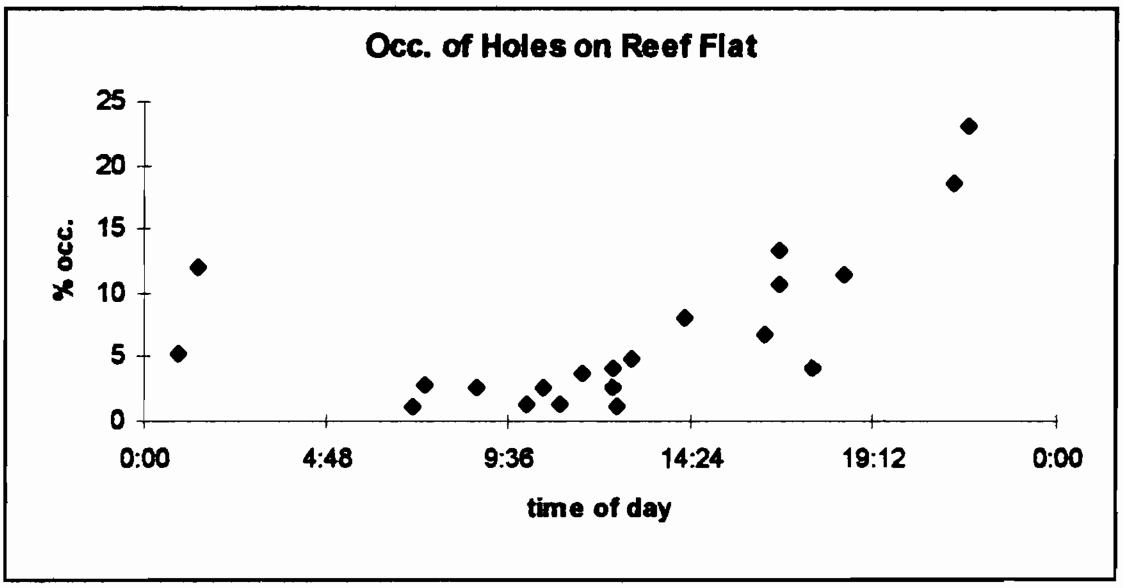


Figure 8: Percentage of nest sites that were visually observed to be occupied at various times of day/night.

Figures 9-10 chart the nail data for the flat of reef 42. In the five day run, from 4/20 to 4/24 (Figure 9), 67 sites were nailed and 217 knockdowns occurred. In the one day run, from 5/21 to 5/22 (Figure 10), 78 sites were nailed and 95 knockdowns occurred.

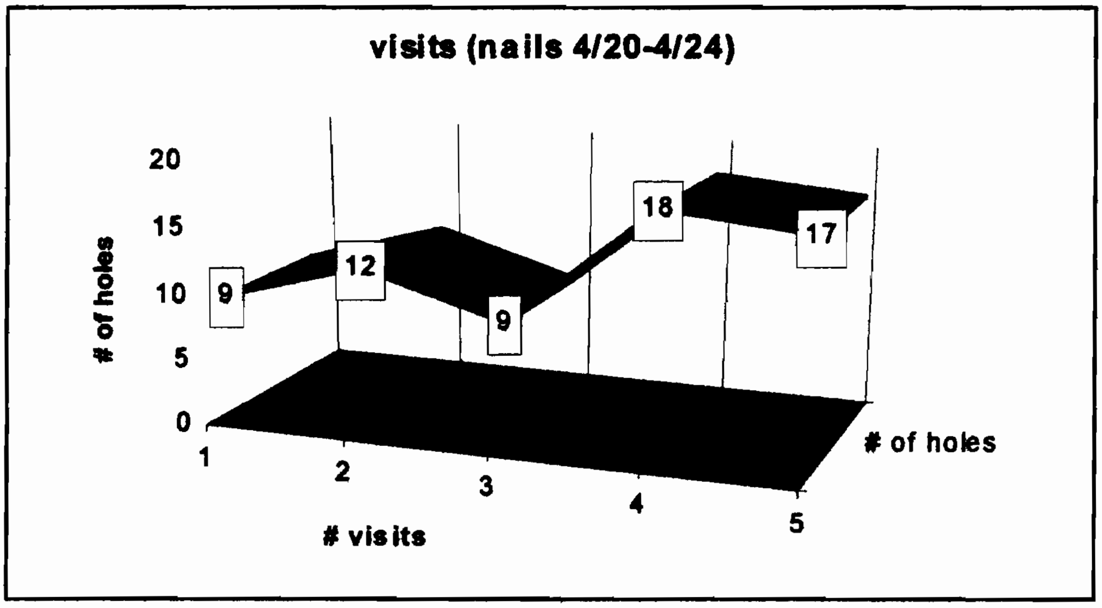
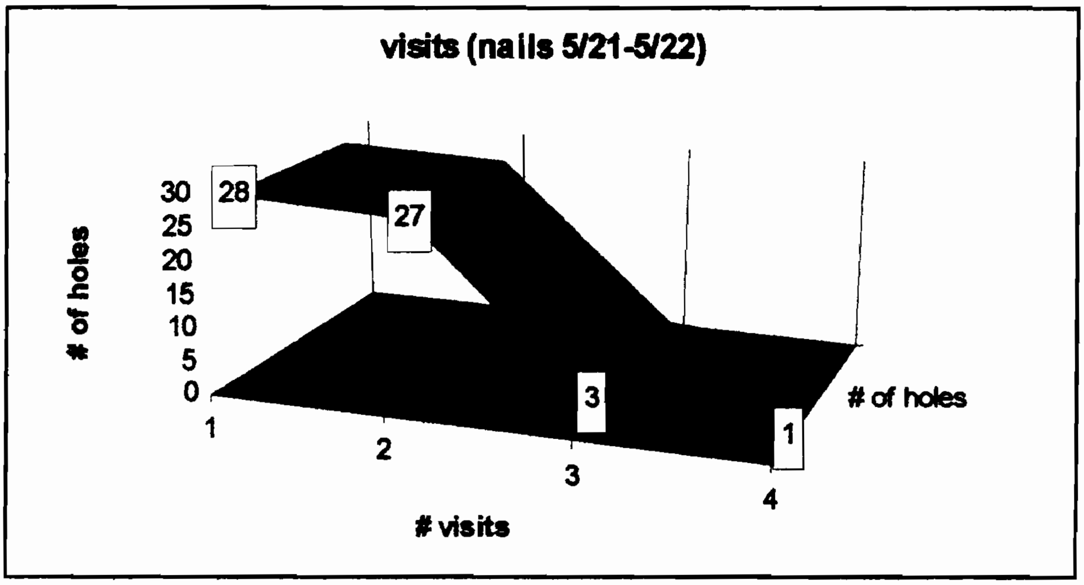


Figure: 9 (above) –10 (below): Number of visits to specific nests, as recorded by nail surveys, on the flat of patch reef 42.



Finally, Table 2 lists turtles that were seen associated with specific nests or seen multiple times on patch 42 as well as distinguishing deformities such as a tumors or amputations that made them notable.

Nest #	~Size (juv, sub-adult, adult)	Distinguishing Characteristics
----	large juvenile	tumorous mass over whole left eye
----	sub-adult	amputated front right flipper
----	adult female	amputated front left flipper
8	large sub-adult	grapefruit size tumor right shoulder
		orange size tumor base of right hind flipper
13	juvenile	blue tag left front flipper
		grapefruit size tumor left front flipper just below tag
33	sub-adult	orange size tumor under right front flipper
33	large sub-adult	amputated front right flipper
35	juvenile	amputated front right flipper
37	adult male	----
44	juvenile	tangerine size tumor under left front flipper
		tangerine size tumor left shoulder
		orange size tumor mass under right front flipper
		multiple <dime size tumors around left eye
51	juvenile	multiple nickel size tumors above left eye
		multiple nickel size tumors below right eye
65	sub-adult	amputated front left flipper
65	sub-adult	silver tag right front flipper
68	----	orange size tumor under left front flipper
100	sub-adult	cantaloupe size tumor at base of neck on right side

Table 2: List of turtles with distinguishing characteristics and the number of the nest where the turtle was seen resting.

Discussion

Kaneohe Bay

Bay wide our survey was incomplete with only 28 of the 57 reefs in the bay receiving attention (Figure 5, p. 16) and some of those did not receive sufficient attention to get an accurate measure of the number of nests present. Because of the difficulty in finding sites on substrates other than those that are mostly coral and the depths to which sites can be found it is our opinion that a more in-depth study of the bay wide distribution will require the use of scuba and either a substantially longer time frame or more field assistance. Having said this we can determine from the data gathered that while turtles are utilizing most of the reefs in the bay to one extent or another they are concentrating their nests on patch reefs in the north end of the bay and in the Mark's reef area (Table 1, p. 17). It is our opinion that reefs 24 and 7, as well as those listed in Table 1 as having no nests or turtles seen resting, are not being used to rest even though we observed turtles "resting" on these reefs. This is because at patch 24 the one turtle seen was not in a site, had advanced fibropapilloma and was so weak that it was considered that he/she was resting out of necessity rather than preference to that reef. Reef 7 on the other hand had three turtles "resting" in an area of sand and alga and it is our belief that they were feeding rather than resting.

Patch 42 in Kaneohe Bay

On patch 42, 97% of the 67 nests that were surveyed in run 1 of the nail assays had the nail dislodged at least once and 65% had the nail dislodged three or more times (Figure 9, p. 21). Additionally, 76% of the 78 sites surveyed in the 24-hour run had the nail dislodged at least once (Figure 10, p. 21). It should be noted that some underestimation might be present due to juvenile turtles on occasion entering and exiting nests without dislodging the nails, as was observed to happen on occasion. Visually observed resting occurred in 40% of the 96 nests and showed a pattern with numbers of resting turtles lowest from sunrise until ~1 p.m., with less <5% of nests occupied, and gradually increasing after 1 to reach a peak around 11 p.m. (Figure 8, p. 20). At no time did we visually observe more than 25% of assayed nests as being occupied. The increased percentage of occupation at night is consistent with the findings of Brill et. al. (1995) that both tumor-bearing and normal turtles within Kaneohe Bay tended to move into shallower areas or on to patch reefs at night.

Placement of sites on patch 42 did not appear to show a pattern, as sites were located on every part of the flat. This may be an indication that any part of a reef will be utilized for resting given that the available substrate is adequate. The occupation of the sites was not as random as there placement. Most of the daytime activity concentrated on the north end of the patch in the vicinity of holes 33 and 93. Evening occupation was more disperse with turtles resting in nests located all over the flat. This daytime concentration on the north end of the patch seems to be associated with the presence of a cleaning station at nest 33. Not only did this nest have the highest percentage of visually observed occupations (48%), but also on several assays we recorded from 1 to 6 turtles posing for cleaning (Losey et. al., 1994) in and around the site.

In relation to nest fidelity, it appears that turtles show some preference by returning to the same site multiple times, but they will rest in more than one nest. Whether the number of nests used by an individual is limited to two, as we observed, or unlimited is still unknown. Likewise what makes one site favorable to another at a given time unknown. In addition, we found that multiple turtles will occupy the same nest at different times and large nests at the same time. Whether this is a social behavior or just happens due to site preferences is an interesting question.

It is suggested that additional research in Kaneohe Bay take the form of continued tag and recapture to monitor individual and population growth rates as well as to follow the spread of Fibropapillomatosis. In addition, a more in-depth study of all fringe and patch reefs as well as the bay side of the barrier reef using set guidelines for site identification should be undertaken. In conjunction to that study a through study on the distribution and coverage of alga within the bay should be made in order to determine the maximum turtle population size the bay will support. Green turtle populations are on the upswing and with continued research efforts and public awareness maybe one day they can shed the protected and endangered tag.

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