ASSESSMENT OF THE RESIDENT GREEN SEA TURTLE POPULATION IN THE VICINITY OF THE LAUNIUPOKO STATE PARK, WEST MAUI, HAWAII

Submitted to:

Sea Engineering, Inc.
Makapuu Research Pier
Waimanalo, Hawaii 96795

By:

Dr. Richard E. Brock, Principal
Environmental Assessment Co.
1804 Paula Drive
Honolulu, Hawaii 96816

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INTRODUCTION

Because of declining population sizes the green sea turtle (Chelonia mydas) was granted protection under the federally mandated Endangered Species Act in 1977-78. Green sea turtles as adults are known to forage and rest in the shallow waters around the main Hawaiian Islands. Reproduction in the Hawaiian population occurs primarily in the Northwest Hawaiian Islands with adults migrating during the summer months to these isolated atolls and returning in late summer or early fall. In the main Hawaiian Islands green sea turtles will rest along ledges or in caves in coastal waters from 40 to 80 feet in depth during the day. Under the cover of darkness turtles will travel inshore to shallow subtidal and intertidal habitats to forage on algae or limu (Balazs et al. 1987). The normal range of these daily movements between resting and foraging areas is about one kilometer (Balazs 1980; Balazs et al. 1987). Thus from the present state of knowledge, an ideal green sea turtle habitat would have the presence of appropriate offshore resting areas (caves, ledges or undercuts) being located within a kilometer or less of a sufficient abundance of appropriate forage algal species situated in shallow water. Selectivity of algal species consumed by Hawaiian green sea turtles appears to vary with the locality of sampling but stomach content data show Acanthophora spicifera and Amansia glomerata to be quantitatively the most important (Balazs et al. 1987); this may be related to their ubiquitous distributions.

Harbor and docking facilities have been at a premium for years in the Lahaina, Maui area. This space shortage has prompted private enterprise to consider the development of such facilities. Preliminary analyses have suggested that the area south of Lahaina bordered by Puamana Park on the north and Launiupoko State Park on the south may be an appropriate location for marina development. Biological studies (AECOS 1987, Brock 1988) have noted that marine communities in the Launiupoko area to be depauperate of fishes and lacking much live coral probably as a result of occasional high energy impact. In their ecological assessment, these authors noted only one green sea turtle; this individual was seen alongside of a large Porites lobata colony approximately 600m offshore (outside of the study area) in 14m of water (Brock 1988). This turtle was in an area reputed to be a turtle resting site by local divers. Statements by local divers suggest that no more than three turtles have been seen at any one time in this location. The substratum surrounding this resting site was quite flat being comprised of sand and rubble with little apparent bottom relief. The study concluded that within the area surveyed, little green sea turtle resting habitat was present. Both studies however noted the presence of considerable algae in the inshore areas at Launiupoko. Among the common species were several known to be preferentially consumed by green sea turtles.

The presence of potential forage ground at Launiupoko has prompted permitting agencies to request further study to determine if Hawaiian green sea turtles are present in the area and if so, to assess the potential impact that may occur with such development. This study is responding to this request; the objectives are:

1. To determine if appropriate green sea turtle resting habitat exists in the offshore waters at Launiupoko extending from shore to the 20m isobath along a 1.6km section of coast centered on the proposed project site;

2. If present, quantify the abundance of green sea turtles in this resting habitat;

3. To quantify the algal resources both within the "footprint" of the proposed marina and adjacent to it;

4. To ascertain if green sea turtles are utilizing the shallow subtidal/intertidal algal resources at Launiupoko;

5. To assess the potential for impact on green sea turtles with the development of the marina.

METHODS

Appropriate turtle resting sites were searched for by systematically towing a diver behind a vessel over much of the study site. This effort was supplemented by SCUBA surveys particularly where water clarity did not permit adequate observation from the surface. Additionally, nearshore areas were examined by swimming from shore. At all times, an individual in the support vessel noted any turtles seen on the surface. If turtles were encountered either on the surface or underwater, estimates on straight line carapace lengths were made and if visually apparent, we noted the presence of deformities, tumors or tags.

To quantitatively describe the macrothalloid algal communities present in the shallow subtidal regions (0.7 to 1.5m) of the study area, five stations were established; three of these were within the "footprint" of the proposed marina and two (one to the 940m north and the second 630m to the south of the harbor centerline) were outside of it. At each station six one square meter quadrats were used to sample the algae by placing a 1 x 1m frame on a 25m transect line at the 0, 5, 10, 15, 20, and 25m points; this effort was repeated to provide one replicate for each station. Qualitative notes were taken on common and visually dominant algal species encountered in the vicinity of each station.

As noted above, green sea turtles are known to forage in

shallow subtidal/intertidal areas at dusk, under the cover of darkness or at dawn. Thus to ascertain if foraging is occuring in these nearshore areas, a visual reconnaissance was made at these times from shore using binoculars.

RESULTS

Field data were collected on two occasions: 4-5 November and 15-16 November 1988. The 4-5 November field effort was greatly hampered by the arrival of a tropical storm which within 8 hours resulted in water clarity in the study area going to zero due to storm generated surf, high rainfall and runoff. Thus a second two-day field sampling was undertaken on 15-16 November 1988.

The field survey for turtle resting areas covered an area from shore to the 20m isobath and laterally to the north and south at least 800m from the centerline of the proposed marina (Figure 1). Also shown in Figure 1 are the approximate tracks of our surface tows, SCUBA surveys and shoreline swims made to locate potential turtle resting sites. Earlier surveys (Brock 1988) located one large Porites lobata coral colony about 600m offshore of the proposed marina with one resting green sea turtle; this site was rechecked on 4 and 15 November 1988 and no turtles were present. No turtles were encountered underwater in any of the present field effort.

Figure 2 presents the approximate boundaries of the five biotopes recognized in earlier surveys (AECOS 1987, Brock 1988) as well as one new biotope -- the biotope of scattered Porites lobata colonies that commences along the southern boundary of the study site. Throughout the study area cover that may be appropriate as turtle resting sites is almost nonexistent. In the offshore region (i.e.,depth ranges from 5 to at least 25m) the substratum is comprised primarily of sand and Halimeda beds with little relief present. Porites lobata coral colonies (usually mostly dead and eroded) are occasionally encountered in this offshore area; the spacing on these corals is approximately one colony per 450-500m linearly traversed and mean colony size is about 1.5m. If resting green sea turtles require shelter, the only area located in this study that may have approriate shelter is in the biotope of scattered Porites lobata colonies (Figure 2) commencing about 800m south from the center of the proposed marina and about 100m south of Launiupoko State Park. It should be noted that most of the larger corals in this biotope are dead and the water depth is only 4 to 5m. The area appears to receive considerable wave impact (similar to the rest of the study site) and roiling sand was apparent between the corals even with low surf conditions on 15-16 November.

During the resting habitat survey on 4, 15 and 16 November records were kept on all turtles sighted at the surface; these

Figure 1. Map of the study area situated between Launiupoko Park on the south and Puamana Park on the north at Launiupoko, West Maui with the north and south boundaries shown with straight lines. The study area is also bounded by the shore and the 20m isobath. Also shown are the approximate tracks of our surface tows behind a vessel (long dashed lines), SCUBA surveys (solid lines) and shoreline swims (short dashed lines) conducted to locate turtles and resting habitat in the study area.

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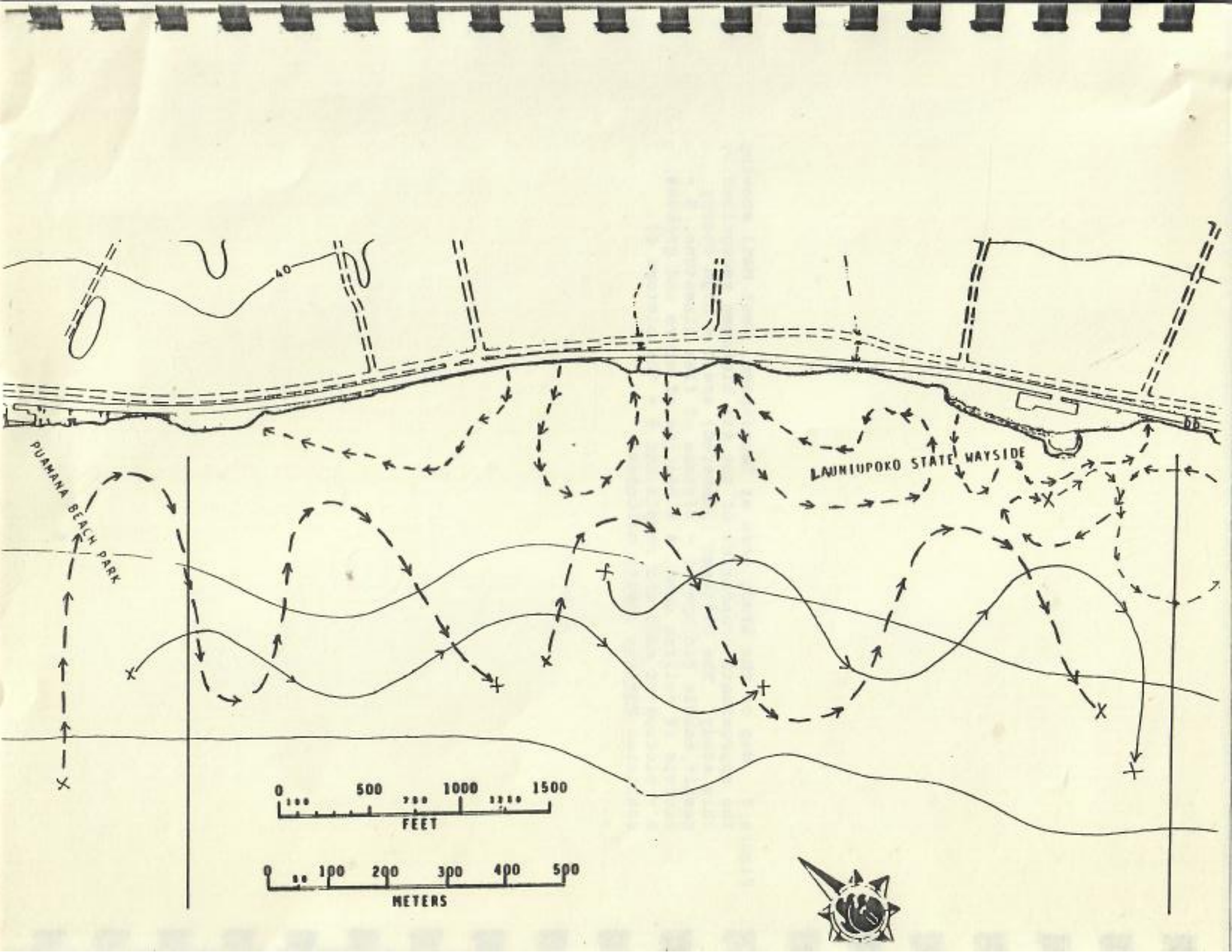
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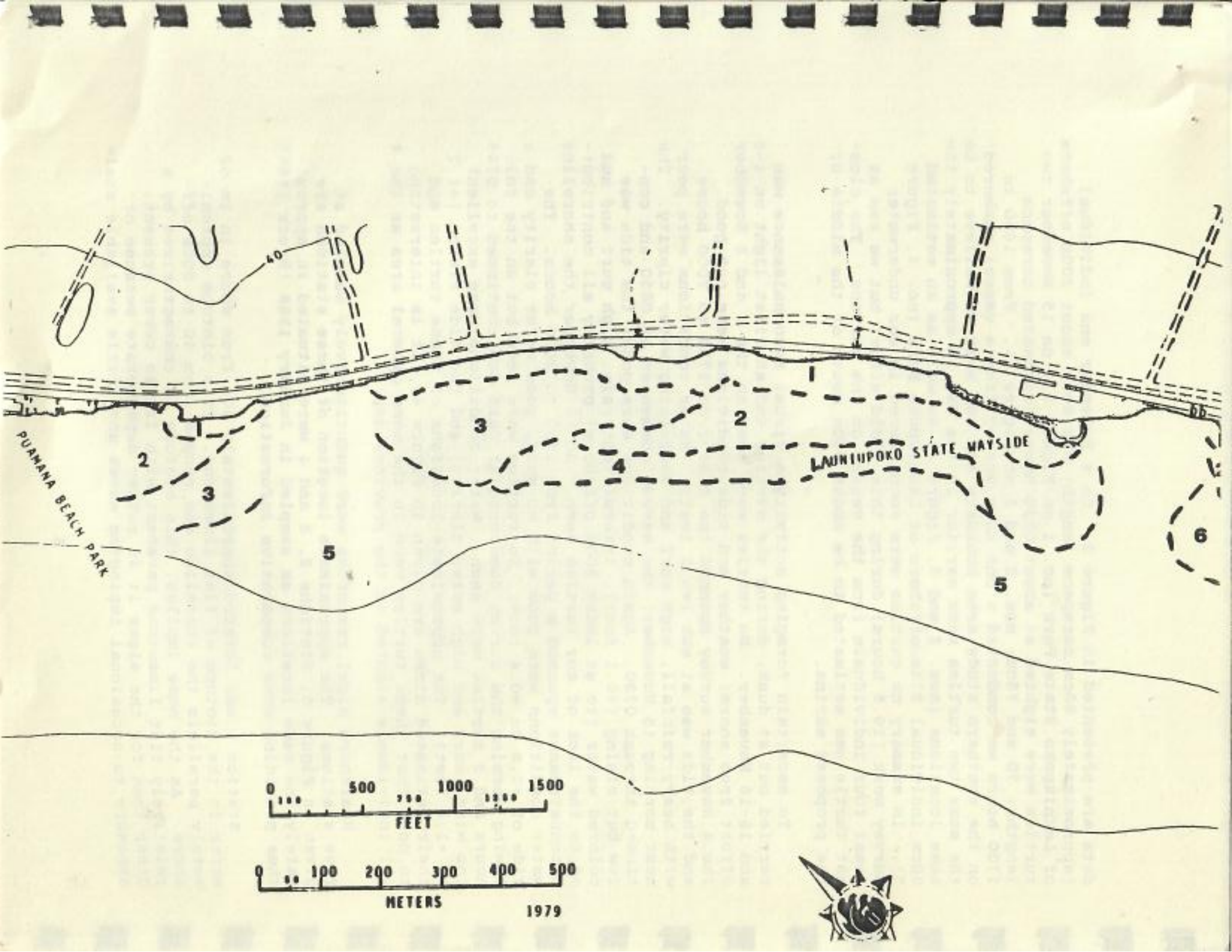
Figure 2. Map of the study area at Launiupoko, West Maui showing the approximate boundaries of the six biotopes recognized by this study. The biotopes (numbered) are 1 = high energy basalt cobble biotope, 2 = biotope of flat limestone, 3 = biotope of roiling sand, 4 = biotope of spurs and grooves, 5 = biotope of sand and rubble and 6 = the biotope of scattered Porites lobata colonies.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data are presented in Figure 3. On 4 November one individual (approximately 60cm carapace length) was seen about 200m offshore of Launiupoko State Park (no. 1 on Figure 3); on 15 November two turtles were sighted at about 0930 hours (estimated carapace lengths: 70 and 75cm; nos. 2 and 3 on Figure 3). From 1600 to 1700 hours we conducted a one hour survey from a vessel anchored on the southern study area boundary and saw what we believe to be the same two turtles seen earlier in the day in approximately the same locations (nos. 2 and 3, Figure 3) as well as an estimated 60cm individual 275m offshore of Launiupoko Park (no. 4, Figure 3). In summary no turtles were encountered in our underwater survey work (29.5 hours) during this field effort but we saw at least four individuals from the vessel on the surface. The closest turtle was estimated to be about 400m south of the middle of the proposed marina.

To ascertain foraging activity a visual reconnaissance was carried out at dusk, during the evening and at first light on 4-5 and 15-16 November. No turtles were seen on the 4 and 5 November effort from shore; weather and tide conditions were not good. The 4 November survey spanned the time from 1730 to 2000 hours and the tide was at ebb (+0.2 feet). Water conditions were poor with heavy rainfall, high surf and decreasing water clarity. The next morning (5 November) the survey commenced at 0630 and continued through 0730. Again conditions were poor; the tide was low but rising (+0.1 foot), intermittent rain, high surf and mud colored water (to at least 500m offshore) probably all contributed to the lack of any turtles seen. On 15 November the shoreline reconnaissance spanned a period from 1730 to 2000 hours. The water conditions were good with no surf, good water clarity and a tide of +0.3 to +0.4 foot. No turtles were seen but on the following morning the survey commenced at 0615 and continued to 0745 hours and 3 turtles were seen. Water conditions were excellent (no wind, surf and high water clarity) and the tide rising (+1.2 to +1.4 feet). The approximate locations of these turtles and their estimated sizes are given in Figure 4. It is interesting to note that these turtles were in the same general area as the 4 (?) individuals sighted on the previous day.

Nearshore algal resources were quantitatively sampled at five stations. The approximate location of these stations are given in Figure 5; Stations 2, 3 and 4 were situated in approximately the same locations as sampled in January 1988 (Brock 1988) thus providing some comparative information.

Station 1 was located approximately 40m from shore in 1m of water in the biotope of flat limestone. This biotope approximately parallels the shoreline and ranges from 40 to 200m offshore. As the name implies, this biotope is characterized by a relatively flat limestone pavement with little cover present. Other than for the algae it is rather depauperate because of exposure to occasional impinging waves and little available shel-

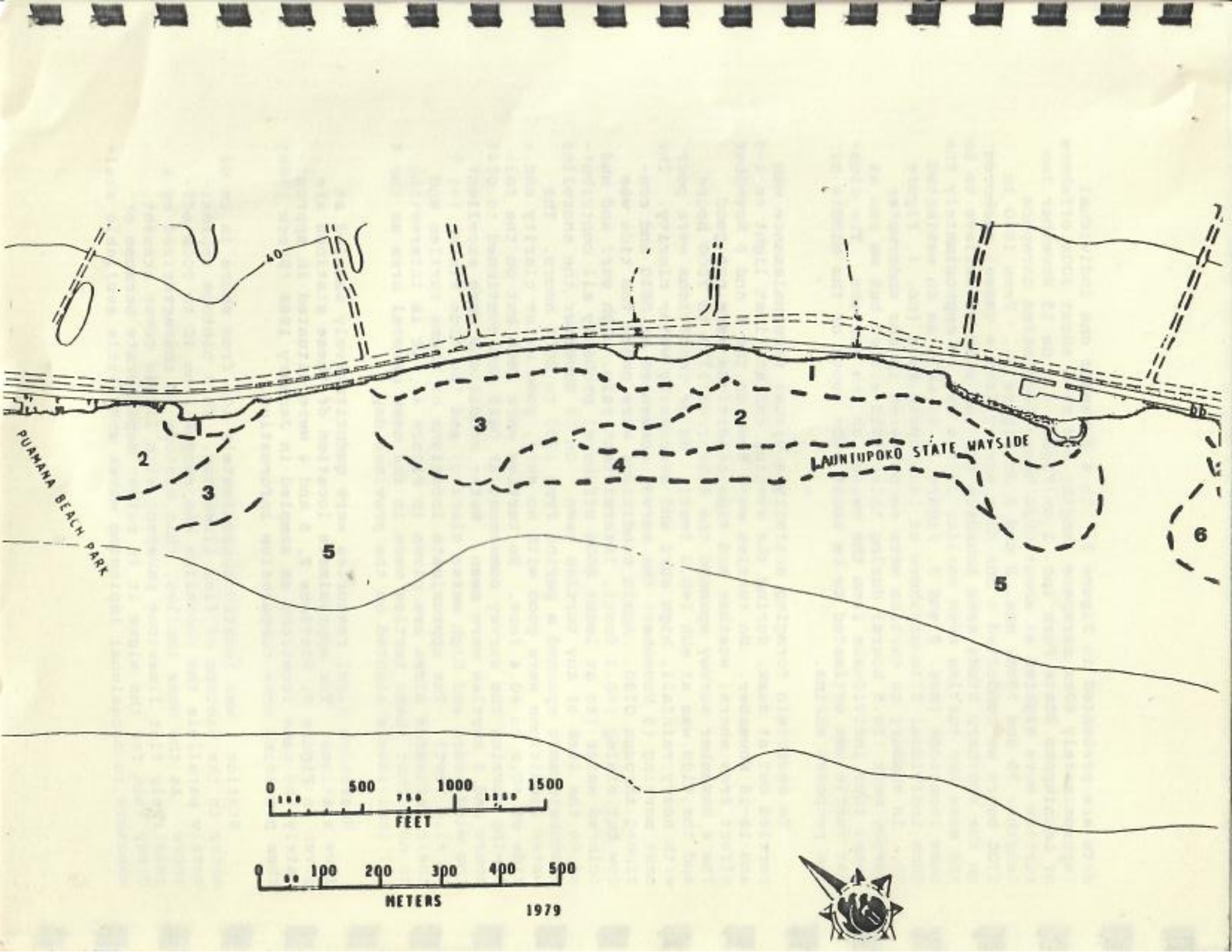
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Figure 3. Sightings of green turtles on the surface made from the vessel in the Launiupoko, West Maui study area; locations are shown by numbers and are described thusly: 1 = 4 November 1988, estimated carapace length of 60cm; 2 = 15 November 1988, estimated carapace length of 70cm; 3 = 15 November 1988, estimated carapace length of 75cm; and 4 = 15 November 1988, estimated carapace length of 60cm.

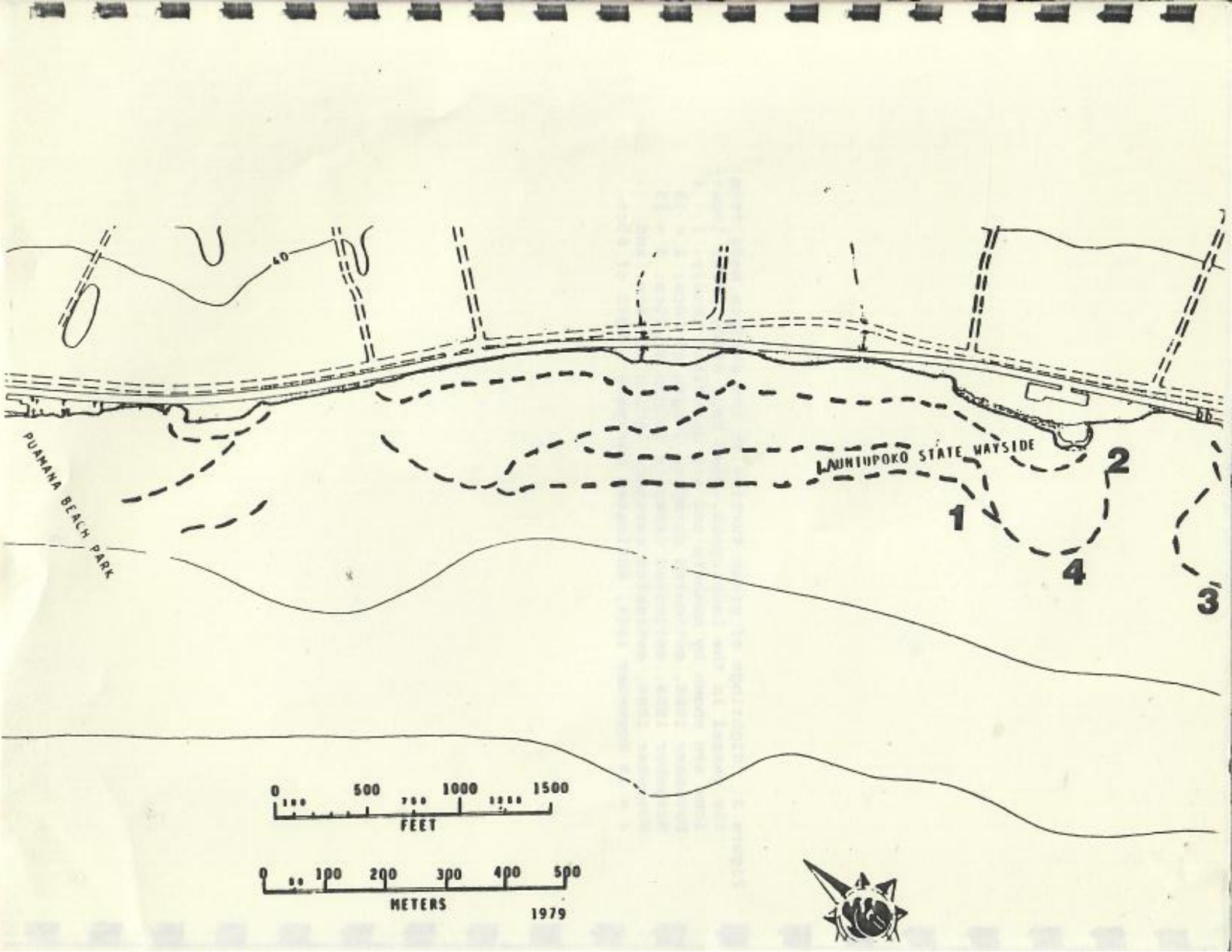
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Figure 4. Sightings of green turtles in the shoreline surveys of foraging habitat at Launiupoko, West Maui. Surveys were conducted on the evenings of 4 and 15 November 1988 and mornings of 5 and 16 November 1988. Turtles were all seen on 16 November and their locations are shown with a number: 1 = estimated 60cm carapace length, 2 = estimated 70cm carapace length, and 3 = estimated 75cm carapace length turtle.

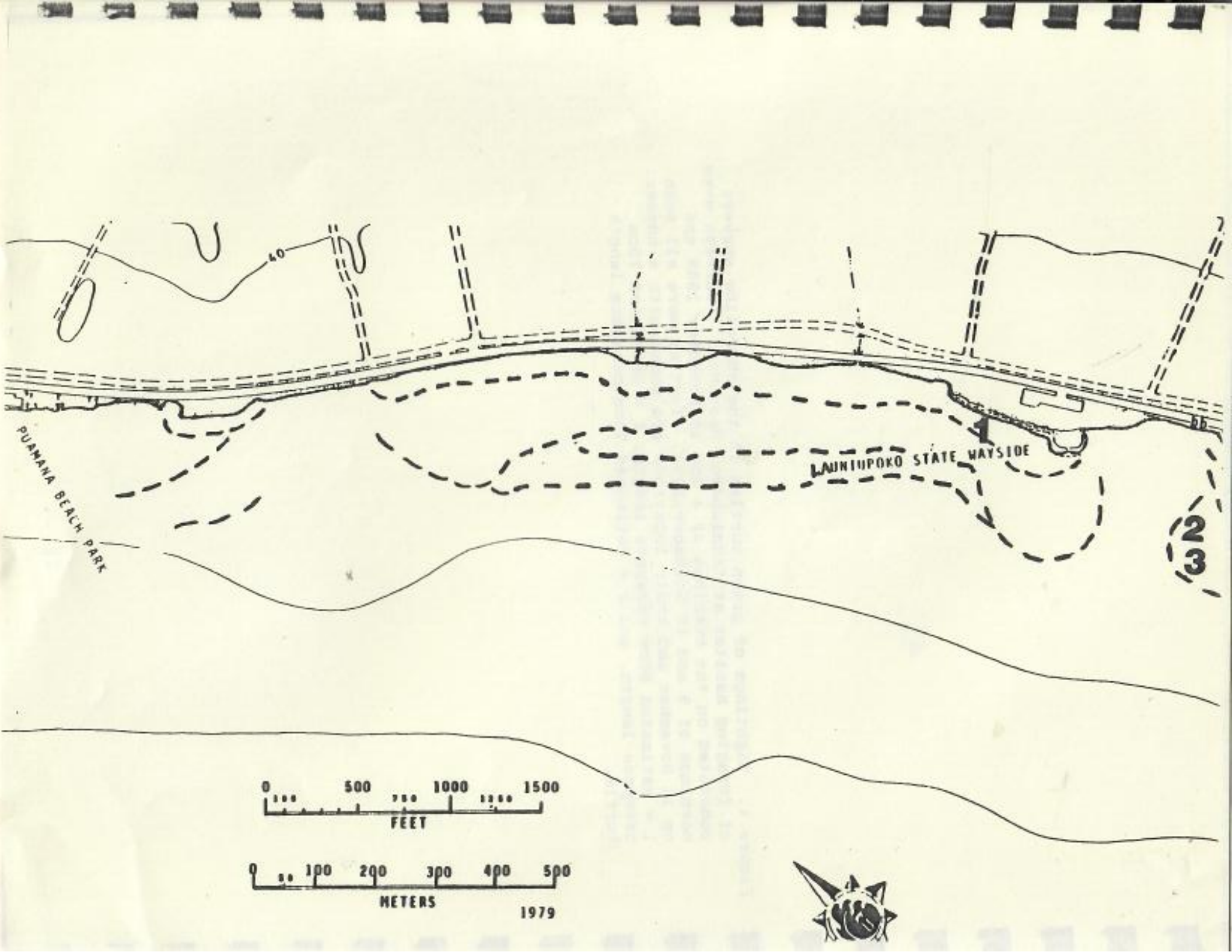
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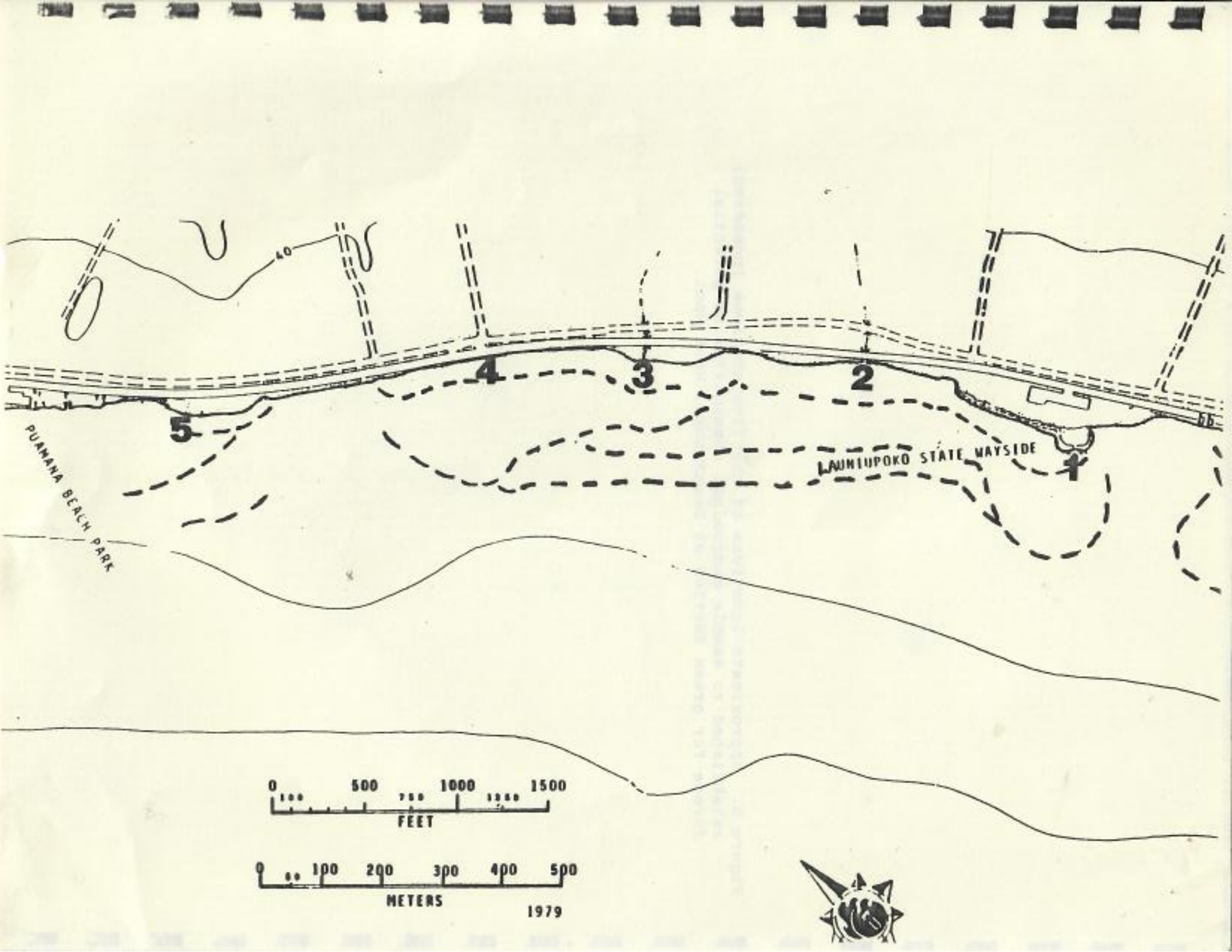
Figure 5. Approximate locations of the five stations (numbered) established to sample macroalgal communities as potential forage for green turtles at Launiupoko, West Maui.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ter. Brock (1988) quantitatively describes the fish and benthic communities present in this biotope. The substratum at Station 1 is comprised of limestone with some sand and rubble present patchily forming a veneer. Little relief is present and small depressions 0.25 to 1m in diameter, to 10cm deep are spaced from 0.5 to 7m apart. The algal community at this location is diverse; in total 26 algal species were enumerated in the 12 square meters that sampled this station. Twenty algal species were encountered in Transect 1 (mean fleshy algal coverage = 12.3%; Table 1) and 22 species in Transect 2 (mean fleshy algal coverage = 14.4%; Table 2). In terms of coverage, the most important species were kala (Sargassum polyphyllum), Coelothrix irregularis, Acanthophora spicifera and mane'one'o (Laurencia nidifica). No corals were encountered at this station.

Station 2 was established approximately 20m offshore of the culvert 165m north of Launiupoko State Park in 1 to 1.5m of water in the high energy cobble biotope. This biotope occurs as a near continuous feature in the area affronting the proposed marina site and extends seaward from 30 to about 50m. The substratum of the high energy cobble biotope is dominated by basalt rocks ranging in diameter from about 20 to 80cm. The cobble substrate probably serves to buffer the shoreline from erosional effects of waves. Some groundwater seepage is in evidence at the shore-water interface particularly affronting the culverts. In the intertidal/shallow subtidal area among the emergent basalt rock are pupipi (nerita picea), littorines (Littorina pintado), ama'ama crabs (Grapsus tenicrustatus), blennies or pao'o (Istiblennius zebra and Entomacrodus marmoratus), goby (Bathygobius fuscus) and small hermit crabs (Calcinus laevimanus and Clibanarius zebra). On the intertidal rocks several algal species occur in abundance including limu lipoa (Dictyopteris plagiogramma), Pterocladia capillacea, Porolithon onkodes, Plocamium sandvicense, Grateloupia phuguoensis, Acanthophora spicifera, Turbinaria ornata, hulu'ilio (Giffordia breviarticulata), and aki'aki (Ahnfeltia concinna). Slightly subtidal one encounters the sea urchins (Echinometra mathaei, E. oblongata, Echinothrix diadema and Tripneustes gratilla), sea cucumber (Actinopyga mauritiana), soft coral (Palythoa tuberculosa), juvenile manini (Acanthurus triostegus), ala'ihi (Adioryx lacteoguttatus), kupipi (Abudefduf sordidus) and aholehole (Kuhlia sandvicensis). Subtidal fish and benthic communities of the high energy basalt cobble biotope are described in Brock (1988).

One coral species (Porites lobata) was encountered at Station 2 with an estimated coverage of less than 0.2 percent. Nine species of algae were enumerated in the two transects (12m^2 sampled); nine species were noted in Transect 1 (mean fleshy algal coverage = 11.7%; Table 3) and 6 species were censused in Transect 2 (mean fleshy algal coverage = 11.4%; Table 4). The most important species to this cover were wawae'iole (Codium edule),

Table 1. Results of the algal survey conducted at Station 1, Transect 1 in the biotope of flat limestone at Launiupoko, West Maui. Data in the body of the table is based on $6m^2$ of sampled substratum and are expressed as a percent cover. Water depth is 1m and the mean coverage by fleshy algal species is 12.3 percent.

	QUADRAT NUMBER					
SPECIES	1	2	3	4	5	6
ALGAE						
Sargassum polyphyllum	3	1	3	5	1	3
S. obtusifolium					2	
Acanthophora spicifera	3	2.5	2	1		
Padina japonica	0.1	1	0.1		0.1	
Sphacelaria furcigera	0.1	1				
Dictyota acutiloba	1					0.1
D. sandvicense	0.1	0.1			0.3	
D. bartayresii	0.1			0.1		
Dictyopteris plagiogramma			0.1			0.1
Lyngbya majuscula		2				
Laurencia nidifica	1	6	3	0.1	2	
Plocamium sandvicense			0.1			
Grateloupia filicina				0.1	1	0.1
Gracilaria bursapastoris				0.1	3	0.2
Coelothrix irregularis			3	4	5	3
Turbinaria ornata					1	
Spatoglossum solierii		0.1	0.1			
Microdictyon setchellianum					2	2
Hypnea musciformis						4
Halimeda opuntia	0.5	1	4			0.5
SAND	30		60	37	38	2
RUBBLE	6	2		3		
HARD SUBSTRATUM	55.3	83.2	24.5	49.7	46.8	82.7

Table 2. Results of the algal survey conducted at Station 1, Transect 2 in the biotope of flat limestone at Launiupoko, West Maui. Data in the body of the table is based on $6m^2$ of sampled substratum and are expressed as a percent cover. Water depth is 1m and the mean coverage by fleshy algal species is 14.4 percent.

	QUADRAT NUMBER					
SPECIES	1	2	3	4	5	6
ALGAE						
Sargassum polyphyllum	2.5	0.5	7	7	3	2
S. obtusifolium				4	3	
Padina japonica	0.5	1	0.1			
Grateloupia filicina		0.1	0.1			
Gracilaria bursapastoris	0.1	0.5				
Dictyota acutiloba	0.7			0.1		
D. sandvicense	0.1					
Dictyopteris plagiogramma	0.1					0.1
D. australis				0.1		
Lyngbya majuscula	1					
Sphacelaria furcigera			0.1			
Laurencia nidifica	3	5	1		0.5	
L. obtusa	0.1					
Coelothrix irregularis	2	3	2	4	7	7
Hypnea musciformis		1				
Acanthophora spicifera		4				2
Dictyosphaeria cavernosa			0.1	1		
Microdictyon setchellianum				4	1	
Ulva fasciata					0.01	
Porolithon onkodes		2				
Halimeda opuntia			0.1			
H. discoidea	0.1			2	0.1	
SAND	15		6	28	2	6
RUBBLE			30			3
HARD SUBSTRATUM	75	82.7	53.5	55.9	80.39	76.8

Table 3. Results of the algal survey conducted at Station 2, Transect 1 in the high energy basalt cobble biotope at Launiupoko, West Maui. Data in the body of the table is based on $6m^2$ of sampled substratum and are expressed as a percent cover. Water depth is 1-1.5m and the mean coverage by fleshy algal species is 11.7 percent.

	QUADRAT NUMBER					
SPECIES	1	2	3	4	5	6
ALGAE						
Codium edule	35	5	8	1		
C. arabicum			0.1			
Acanthophora spicifera	2	5	2		0.5	0.5
Turbinaria ornata	0.1					
Laurencia obtusa		2		4		0.5
Amansia glomerata			4			
Centroceras clavulatum						0.1
Porolithon onkodes	56	64	3	3		
P. gardineri		0.1	0.5			
SAND					70	61
BASALT ROCK	6.9	24	82.9	91.4	29.5	37.9

Table 4. Results of the algal survey conducted at Station 2, Transect 2 in the high energy basalt cobble biotope at Launiupoko, West Maui. Data in the body of the table is based on $6m^2$ of sampled substratum and are expressed as a percent cover. Water depth is 1-1.5m and the mean coverage by fleshy algal species is 11.4 percent.

	QUADRAT NUMBER					
SPECIES	1	2	3	4	5	6
ALGAE						
Codium edule	19	11	5	1		
Acanthophora spicifera	3	6	1		0.1	
Amansia glomerata		1		15		
Laurencia obtusa		1.5	3	0.5		1
Centroceras clavulatum					0.1	
Porolithon onkodes	28	48	5			1
CORALS						
Porites lobata		1				
SAND				1	23	3
BASALT ROCK	50	31.5	86	82.5	76.8	95

Acanthophora spicifera and Amansia glomerata. The encrusting coralline alga, Porolithon onkodes was common at this station but is not utilized by green turtles.

Station 3 was also established 25m from shore in the high energy cobble biotope; the basalt cobble at this station ranged in size from 20 to about 75cm and the water depth from 0.3 to 1.2m. This station was located approximately 350m northwest of Station 2. Thirteen species of algae were found at Station 3; 9 algal species were seen on Transect 1 (Table 5) and 11 species on Transect 2 (Table 6). The coverage by fleshy algal species was estimated to be 10.4 percent on Transect 1 and 4.6 percent on Transect 2. The most important macrothalloid algal contributor to this coverage was Pterocladia capillacea because of a near emergent basalt rock encountered in Transect 1. Sea urchins were very abundant at this station and probably contributed to the low subtidal coverage by fleshy algal species. Again, the encrusting coralline, Porolithon onkodes, was the most abundant algal species at this station.

Station 4 was established in the biotope of roiling sand which is characterized by a limestone substratum over which a veneer of sand occurs that is frequently moved about by passing waves causing considerable scouring of the substratum. This situation promotes the development of benthic community components that are able to rapidly colonize, grow and reproduce before the next storm event clears the substrate. Many of the algae have adapted this strategy and macrothalloid algae are a common element in this area. Brock (1988) provides a quantitative description of the fish and benthic communities present in this biotope. Station 4 was located approximately 250m northwest of Station 3 about 60m offshore in 1 to 1.2m of water. The substratum at this station is limestone with small sand filled depressions spaced 1 to 5m apart. These depressions are 0.5 to 1m in width and 0.5 to 1.5m in length. The sand in these depressions roils with the passing waves. There is very little shelter available in the area for fishes and invertebrates. The $12m^2$ of substratum sampled at this station found 14 species of algae; twelve species were encountered on Transect 1 and the mean coverage of fleshy algae was 27.4 percent (Table 7). The second transect had 8 species with a mean fleshy algal coverage of 31.8 percent (Table 8). The most important species contributing to this coverage were limu kala (Sargassum polyphyllum) and Spyridia filamentosa.

Station 5 was established in the high energy cobble biotope approximately 600m northwest of Station 4 about 10m offshore in 1.5m of water. This station lies off the rocky headland about 125m south of Puamana Beach Park. The basalt cobble and rock at this station ranged from 20 to 80cm in diameter. Eleven algal species were censused in the $12m^2$ sampled in the quadrat survey. On Transect 1 seven algal species were encountered with a mean

Table 5. Results of the algal survey conducted at Station 3, Transect 1 in the high energy basalt cobble biotope at Launiupoko, West Maui. Data in the body of the table is based on $6m^2$ of sampled substratum and are expressed as a percent cover. Water depth is 0.3-1.2m and the mean coverage by fleshy algal species is 10.4 percent.

	QUADRAT NUMBER					
SPECIES	1	2	3	4	5	6
ALGAE						
Turbinaria ornata	1	0.3				
Acanthophora spicifera	3	2				2
Codium edule	0.5				1	
Galaxaura filamentosa	3	1.5				
Laurencia nidifica	1					
Pterocladia capillacea			38			
Centroceras clavulatum			3			
Hypnea musciformis						6
Porolithon onkodes	42	29	51	87	65	31
CORALS						
Porites lobata					2	2
BASALT ROCK	49.5	67.2	8	13	32	59

Table 6. Results of the algal survey conducted at Station 3, Transect 2 in the high energy basalt cobble biotope at Launiupoko, West Maui. Data in the body of the table is based on $6m^2$ of sampled substratum and are expressed as a percent cover. Water depth is 0.3-1.2m and the mean coverage by fleshy algal species is 4.6 percent.

	QUADRAT NUMBER					
SPECIES	1	2	3	4	5	6
ALGAE						
Acanthophora spicifera						6
Codium edule	0.1					
C. arabicum				0.5		
Galaxaura filamentosa	4	2				
Laurencia nidifica		6				1
Asparagopsis taxiformis		0.1	1			
Centroceras clavulatum			2			
Dictyota bartayresii		0.1				
Pterocladia capillacea			4			
Spyridia filamentosa						1
Porolithon onkodes	29	43	15	86	76	41
SOFT CORALS						
Palythoa tuberculosa			3			
BASALT ROCK	66.9	48.8	75	14	23.5	51

Table 7. Results of the algal survey conducted at Station 4, Transect 1 in the biotope of roiling sand at Launiupoko, West Maui. Data in the body of the table is based on $6m^2$ of sampled substratum and are expressed as a percent cover. Water depth is 1-1.2m and the mean coverage by fleshy algal species is 27.4 percent.

	QUADRAT NUMBER					
SPECIES	1	2	3	4	5	6
ALGAE						
Sargassum polyphyllum	60	52	1	4	3	5
Spyridia filamentosa	9	4	6	6	4	6
Gracilaria burapastoris				0.1		
Plocamium sandvicense			0.1			
Dictyopteris plagiogramma	0.5					
Dictyota actiloba					0.1	
D. bartayresii	0.1					
Padina japonica		1	1			
Laurencia nidifica			0.1			
Halimeda opuntia		0.5	0.1		0.5	
Porolithon onkodes						4
Jania sp.						1
SAND	8	8	19	40		
HARD SUBSTRATUM	22.4	34.5	72.7	49.9	92.4	84

Table 8. Results of the algal survey conducted at Station 4, Transect 2 in the biotope of roiling sand at Launiupoko, West Maui. Data in the body of the table is based on $6m^2$ of sampled substratum and are expressed as a percent cover. Water depth is 1-1.2m and the mean coverage by fleshy algal species is 31.8 percent.

	QUADRAT NUMBER					
SPECIES	1	2	3	4	5	6
ALGAE						
Sargassum polyphyllum	41	65	19	28	1	1
Spyridia filamentosa	5	5		9	6	3
Gracilaria burapastoris					0.2	
Amansia glomerata	2	0.5				
Dictyopteris plagiogramma		1				
Dictyota bartayresii	0.1		2			
Padina japonica	0.5		1.5			
Halimeda discoidea		0.1		1		
SAND	2	9	20	4		2
HARD SUBSTRATUM	49.4	19.4	57.5	58	92.8	94

coverage by fleshy species amounting to 11.3 percent (Table 9); Transect 2 had 9 species of algae with a mean coverage by the fleshy species of 4.2 percent (Table 10). The most important species in the coverage were Acanthophora spicifera and Spyridia filamentosa.

To obtain a more complete picture of the algal resources in the vicinity of the proposed marina at Launuiupoko, some time was spent walking the coast to the north and south of the study site. In general, wherever a rocky intertidal is encountered without scouring sand, one finds the same complex of fleshy algae as noted in the intertidal of the high energy cobble biotope. From the standpoint of green turtles, algal species that may be of importance in this complex of intertidal/shallow subtidal species include Pterocladia capillacea, limu lipoa (Dictyopteris plagiogramma, Plocamium sandvicense, Grateloupia phuquoensis, Acanthophora spicifera and aki'aki (Ahnfeltia concinna). This complex of algal species was found on the rocky point 550m to the northwest of the proposed marina (affronting Station 5). No similar rocky intertidal was encountered continuing in that direction (towards Lahaina) from this point. To the southeast of Launiupoko State Park are a number of rocky intertidal areas; the closest is about 100m southeast of the park. At this location Pterocladia capillacea appeared to be a common element in the intertidal.

DISCUSSION

The survey for potential green sea turtle resting habitat found one turtle on 4 November and three on 15 November 1988. All of these turtles were seen south of the project area and none of these were encountered underwater. Approximately 114ha were covered in 29.5 hours of effort and the only seemingly appropriate resting shelter was located about 100m southwest of Launiupoko State Park in 4 to 5m of water however no turtles were found resting at this location. Usually green sea turtles will select resting sites in water from 12 to 25m in depth. At those depths in the area surveyed by this study, we found little cover; rather sand flats with beds of Halimeda discoidea were common. Shoreward of the offshore sand and algal beds is the biotope of spurs and grooved limestone (Brock 1988); again, there is little cover for larger species such as turtles in this biotope. In short, it appears that resting habitat appropriate for green sea turtles is uncommon in the area surveyed at Launiupoko. Admittedly, appropriate resting habitat with turtles may have been missed in this survey but if any concentration of turtles were present in one location we probably would have seen them surfacing for air.

Conversations with dive charter operators and fishermen familar with the Launiupoko area suggest that turtles are not usually encountered offshore of the proposed marina site. All

Table 9. Results of the algal survey conducted at Station 5, Transect 1 in the high energy basalt cobble biotope at Launiupoko, West Maui. Data in the body of the table is based on $6m^2$ of sampled substratum and are expressed as a percent cover. Water depth is 1.3-1.5m and the mean coverage by fleshy algal species is 11.3 percent.

	QUADRAT NUMBER					
SPECIES	1	2	3	4	5	6
ALGAE						
Spyridia filamentosa	12	7	1	5	1.2	
Acanthophora spicifera	28	2		2		
Gracilaria burapastoris			0.1			
G. coronopifolia	0.1					
Laurencia nidifica			0.1		0.1	0.1
Amansia glomerata				1.5	6	1.75
Jania sp.	0.1					
SAND	3		12			
RUBBLE	56.8	91	6	12	3	62
BASALT ROCK			80.8	79.5	89.7	36.15

Table 10. Results of the algal survey conducted at Station 5, Transect 2 in the high energy basalt cobble biotope at Launiupoko, West Maui. Data in the body of the table is based on $6m^2$ of sampled substratum and are expressed as a percent cover. Water depth is 1.3-1.5m and the mean coverage by fleshy algal species is 4.2 percent.

SPECIES	QUADRAT NUMBER 1	2	3	4	5	6
ALGAE						
Spyridia filamentosa	9	2	0.5	0.1	0.75	
Acanthophora spicifera	5		4	0.1	0.1	
Hypnea musciformis		0.1				
Laurencia nidifica	0.1					
Gracilaria burapastoris		0.1				
Coelothrix irregularis			0.5			
Amansia glomerata				0.5	2	0.3
Sargassum polyphyllum						0.1
Halimeda discoidea	2					
SAND			66			
RUBBLE	83.9	97.8	29	6	70	99.4
BASALT ROCK				93.3	27.15	

individuals noted that offshore cover (appropriate resting habitat) is near absent in the area and that turtles are sometimes seen off of Launiupoko State Park as well as to the southeast.

Similar to our field efforts to locate appopriate resting habitat offshore, the shoreline foraging observations found few turtles. Three turtles were observed foraging on the morning of 16 November offshore of Launiupoko Park and to the south. These turtles were not browsing on the intertidal algae, rather one turtle was about 60m offshore (of the park) and the other two were at least 175m offshore and further south. The weather and tide conditions were ideal on 16 November for shallow foraging by turtles -- there was no surf or wind which resulted in "glassy" conditions thus simplfying the locating of any turtles present. However the field conditions were less that ideal during the other field survey periods and could explain the absence of turtles.

Despite the lack of appropriate offshore resting sites and the low number of turtles encountered in this survey, our data indicate that a considerable green sea turtle food resource is available in the area. This food resource is not restricted to the area of the proposed marina but occurs to the northwest and southeast of the project site. Table 11 presents a summary of the mean number of algal species and coverage for the five stations surveyed in this study. Also presented in this table are the means for stations (numbers 1,4 and 7) sampled in January 1988 by Brock (1988). The location of these latter stations are not exactly duplicated between the two studies, but probably fall within 20m or less of one another. In any case some similarity exists in the number of species and their coverage between the two studies. The dominant species have for the most part remained unchanged. At Station 2 dominant species in January 1988 included Amansia glomerata, Spyridia filamentosa and Acanthophora spicifera; in November 1988 the important species at this station were Codium edule, Acanthophora spicifera and Amansia glomerata. At Station 3 the January survey found Asparagopsis taxiformis and Pterocladia capillacea to be the dominant forms and in November the most abundant species was Pterocladia capillacea. At Station 4 the common algal species in January were Plocamium sandvicense and Sargassum polyphyllum; in the November survey the dominant algal species at Station 4 were Sargassum polyphyllum and Spyridia filamentosa.

In many instances biological diversity in marine communities is related to impinging physical forces. Thus where freshwater enters the sea, resident species are those able to tolerate the wide ranges in salinity that they are exposed to. In the case of benthic communities that receive occasional high energy conditions, an ability to withstand scouring due to sand movement or a shifting substratum must be a part of the successful species

Table 11. Summary of the mean number of species and coverage by macroalgae at five stations surveyed in this study. Also included are comparative data for stations 2,3 and 4 sampled 11 months earlier (January 1988) by Brock (1988).

	STATION NUMBER				
	1	2	3	4	5
PRESENT SURVEY					
Mean No. Species	21	8	10	10	8
Mean Coverage (%)	13	12	8	30	8
JANUARY 1988 SURVEY					
Mean No. Species		8	5	10	
Mean Coverage (%)		9	4	33	

repertoire to survive. One strategy available to a species subjected to occasional high energy conditions that may clear the substratum is to have a lifecycle that allows for rapid colonization, growth and reproduction prior to the next catastrophic event. Species that employ this strategy are termed "weedy species" by ecologists. Another successful strategy is to allow the loss or attrition of much of the individual organism under storm conditions to reduce drag, but to leave a viable bit behind attached to the substratum that may regrow.

The benthic communities in the Launiupoko area are situated on a shallow subtidal limestone bench that appears to occasionally receive considerable wave impact. This condition is reflected in the low coverage and diversity of corals present (Brock 1988). Corals are notoriously slow growing, thus are particularly susceptible to occasional storm events that may impinge on and destroy them (Dollar 1982). On the other hand, many algal species successfully colonize and survive in habitats subjected to these conditions. These algae accomplish this by either employing the "weedy species" strategy or by leaving just their holdfasts on the substratum to regrow following a storm event.

AECOS (1987) and Brock (1988) found benthic and fish communities to be poorly developed at the Launiupoko area. These authors found the algae or limu as a group to be the most successful at Launiupoko. This success was attributed to the abundance of hard substratum, coastal nutrient rich groundwater input, occasional high energy that retard the development of slower growing benthic competitors such as corals and the general paucity of grazing fishes. With most marine construction projects in Hawaii, concerns over impacts usually center around two visually dominant groups, the fishes and the corals. In most cases, the algae or limu are not considered to a similar degree. In a relative sense the proposed development of a marina at Launiupoko would have little direct negative impact to extant fish and coral communities for these are poorly developed in the area (Brock 1988). However, the diverse algal communities of the area would be impacted within the proposed site by their direct removal and indirectly in the surrounding area by changes in water quality.

Our study suggests that appropriate green sea turtle resting habitat is at a premium in the area surveyed but there exists a considerable food resource available for turtles. Thus if marina development were to proceed, the most obvious direct impact to turtles may be through changes in the algal resources in the footprint of the marina. Shoreline algal resources in the area to be occupied by the marina would disappear; however several points should be considered in assessing this potential impact. First, our field observations found no green turtles utilizing either the intertidal or shallow subtidal algal resources in the area proposed for marina development. Secondly, this study has noted the substantial algal resource outside of the area proposed

for development and no unusual communities were identified in this area. Additionally, the basalt boulder breakwater could provide a habitat similar to the high energy basalt cobble biotope that presently exists along the shoreline in the proposed marina site. If this basalt boulder rip-rap and ecological conditions were appropriate for colonization by a similar intertidal algal assemblage, then development of the marina and rip-rap would significantly increase the habitat available over what presently exists on the site.

If the marina is developed, the potential exists for direct and indirect impacts to occur to the turtle resource in the area. Among the possible impacts are those associated with the operation of vessels in the vicinity of a marina on green turtles in their resting and foraging grounds. Drawing on the example of the Hawaii Kai Marina on Oahu, a green turtle resting site occurs along the seaward reef front within 150m of the entrance channel of this busy marina. These turtles presumably forage on the nearby reefs sharing the area with many users of the Maunalua Bay reef. This resting area may have as many as 40 turtles present (Mr. J. Naughton, NMFS, pers. comm.) yet the operation of private vessels and commercial ventures for many years in this area apparently has not caused a decline in the resident turtle population. One dive tour operator operating out of Mala Wharf related that a number of green turtles rest offshore of the wharf around an old sunken vessel that now serves as a mooring for his boat; these turtles forage around the wharf and amongst the moored vessels. This information suggests that green turtles presently coexist with moored and moving boats.

Long-term impacts could derive from changes in water quality associated with the operation of a marina. Water quality changes may come about through the introduction of a number of pollutants including fuel and sewage from boats and trash. Marine sanitation devices may discharge disinfectants or other chemical additives of greater potential harm to marine biota than untreated waste, however the latter potentially posing a health problem. Trash of various kinds can smother or mechanically damage corals and algae or other sessile biota. Sewage should not pose a problem in this project because marina development will include shoreside facilities, precluding the need to use shipboard facilities. Vessels could leak or spill fuel and oil; floating petroleum products and oil have not been conclusively shown to damage corals (Grant 1970, Rutzler and Sterrer 1970, Johannes 1975) and reef communities can exist in areas subjected to chronic, long-term oil pollution (Spooner 1970, Shinn 1972). All of these impacts are usually minor pollution problems and they can be controlled through careful management of the proposed facility. Many of the marina users will derive their livelihood from the nearby marine resources (e.g., dive and other water related tour activities). In the case of a facility operated by a private concern as is proposed, the management as well as the users have

an economic incentive to prevent pollution problems and protect the substantial value that the surrounding natural environment represents in terms of attracting a diverse clientele. In short, impacts due to the operation of the proposed marina on green turtles or their forage areas are not expected to be significant.

In conclusion, the development of a marina at Launiupoko will increase the range and number of recreational and economic opportunities available to Lahaina residents and visitors alike. The results of this survey suggest that the development of the proposed marina should not have a significant impact on green turtles because (1) the few resident turtles found in this study are concentrated outside of the project area and (2) the appropriate turtle forage species are found in abundance not only within but as well as outside of the project area.

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