

3 of 3

11-18 NOVEMBER 00 - Midway IV #17 421

**BALAZS** Mead **2000**  
**COMPOSITION**

**MIDWAY II** Book

"NAVAL AIR FACILITY"

NAF

100 sheets • 200 pages • 100 hojas  
9¾ x 7½ in / 24.7 x 19.0 cm

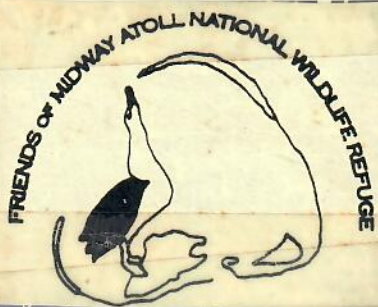
wide ruled / réglage large / rayado ancho

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George Balazs

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ME 429



WH6BLQ  
George H. Balazs  
992-A Awaawaanoa Place  
Honolulu, Hawaii 96825



FREGATIDÆ.

*Fregata aquila* Linn.—Man-o'-war Bird.

There was quite a large colony of Man-o'-war Birds nesting on the top of the bushes on Eastern. Twenty-eight nests were counted all within a space a few rods square. The clatter of the bills of the downy young birds as one entered the colony was most interesting and curious.

SCOLOPACIDÆ.

*Numenius tahitiensis* (Gmel.).—Bristle-thighed Curlew.

The Curlew was quite common on the shore of Eastern Island, where I had little difficulty in securing a series of twelve specimens.

*Arenaria interpres* (Linn.).—Turnstone.

The Turnstone was met with on both islands at Midway.

RALLIDÆ.

*Porzanula palmeri* Frowh.—Laysan Island Rail.

A number of years ago Captain Walker, of Honolulu, carried a cage of the Laysan Rails down to Midway and liberated them on Eastern Island. They have multiplied until, at the time of our visit, they were almost as abundant there as they are on Laysan. A single immature specimen was taken, which, when compared with a large series in the Museum from Laysan, exhibits differences in coloration which would lead one unfamiliar with the circumstances of its introduction to separate it by a specific name.

August 26, 1905.

OCCASIONAL PAPERS

OF THE

BERNICE PAUahi BISHOP MUSEUM OF  
POLYNESIAN ETHNOLOGY AND  
NATURAL HISTORY.

VOL. II. — No. 4.

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Director's Report for 1905.

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HONOLULU, H. I.  
BISHOP MUSEUM PRESS.  
1906.

November, 1936 • 48(10) Paradise of the Pacific

• 27

## Wrecked on Midway Islands in 1888

By MRS. F. D. WALKER as told to CALLA J. HARRISON

ONE day, June 5, 1895, when the shadows of the vine leaves played over the table on Mrs. Walker's lanai, and we were drinking our tea from the battered old silver tea-set referred to below, I heard from her own lips the following story and of her victory through faith. Storm and stress seemed very far away and the peace that had fallen upon her life is the peace that this world knows not of.

\* \* \*

Midway Islands is a group of two islands—one is Sand Island, the other Green Island. Sand Island is a rocky, sandy, barren knoll; Green Island is a tangle of creepers. Both are so small they can be gone over in a very short time.

That autumn a terrible typhon raged through the southern Pacific. Ships of many nations took refuge in the harbors of Samoa and other islands; many were wrecked because they were ground to pieces on the reefs and rocks. A few escaped by getting out to sea.

As the *Wandering Minstrel* came near the Midway Group, she was swept on by the besom of the storm. Being dashed upon the reefs of Midway she began to break to pieces. The only resource was to take to the boats. It was bitter cold. Mrs. Walker prepared for her struggle with the sea by putting on a pair of her husband's trousers, six heavy sea jackets, and an old felt hat tied down with a handkerchief.

She was not allowed to take any of her possessions, but when all was ready she slipped down a rope, and at a given signal was to let go of the rope and fall into the boat. The signal was given too soon and she came near going into the sea. Her pet dog ran wildly around the deck begging to go with his beloved mistress. Finally a sailor, in answer to her entreaties, threw the dog impatiently down. Fortunately he landed safe in his mistress' arms.

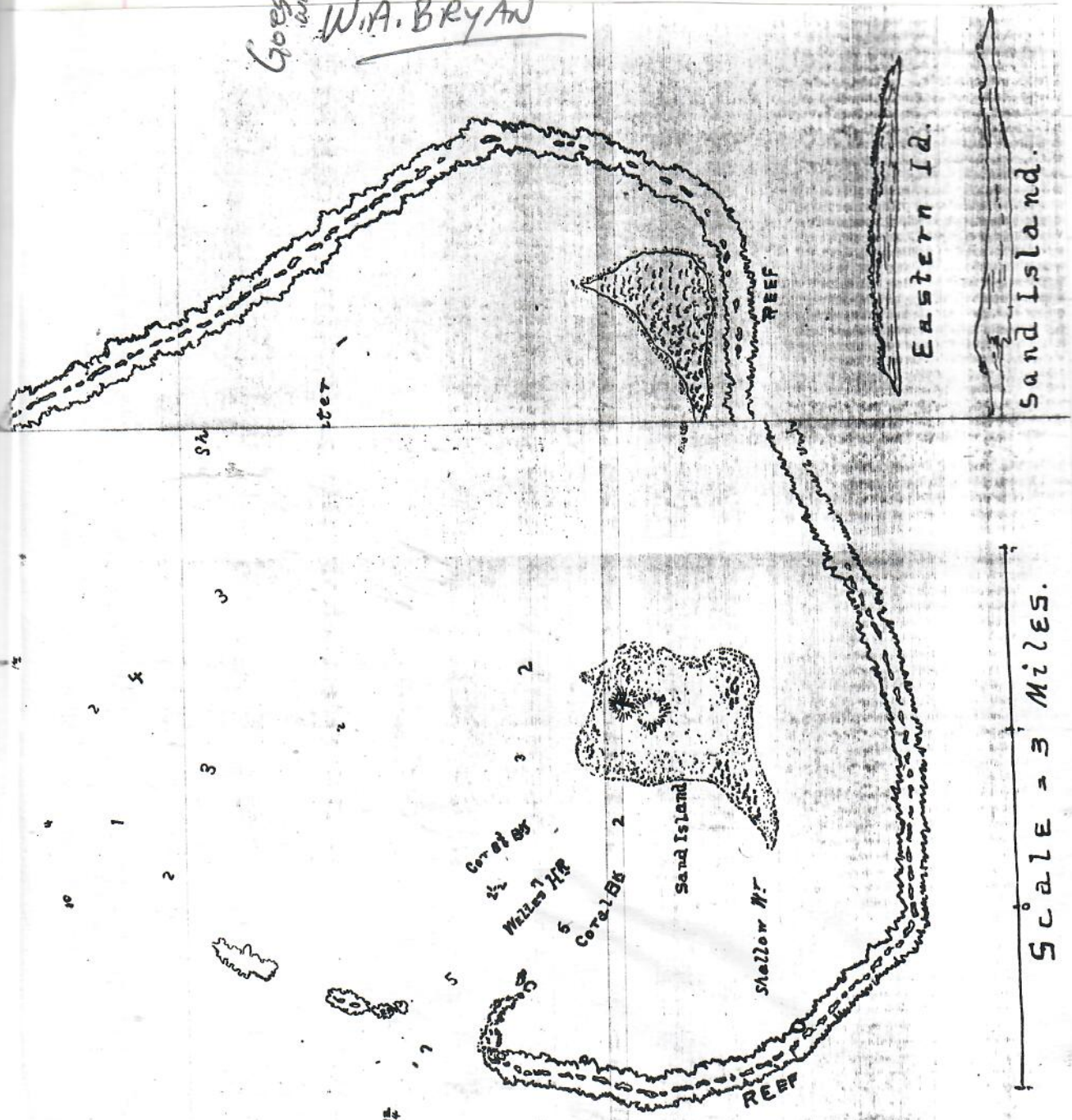
The sailors nearly swamped the boats by throwing into them great bags containing their possessions. This was finally stopped by the captain's orders. In the excitement a bag of biscuits, their only food supply, was thrown out. All managed to get into two boats safely and they started for land.

After much difficulty they reached Sand Island and landed safely. The only inhabitant of the island was a sea convict, named Jorgensen. He had murdered the mate of his vessel and was put off there and left to die by his ship. He lived in



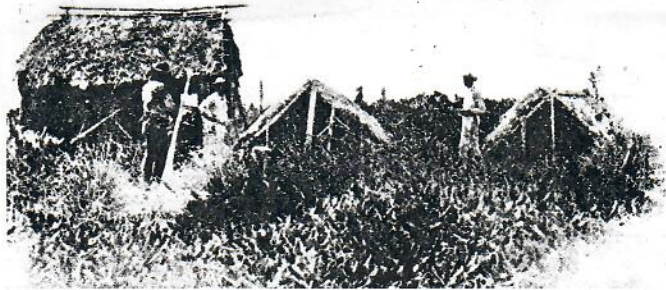
Capt. Walker's Midway Island Home, 1888—"Log of Kaalokai"

Goes with W.A. BRYAN



Scale = 3 Miles.

carefully divided however, and Mrs. Walker put  
and made a small out of their party, and the  
was delicious.



Deserted Village, Sand Island, Midway, 1891—"Log of Kaalokai"

a small hut and had dug a well of brackish water. No food was washed up from the wreck for many months. Nothing green was growing on the island but at this time of the year it was the haunt of sea birds, the southern albatross or *gooney-bird*, as the sailors called it.

These birds and their eggs were all they had to eat. The eggs often weigh one pound and are quite rich. Three in a day was as much as a hearty man could eat. They broke the eggs and beat them up with hot water and made a kind of a custard. During the laying season the eggs were plentiful, but later the birds suddenly left the islands and they were much distressed for food.

There remained only a small bird with plumage, soft as velvet, that burrowed in the sand like a rabbit. It had a note like a puppy's bark. They called it "the puppy bird." Little Jessie, Mrs. Walker's pet dog that had been saved from the wreck, was of great service in tracing out the burrows of these birds. If there was no bird in the hole, Jessie would sniff and go on to the next. By her aid enough of these birds were caught to save them from starvation. There were scarcely any fish and but little fresh water. They dug two more wells and made salt by evaporation of sea-water.

After a while the wreck began to break to pieces and most of the parts floated out to sea. There came ashore three mattresses, some blankets, five plates and five knives and forks—just the number of the Walker family. One day, Mrs. Walker, walking along the beach, found a soup tureen sticking endwise out of the sand.

They were cast on the island February 3, 1888. Twenty-three sailors were wrecked with them. After three weeks on the island, six men rigged up one of the boats and set sail, determined to find land. \* \* \*

Later, three men, the mate of the *Minstrel*, a Chinese boy, and the ship's convict, went to the other island and there fitted up a boat. Captain Walker gave them a compass and some water casks. The three left the islands and arrived safely at Jalute. Although they had promised, they failed to tell of those left behind.

At one time a heavy tempest swept over the islands; they were submerged and Mrs. Walker stood in water up to her waist for twenty-four hours.

On another occasion food gave out and Mrs. Walker failed rapidly. They determined to get some fish. Captain Walker and the oldest boy went out to a small patch of coral. Their anchor was a crooked piece of iron that had but little grappling power. At the first they found no fish but they went on until at last fish were plentiful. A storm of wind and rain came up and they were unable to return. They were in great fear lest their anchor should break and they be washed out to sea. Unfortunately they had also lost an oar.

Mrs. Walker waited in vain for their return. Late in the afternoon she could see them. As night came on she and the two younger boys gathered wood and made a bonfire. The rain beat upon their fire, but all night long she and the boys patiently fed it with *gooney* oil. With great difficulty they kept this "home fire" burning. It was a beacon of hope to the father and older boy who were clinging to the coral ledge to keep from being swept away by the surf.

On the next night they filled a large red lamp with *gooney* oil. All this second night she watched and tended this light. This gave courage to the castaways and on the morning of the third day, they made an agonized effort and swung around so that the two younger boys could swim out to them carrying oars. Mrs. Walker tried to get the other men to go to their help but they would make no effort. Of all the twenty-three men that were taken off the ship, one was drowned, six were lost in the boat that left the Islands, two went to another island, three died of scurvy, one died on the way to Honolulu, after being rescued, and one is at present in the lunatic asylum at Honolulu.

Those that left the Walker's and those that died were physically the strongest, but they were also the most violent and greedy. One of the first to die was especially greedy. He would kill as many as fifty birds at a time—more than he could possibly eat—but would share with none.

Another strong man lost all hope. He had a barrel or cask into which he was wont to crawl head first to sleep. One night, while talking to Mrs. Walker, he seemed very much depressed. She spoke to him of her faith in God, her feeling that help would surely come. The next morning he did not leave his cask. Captain Walker called and finally pulled him out; but he was dead.

A short time after they left the wreck a hen-coop of potatoes washed ashore. Rice had been packed in wine casks. All but one washed out to sea. After many months that one cask was found but the rice had fermented. It was carefully divided however, and Mrs. Walker pounded it and made a mush out of their part; fried in *gooney* oil it was delicious.

After these hard experiences they learned to provide themselves with eggs and stores of *gooney* breasts dried in the sun. The only flesh is on the breasts of the birds and that is rank with oil.

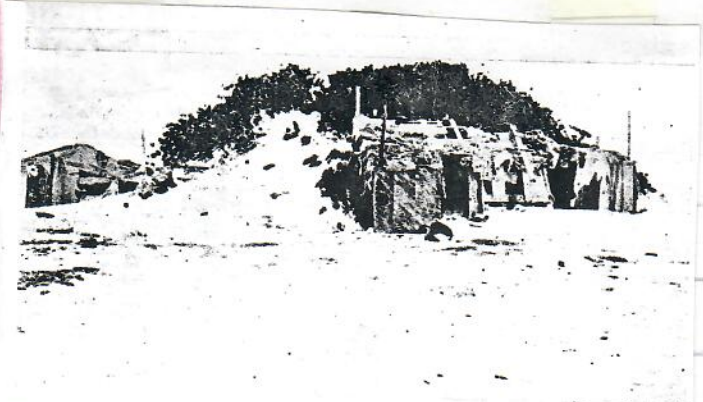
The men caught a man-eating shark and dried its flesh, but Mrs. Walker could not eat this and was three days without taking food. Once or twice the boys dived and found specimens of *beche de mer*, a sea animal-vegetable, tough as rubber; but when boiled properly it became soft and palatable.

One of Mrs. Walker's sons became sick of scurvy and was about to die for want of proper food. He begged piteously for rice but there was none to give him. His

mother was in despair, for he was in the last stages of that dreadful disease. His legs were patches of purple, green and red. The press of a finger left a dent in the flesh. The younger boys roamed the island looking for eggs. They could only find a small bird about the size of a pigeon. Finally they took to wading about in the water and one of them saw something below in the sand that looked like a bottle. They dived and brought up a bottle of lime juice. It had lain there thirteen months but was still fresh and good. This lasted the sick boy until the schooner came to take them away.

Among Mrs. Walker's most cherished possessions was a tin box containing some relics of her girlhood home—especially a silver tea set. She often longed for this and desired above all that it might have been brought away from the ship. One day a portion of the wreck was washed on shore. Jammed between the timbers was the much prized tin box.

During the time of their exile several ships showed above their horizon. In spite of all signals and their every effort, these ships passed on and their hopes faded into bitter disappointment. A miserable death seemed staring them in the face. One day they caught sight of a far-off sail. They hastened to put up a flag and build a bon-fire. In the morning the schooner was much nearer. They heard the welcome sound of a gun! The ship came nearer and a boat put off. At last relief had come! The schooner was the *Norma* of Japan.



Deserted Village, Green Island, Midway, 1891—"Log of Kaalokai"

Mrs. Walker's brother had married a Japanese wife who was very fond of her white sister-in-law. She became ill and later died. Before her death she consulted a Japanese soothsayer who told her that Mrs. Walker was still living, but in great distress, and longed to get away from the place they were in. The dying woman begged her husband to make every effort to find them. The brother asked the captain of the *Norma* to make particular examination of all the islands in his rounds.

With great joy they left Midway, March 26, 1889; arriving in Honolulu, April 7, 1889. All her family recovered from their hardships.

QUOTATIONS FROM AUTHORITIES

*Daily Bulletin of Honolulu, April 8, 1889*

"The British schooner *Norma* arrived off port Saturday (April 6, 1889) evening, having on board the captain and shipwrecked crew of the bark *Wandering Minstrel*, who had been on Midway Island some fourteen months. The

...  
...  
... were immersed and Mrs. Walker stood in water up to her  
...  
...



names of those rescued are Captain Walker, wife and four children, George Hanker, E. Biles, F. Noysette, S. Clarelles, L. Sacramento, A. Santos, B. Nico, T. Lucas, P. Militana, G. Gracia, and L. A. Chang."

*Daily Pacific Commercial Advertiser, April 8, 1889*

"Captain Walker, wife, and four children all show evidence of their severe privations on the desert island whereon they were cast. During the fourteen months on Midway Island they had to subsist upon the abounding sea-birds and their eggs, and the fish that they were able to catch. \* \* \*

"Captain Walker, on being informed of the report that Cameron, his mate (who was master of the I. I. S. N. Company's *Planter* when wrecked) was reported to be keeping a saloon at Tacoma, Washington, said he well believed it. Cameron took up with the desperate Jorgensen, who was left on Midway Island when the *General Seigels'* crew was rescued and both of them made a great deal of trouble. \* \* \* So dangerous a character was Jorgensen proving himself to be, Captain Walker several times decided to shoot him for self-protection. Each time his wife restrained him. Jorgensen \* \* \* was left on the island a menace to any persons unfortunate enough to be cast away there." [The Walkers found him such].

*Report of Master of Schooner Norma*

C. Johnson, Master of the British schooner *Norma*, as quoted in the *Daily Bulletin* and also the *Daily Pacific Commercial Advertiser*, of April 8, 1889, reported: "Made sail for Midway Island on the 16th [of March, 1889]. Weather fine. At Midway Island found Captain F. D. Walker of the wrecked bark *Wandering Minstrel* with crew, in a very bad condition from want of food. \* \* \* remained there to get wood and water until the 26th of March, when the sick were fit to embark. \* \* \* On the 26th sailed for Honolulu being chartered by Captain F. D.

Walker. \* \* \* Arrived at Honolulu April 6th at 2:00 p.m."

*Report of Captain Walker*

"Left Honolulu December 10, 1887. \* \* \* Arrived at Midway Island and anchored in Welle's Harbor January 9, 1888. \* \* \* Found a man named Jorgensen on the island having been wrecked in the Schooner *General Seigel*. \* \* \* At 1:30 p.m. [February 3, 1888] abandoned the vessel \* \* \* all-hands saved.

"October 13th, the mate John Cameron, a Chinese lad, and Jorgensen, left for Honolulu in a boat fitted up with sails. \* \* \* My family suffers, one severely from the same malady [scurvy].

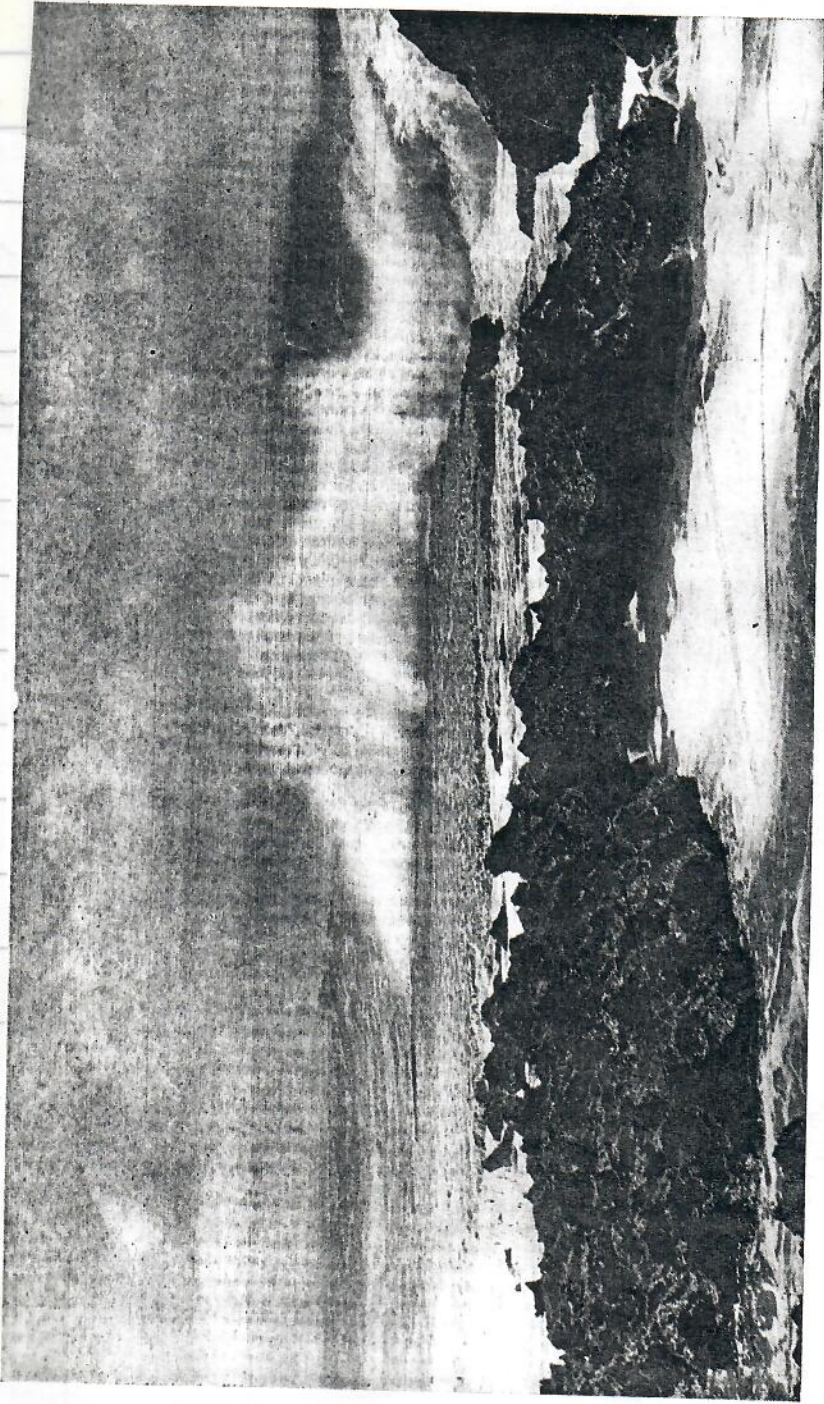
"March 17, 1889, the schooner *Norma* arrived at Midway Island, shark fishing and under agreement conveyed the balance of crew, self and family to this port."

*Log of the "Kaaloka" by Captain Walker*

"In 1888 my ship the *Wandering Minstrel* was wrecked, while anchored in Welle's Harbor, February 3d. \* \* \* The *Wandering Minstrel* was purchased in Hong Kong by The Shark Fishing Company, Limited, of that port for the purpose of shark fishing." Sailed October 13, 1887. "When we sighted Midway we spent three days waiting for the sea and wind to moderate. We entered Welle's Harbor, never to get out again. \* \* \* In about two months time part of the stern was washed up on the beach opposite the *Hut*, from which we secured some cloth, and a chest containing some valuables.

"On arrival at Midway we found a man named Jorgensen on the island. \* \* \* This Jorgensen became a very objectionable character, and we were not sorry at his departure, in company with the mate and a Chinese boy, in October. \* \* \* They also reached Jalnit."

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SURF BREAKING ON THE RUGGED LAVA COAST

Shawn  
TDS  
with return

SEA

Nanette Seto, Midway Atoll NWR  
US Fish and Wildlife Service  
PO Box 4

ID numbers of new tags attached and any old tags already present <sup>1</sup>		Species <sup>2</sup> and sex (if known)	Date and time	Place-name location (or latitude and longitude)	Activity of the turtle <sup>3</sup>	Curved carapace length <sup>4</sup>
Left front flipper	Right front flipper					
N-26 ✓	N-18 ✓	Green ♀	12 May 97 12:45 pm	Sand Is, Midway East of seaplane ramp	Basking resting 2 feet out of water	91.5 cm
N-21 ✓	N-20 ✓	Green ♀ ✓	19 May 97 9:20 am	Sand Is, Midway East of seaplane ramp	Basking Same as above	95 cm

S Craig Paulson / Brenda Becker  
USFWS NMFS

Hard Sminkel

\* All tag locations are primary tag site

ID numbers of new tags attached and any old tags already present <sup>1</sup>		Species <sup>2</sup> and sex (if known)	Date and time	Place-name location (or latitude and longitude)	Activity of the turtle <sup>3</sup>	Curved carapace length <sup>4</sup>
Left front flipper	Right front flipper					
N11 ×	N10 ×	CM Unknown sex	8/6/91 0747 1991	Midway Sand Island 1/2 way between Rusty bucket & the pavilion North shore	Swimming ×	46.5 cm ×
N13 ×	N12 ×	CM Unknown sex	8/6/91 0812 1991		Swimming ×	44.0 cm ×

Time intervals of downloads

AS of 11/00 = <sup>18</sup> Midway #1 (1187)

INNER HARBOR TUG PIER = 10/19/98 TO 9/23/99      Girder 20  
 11 months  
 15' cord

(1000's only) 10/21/98 TO 3/27/99      15 months  
 15' cord

#224566 Full DATA 3/27/99 TO 9/25/99      6 months  
 15' cord

Full DATA 9/25/99 TO Late 1/00      3 months  
 (Nothing out from Late 1/00 until 11/17/01)

N. Side sand Island #224565 CARGO PIER = <sup>SN 4074 Midway #2</sup> Full DATA 10/21/98 TO 3/26/99      15' cord  
 5 months

Full DATA 3/26/99 TO 9/24/99      15' cord  
 6 months

Full DATA 9/24/99 TO Late 1/00      3' cord  
 3 months

(Nothing out from Late 1/00 until 11/17/01)

As 11/00, there are 7 graphics, MINUS ones w/ no data: 5 Total

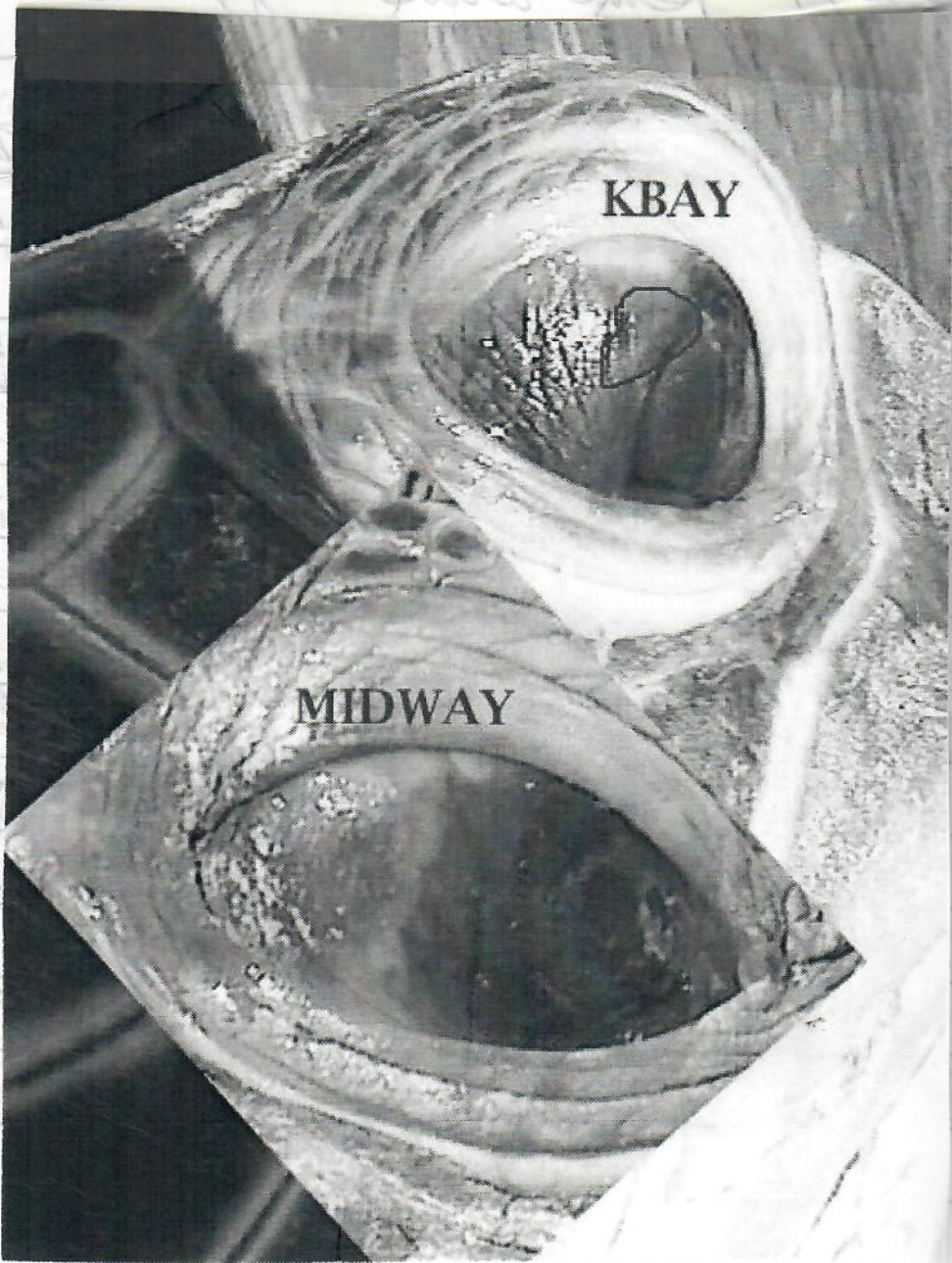
# Records of All Temperature Loggers at Midway 163

Date Deployed	Location	S/N#	Manner			
10-19-98	TUG PIER INNER HARBOR	1187	20' deep Hart Girdler	9-23-99		Reel
10-21-98	CARGO PIER	4674 71054	15' cord	3-26-99	5 months	yes 224565
10-21-98	TUG PIER INNER HARBOR	1054 144014	15' cord	3/27/99	5 months	yes 224566
3-26-99	CARGO PIER	224565	15' cord	9-24-99	6 months	yes 144070
3-27-99	TUG PIER INNER HARBOR	224566	15' cord	9-25-99	6 months	yes 266016
9-25-99	TUG PIER INNER HARBOR	266016	15' cord	Return - 3 months		NO entangled turtle
9/24/99	CARGO SUSPECT PIER	44070	15' cord	Return - 3 months		NO
11-17-00	CARGO PIER	383501	6-00 22' on			NO
		+ 224564	Stowaway Rod			
11-17-00	TUG PIER INNER HARBOR	TABIT=	21 deep on end of pier			

2 Hour Sampling Interval

Temperature Loggers at Midway

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On Thu, 1 Feb 2001, Marc R. Rice wrote:

> George,

> Here is a quick stab at the diving data for #25=8A let me know  
> what you think.

>  
>

> Turtle 25 was captured and tagged on 9/23/99 with a Wildlife Computer  
> MK5 =81 TDR and a Sonotronic=81 sonic tag. First full day of data was  
> taken on 9/24 and recording continued until 11/23, a total of 58 full  
> days of data. The partial days of data on either end of the  
> monitoring period were ignored. Data from days 11/14 and 11/19 were  
> lost in the data download.

>

> This turtle made an average of 17 (s.e.=3D3.3) "\*resting dives"  
> per 24 hour period over the 58 days of sampling. The resting dives  
> lasted an average of 67 (s.e.=3D1.8) minutes with a range of 17 to 128  
> minutes. An average of 1152 (s.e.=3D23.5) minutes per day were spent  
> on resting dives (range from 553 to 1389 minutes).

> This time represents 82% of the 24 hour day. While it is not  
> possible to determine if periods of non-resting behavior represents  
> foraging or movement from one area to another, the graphical data  
> suggests that between 10 and 15% of the remaining 18% of the day was  
> spent in foraging activity. Work done on sub-adult turtles at Puako,  
> Hawaii (Davis, et.al.1999) showed one turtle spending 50%+ of its day  
> exhibiting foraging behavior, a wide departure from that of #25.  
> Another similar study of a sub-adult green turtle in Hawaii (Rice  
> et.al. 1998) showed foraging behavior occurring for an average of 37%  
> of each day.

> This may be a case of sub-adult vs. adult foraging needs or it may be  
> a result of some other factor(s) like environmental or health  
> conditions. The water temperature did drop from 25.6 0C at the end  
> of September to 23.8 0C at the end of November.

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NOTED POOL #25 SON 357

60 days

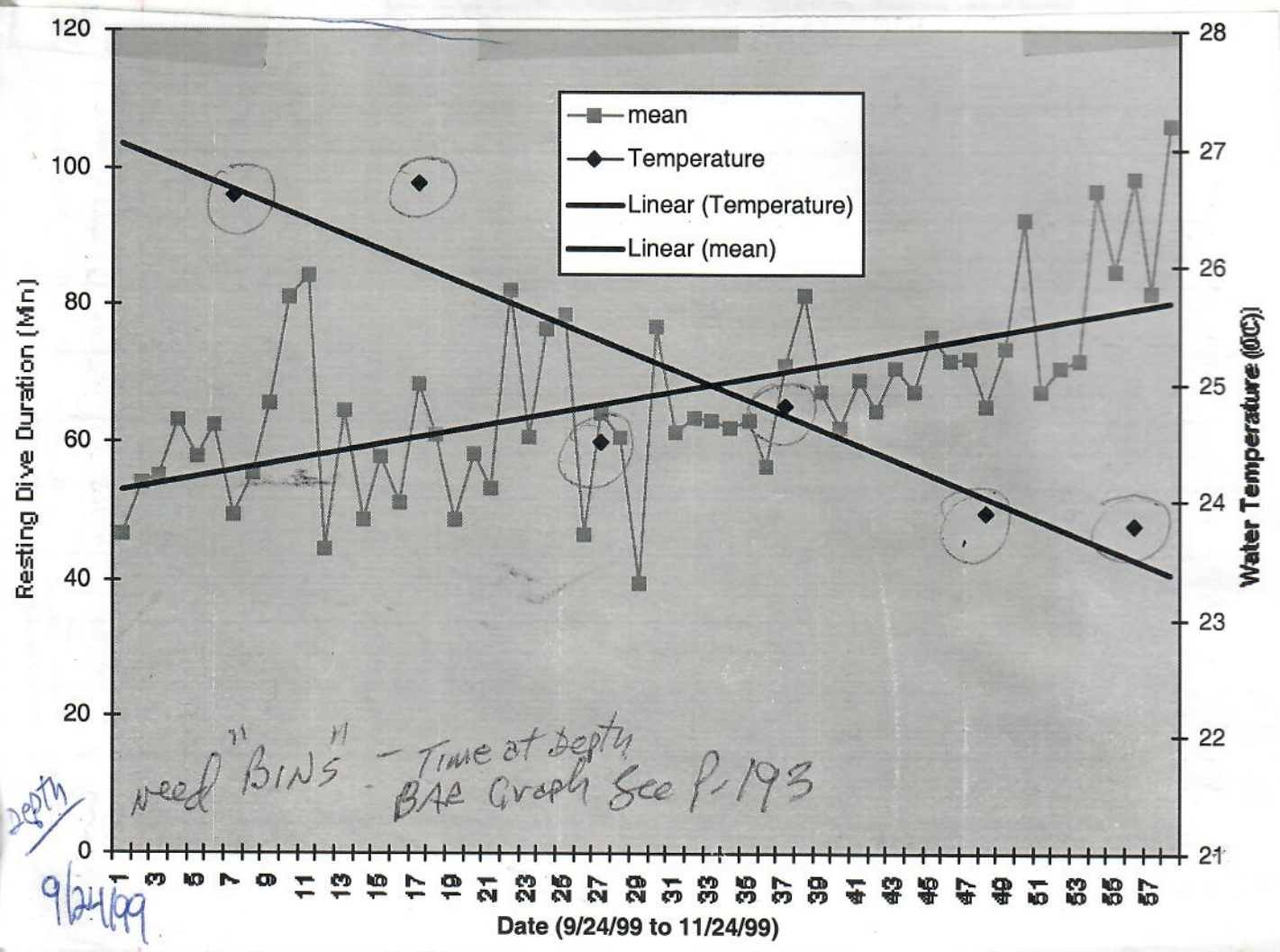
ADULT MALE

88.7 cm

SCL

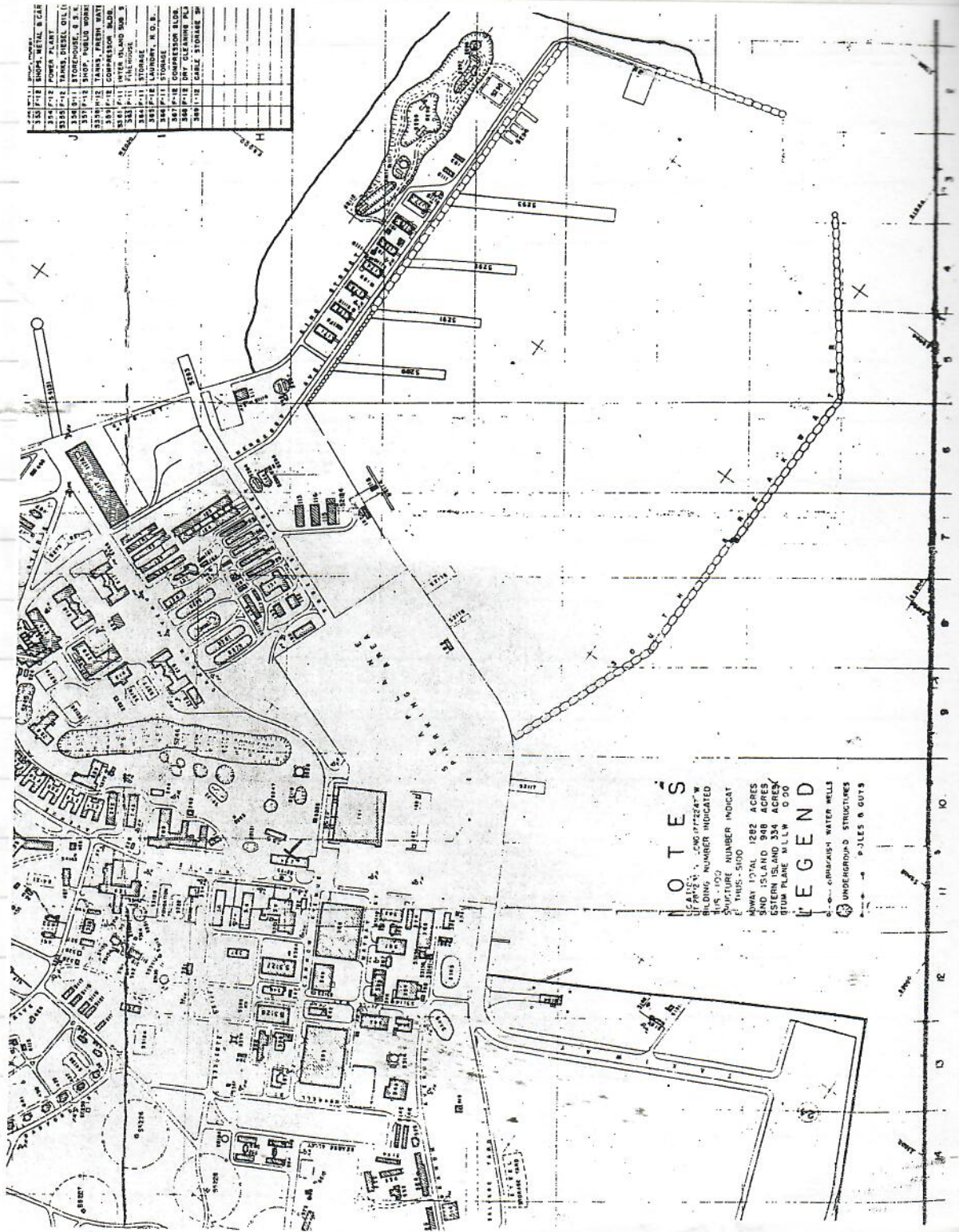
SONIC TAG 357  
MT 25  
TDR 96-368





TDE Temperature  
25.6. → 23.8°C

324-718	SHOP, METAL & CAR
324-719	POWER PLANT
324-720	STAND DIESEL OIL
324-721	STORAGE, F. S. K.
324-722	STAND, DIESEL OIL
324-723	STAND, DIESEL OIL
324-724	STAND, DIESEL OIL
324-725	STAND, DIESEL OIL
324-726	STAND, DIESEL OIL
324-727	STAND, DIESEL OIL
324-728	STAND, DIESEL OIL
324-729	STAND, DIESEL OIL
324-730	STAND, DIESEL OIL
324-731	STAND, DIESEL OIL
324-732	STAND, DIESEL OIL
324-733	STAND, DIESEL OIL
324-734	STAND, DIESEL OIL
324-735	STAND, DIESEL OIL
324-736	STAND, DIESEL OIL
324-737	STAND, DIESEL OIL
324-738	STAND, DIESEL OIL
324-739	STAND, DIESEL OIL
324-740	STAND, DIESEL OIL
324-741	STAND, DIESEL OIL
324-742	STAND, DIESEL OIL
324-743	STAND, DIESEL OIL
324-744	STAND, DIESEL OIL
324-745	STAND, DIESEL OIL
324-746	STAND, DIESEL OIL
324-747	STAND, DIESEL OIL
324-748	STAND, DIESEL OIL
324-749	STAND, DIESEL OIL
324-750	STAND, DIESEL OIL



**NOTES**

1. PLAN NO. 100-177228-W  
 2. BUILDING NUMBER INDICATED  
 3. S. 1000  
 4. STRUCTURE NUMBER INDICATED  
 5. 1000-5000

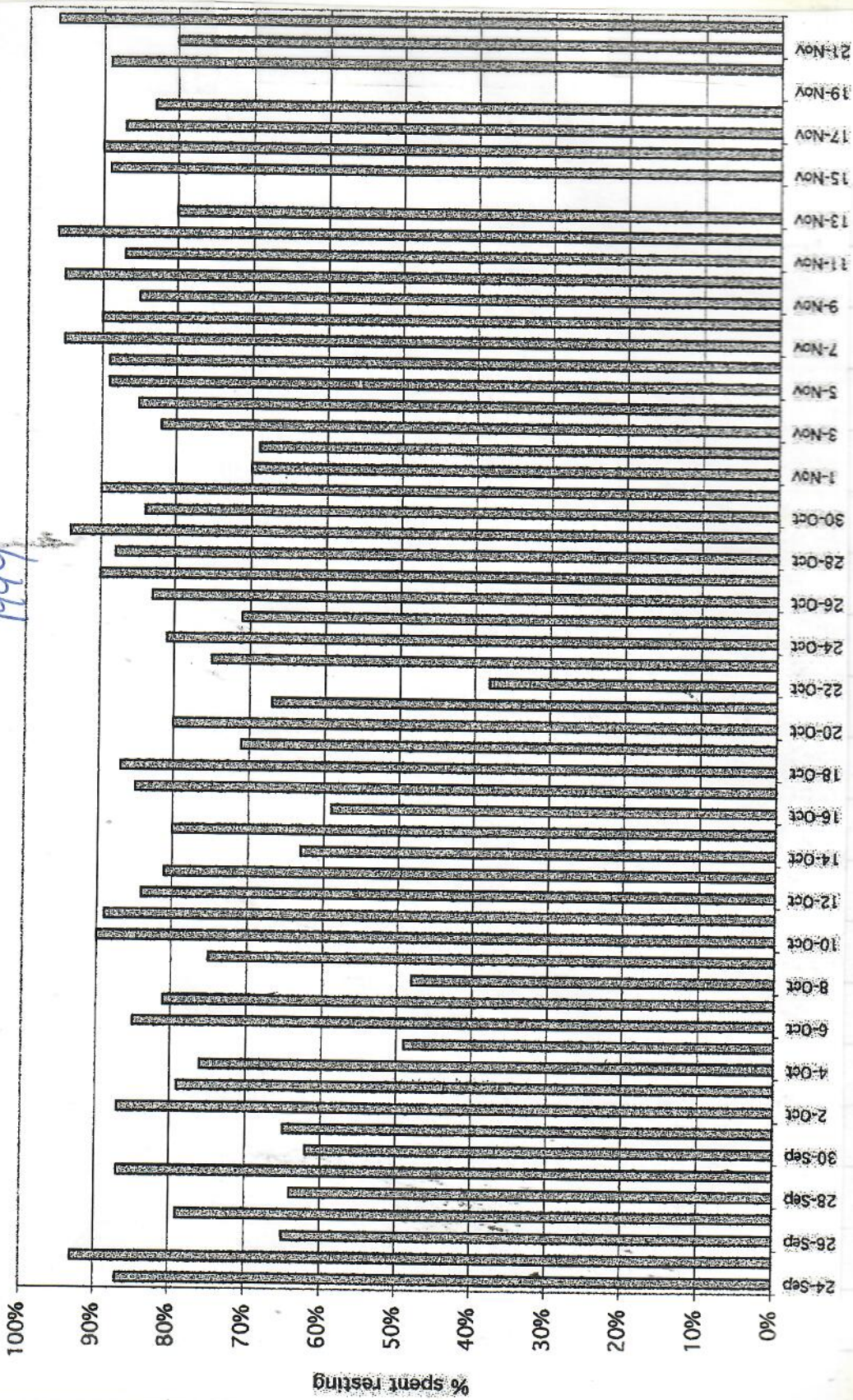
6. AREA TOTAL 1282 ACRES  
 7. AREA UNDER CONSTRUCTION 189 ACRES  
 8. AREA UNDER DEVELOPMENT 100 ACRES  
 9. TOTAL AREA UNDER DEVELOPMENT 289 ACRES  
 10. TOTAL AREA UNDER CONSTRUCTION 189 ACRES

**LEGEND**

- WATER WELLS
- UNDERGROUND STRUCTURES
- PILES & GUTS

Midway #25 % time spent daily resting

1999



Turtle #	Date	Time	Location	Activity	Obs.Type	Obs.	Comments
1							
2	1/3/00	805	S29	2	1	JS	
3	2/26/00	1329	S29	2	1	SC	Spending majority of time on surface of H20. Most of carapace covered w/ algae except on top part of right side - appears evident that turtle is spending a high % of time at surface. Turtle lists down on left side. Doesn't seem healthy. Never saw it dive down
3	2/28/00	1200	S29	2	1	SC	In same area next to cargo pier floating still. No dive observed. Appears it may die soon, somewhat lethargic now.
3	4/20/00	1516	S28	1	1	SC	On beach while tagging #41
3	4/30/00		S29	1	1		On beach by pier
3	6/17/00	1303	S29	2	1	WS	
4							
5							
6							
7	1/3/00		S29	2	1		
7	1/16/00	1530	S29	1	1	PJ	
7	3/5/00	1545	S29	2	1	BC	
7	3/7/00		S29	2	1		
7	3/22/00		S26	2	1		Outer Harbor breakwall
7	3/23/00		S29	2	1		Cargo Pier
7	4/14/00	1400	S28	1	1	CV	
7	4/20/00	1555	S28	1	1	SC	
7	4/22/00		S29	2	1		Cargo Pier
7	4/29/00		S29	2	1		Cargo Pier
7	5/1/00		S27	1	1		Resting on shore
8	1/13/00	1334	S28	1	1	CV	
8	2/15/00	925	S29	2	1	BC	
8	9/9/00	915	S29	2	1	BC	
9							
10							
11							
12	1/11/00	1720	S22	2	1	JS	
12	3/5/00	1600	S22	2	1	BC	
13	1/13/00	1336	S28	2	1	CV	
13	2/15/00	925	S29	2	1	BC	
13	4/7/00	1350	S29	2	1	SC	
13	4/14/00	730	S29	2	1	BC	

13	5/14/00		S29	2	1		
13	5/16/00		S29	2	1		
13	5/20/00		S26	2	1		
13	6/2/00	855	S29	2	1	SC	
13	6/24/00	819	S29	2	1	SC	
13	6/26/00	827	S29	2	1	BC	
13	6/28/00	815	S29	2	1	SC	
13	7/12/00	1025	S29	2	1	BC	
13	7/19/00	1030	S29	2	1	BC	
13	7/22/00	915	S29	2	1	BC	
13	7/25/00	910	S29	2	1	BC	
13	7/27/00	915	S29	2	1	BC	
13	7/31/00	815	S29	2	1	SC	
13	8/2/00	750	S29	2	1	SC	
13	8/4/00	635	S29	1	1	BC	
13	8/6/00		S29	2	1		Cargo Pier
13	8/10/00	700	S29	2	1	BC	
13	8/14/00		S29	2	1		Cargo Pier
13	8/18/00	1645	S29	2	3	SC	Saw under Cargo Pier while snorkeling.
13	8/23/00	1326	S29	2	1	BC	
13	8/30/00	807	S29	2	1	SC	
13	9/29/00	850	S29	2	1	BC	
13	10/9/00	950	S29	2	1	MP	Right of Cargo Pier
13	11/8/00	1000	S29	2	1	AS	Feeding on algae and Port. man of war
13	11/8/00	1115	S29	2	1	AS	Feeding on algae and Port. man of war
13	11/9/00	1630	S29	2	1	AS	Feeding right of Caprgo Pier
14	1/13/00	1336	S28	2	1	CV	
14	2/15/00	925	S29	2	1	BC	
14	3/5/00	1545	S29	2	1	BC	
14	3/27/00		S29	2	1		
14	4/7/00	1350	S29	2	1	SC	
14	4/12/00	1327	S29	2	1	SC	
14	4/12/00		S29	2	1		
14	5/5/00	619	S29	2	1	SC	
14	5/29/00	830	S29	2	1	SC	Swimming by seawall
14	6/7/00	1357	S29	2	1	SC	
14	6/15/00	1329	S29	2	1	BC	
14	6/22/00	1030	S29	1	1	BC	
14	6/26/00	827	S29	2	1	BC	
14	6/28/00	815	S29	2	1	SC	
14	7/19/00	1030	S29	2	1	BC	
14	7/20/00	1406	S29	2	1	SC	Swimming by seawall
14	7/27/00	915	S29	2	1	BC	
14	8/2/00	750	S29	2	1	SC	
14	8/4/00	635	S29	1	1	BC	
14	8/10/00	700	S29	2	1	BC	
14	8/18/00	1700	S29	2	3	SC	Saw under Cargo Pier while snorkeling.
14	8/27/00	920	S29	2	1	BC	

14	9/2/00	1640	S29	2	1	BC	
14	9/15/00	1545	S29	2	1	BC	
14	9/18/00	812	S29	2	1	BC	
14	9/20/00	615	S29	2	1	BC	
14	9/29/00	850	S29	2	1	BC	
15	3/6/00		S27	2	1		Cross pt. Lookout
16	6/30/00		S27	2	1		Cross point
16	8/14/00	1721	S23	2	1	SC	Under Cargo pier, came up for breath (T1)
17							
18							
19							
20							
21							
22	3/10/00	1000	S28	1	1	BC	
22	2/28/00		S25	2	1		In Harbor
23	1/7/00	1316	Sp3	DEAD	1	BC	dead on beach, flippers, head, tail taken by sharks
23	1/3/00	1222	S29	1	1	JS	
23	1/2/00	1415	S28	1	1	BC	
24	6/25/00	1130	S29	2	1	SC	
25	2/13/00		S28	2	1		
25	2/13/00	1530	S28	1	1	BC	Took TDR off.
26							
27	3/2/00		S25	2	1		In Harbor
27	3/22/00		S27	2	1		Cross point look out
27	4/29/00		S29	2	1		Cargo Pier
27	6/20/00	1049	S25	2	1	WS	
28							
29							
30							
31	4/21/00		S25	2	1		At Harbor mouth

32							
33	2/14/00		S26	2	1		
33	5/20/00		S26	2	1		
34	1/3/00	900	S28	1	1	AS	Tagged and Measured by NH, AS
35	1/11/00	1630	S28	1	1	PJ	Tagged and Measured by NH, PJ
35	7/27/00	915	S29	2	1	BC	
37	1/18/00		S28	1	1	CM	Tagged and Measured by NH, CM
37	3/10/00	1000	S28	1	1	BC	
37	4/20/00	1400	S28	1	1	CV	Next to Seaplane ramp
37	4/20/00	1430	S28	1	1	WS	
37	10/1/00	750	S28	1	1	MP	
37	10/5/00	1700	S29	1	1	MP	
37	10/8/00	1805	S28	1	1	MP	Not positive of number
37	10/9/00	955	S28	1	1	MP	
38	4/4/00	1140	E09	1	1	BC	Tagged and Measured by NH, BC & KWL
38	4/14/00	1037	E09	1	1	SC	On beach by pier.
38	4/14/00	816	E09	1	1	BC	
38	4/22/00	1810	E09	1	1	BC	
38	5/1/00	1000	E09	1	1	BC	
38	5/5/00	1105	E09	2	1	BC	
38	5/11/00	1136	E09	2	1	SC	
38	5/17/00	1326	E09	1	1	BC	
38	5/24/00	1306	E09	1	1	SC	On beach by pier.
38	5/29/00	830	E09	1	1	BC	
38	6/2/00	920	E09	1	1	BC	
38	6/13/00		E09	1	1		Saw while on Eastern Tour
38	6/23/00	730	E09	1	1	BC	
38	7/5/00	1610	E09	1	1	SC	On beach by pier.
38	7/14/00	1128	E09	1	1	SC	
38	7/28/00	1629	E09	1	1	SC	On beach by pier.
39	4/5/00	1500	S28	1	1	JSJ	Tagged and Measured by NH, JSJ
39	4/28/00		S28	2	2		By bouy #15, floating
39	5/3/00		S29	2	1		Cargo Pier
39	6/1/00		S29	2	1	BC	
39	7/8/00		S29	2	1		Cargo Pier
39	8/4/00	630	S28	1	1	BC	
40	4/8/00		S28	1	1	NH	Tagged and Measured by NH, ?
40	5/4/00		S29	2	1		
41	4/20/00	1643	S28	1	1	MK	Tagged and Measured by NH, MK
41	4/22/00	1800	S23	2	2	BC	At mouth of Harbor

41	8/9/00	1550	E06	1	1	SC	Saw on beach in sector 6, looks good.
42	9/26/00	1430	S28	1	1	BC	Captured turtle, had pit tag, numbered it 42
125	1/18/00		S28	1	1	NH	Reground # on carapace & painted white. Concave on right side. Flakey shell.
125	4/20/00	1515	S28	1	1	CV	Left beach while people were tagging #41

All data colored RED is from Galley board sightings from guest & residents



MIDWAY turtles that have had Liguamycin injections

Prior to 11-18 NOV 00 TRIP

AS of early Nov. 00

Date caught	Pit tag number	Other tags	SCL (cm)	Method	Place caught	Specific
10/16/98	4104227317	4104134854	42.5	Scoop net	Sand Island	Outer seawall
10/16/98	41041A0725	41037A7E7D	42.4	Scoop net	Sand Island	Outer seawall
10/16/98	4104160C2F	4104180D30	53.3	Scoop net	Sand Island	Outer seawall
10/16/98	20071E2219	1F70031D51	45.3	Scoop net	Sand Island	Cargo pier
10/16/98	1F6D662A64	1F71572871	44.2	Hand/Scuba	Sand Island	Boat ramp
10/17/98	1F68771270	1F72532C70	54.7	Throw setnet	Sand Island	Inner seawall
10/17/98	1F6C012F45	2007094907	50.0	Hand/Snorkel	Eastern Is.	South Shore
10/17/98	1F6D5B6039	1F6F47416A	56.2	Hand/Snorkel	Eastern Is.	South Shore
10/17/98	2008257C37	1F6D1C4117	47.8	Hand/Scuba	Sand Island	Cargo pier
10/17/98	1F75366F47	1F694D3E6D	70.6	Hand/Scuba	Sand Island	Cargo pier
10/18/98	1F71572178	1F6D676D20	47.6*	Throw setnet	Sand Island	Outer seawall
10/18/98	1F75236A5F	1F690F3039	41.0	Scoop net	Sand Island	Outer seawall
10/18/98	414B623004	200C784D0F	83.6	Hand/Scuba	Sand Island	Cargo pier
10/18/98	411F792011	413B610D79	65.3	Hand/Scuba	Sand Island	Cargo pier
10/18/98	411F111E25	411C4C130B	71.5	Boat/Dive	Sand Island	KK Halophila
10/18/98	413B6E3815	414A486806	50.3	Hand/Snorkel	Sand Island	Cargo pier
10/18/98	413B085951	414B31336D	61.4	Hand/Snorkel	Sand Island	Cargo pier
10/18/98	411C770209	414B53240F	47.1	Hand/Snorkel	Sand Island	Cargo pier
10/18/98	414B6C432B	411F4D576F	46.2	Hand/Snorkel	Sand Island	Cargo pier
10/18/98	414912040E	411C670A23	46.7	Hand/Snorkel	Sand Island	Cargo pier
10/18/98	411F481120	414B3F7B6E	39.4	Hand/Snorkel	Sand Island	Cargo pier
10/19/98	411C726819	4144330940	83.5*	Hand/Scuba	Sand Island	Cargo pier
10/20/98	413B186211	413B706D7B	48.4	Hand/Snorkel	Sand Island	Tugboat pier
10/20/98	411F027D57	411F19485B	73.6	Hand/Scuba	Sand Island	Cargo pier
10/20/98	411C73127B	414B1E5328	77.2	Hand/Scuba	Sand Island	Fuel pier
10/21/98	40774B0A3C	411F237B7A	44.3	Scoop net	Sand Island	Cargo pier
9/23/99	4135330A3F (LHF)	4136201E57, MOTO27	44.5	Hand/Scuba	Sand Island	Cargo pier
9/23/99	413643195F (LHF)	4136231F07, MOTO28	48.3	Hand/Scuba	Sand Island	Tugboat pier
9/23/99	41370C237D (LHF)	41360F591C, MOTO29	38.0	Hand/Scuba	Sand Island	Tugboat pier
9/24/99	4136061C1F (LHF)	4136411A2F, MOTO30	51.3	Hand/Scuba	Sand Island	Cargo pier
9/25/99	41363C2156 (LHF)	4136257B0C, MOTO31, SON469, TDR99421(MK7)	88.8	Net	Sand Island	Outer seawall, inside Inner Harbor
9/25/99	41351F753C (LHF)	41360C0239, MOTO32, SON456B	58.0	Hand/Scuba	Sand Island	Tugboat pier

## Growth Rates of Immature Green Turtles in the Hawaiian Archipelago

### Introduction

The formulation of sound management strategies for sea turtles is dependent in part upon an understanding of the rates of growth and age at sexual maturity of naturally occurring members of each population. However, these aspects have received comparatively little attention due to the difficulties of capturing and tagging immature turtles directly from the sea in their resident foraging areas. Most research has instead been directed at the colonial nesting beaches where usually only the adult females are available for tagging and observation. This has resulted in considerable insight into the reproductive ecology, migrations, and growth of the adult female, three critically important but nevertheless limited aspects of the animals' life history. Nesting beaches also offer easy access to large numbers of hatchlings, but the absence of a suitable tag for this size category has hampered research aimed at determining natural growth rates and maturation age. Growth studies conducted with captive turtles, or with turtles released into the wild after being raised for a period of time in captivity, cannot be considered representative of natural conditions. Determining the age of sea turtles from annual present in bones offers some potential, but reliable analyses are not possible at the present time (Balazs 1979b).

Tag and recapture studies of naturally occurring immature sea turtles were first carried out by Schmidt (1916) on green turtles (*Chelonia mydas*) in the Virgin Islands. Subsequent investigations have been conducted on the west coast of Florida by Carr and Caldwell (1956) and at Bermuda by Burnett-Herkes (1974). Preliminary results of my own work in the Hawaiian Archipelago (Balazs 1979a) have been presented currently with those of Limpus (1979) working off Heron Island on the Great Barrier Reef. Other studies of immature sea turtles are also known to be in progress on the east coast of Florida at Mosquito Lagoon (Ehrt and Yoder 1978), on the west coast of Mexico (Felger, Clifton, and Cornejo 1978), in the Galapagos

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Hughes, G. R. 1974. The sea turtles of South East Africa. 2. The biology of the Tongaland loggerhead turtle *Caretta caretta* L. with comments on the leatherback turtle *Dermochelys coriacea* L. and the green turtle *Chelonia mydas* L. in the study region. *Investigational Report of the Oceanographic Research Institute* 36:1-96.

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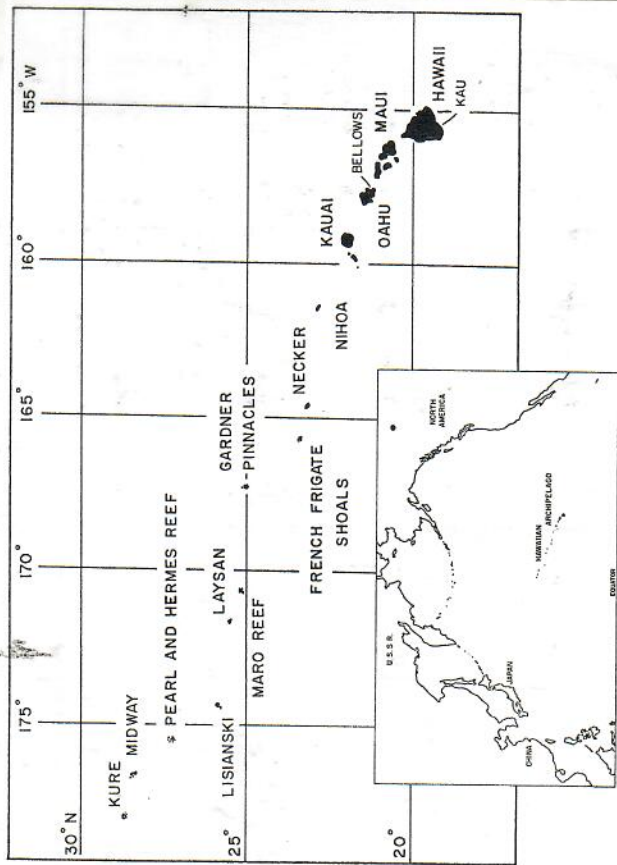


Figure 1. Hawaiian Archipelago, North Pacific Ocean.

Islands (D. Green, in litt.), at Bermuda (Frick 1977), and in the Bahamas (K. Bjorndal, in litt.).

### Study Area

The Hawaiian Archipelago consists of 132 islands, islets and reefs under United States jurisdiction that extend for 2,450 km across an isolated region of the North Pacific Ocean from 18°54'N, 154°40'W to 28°15'N, 178°20'W (Figure 1). Eight main and inhabited islands (Hawaii, Maui, Kahoolawe, Lanai, Molokai, Oahu, Kauai, Niihau) located in the southeastern segment of the archipelago comprise over 99 percent (16,650 km<sup>2</sup>) of the total land area. The remainder consists of offshore islets and the small islands extending to the northwest of Kauai and Niihau known as the Leeward or Northwestern Hawaiian Islands. Except for Kure and Midway, the islands in this segment of the chain comprise the Hawaiian Islands National Wildlife Refuge.

A population of green turtles occurs throughout the Hawaiian Archipelago, with mixed aggregations of adults and immature individuals residing at foraging areas

along the 1,210 km of coastal waters. Turtles measuring less than 35 cm in straight carapace length are not normally found in these resident foraging areas and are assumed to be living somewhere in the pelagic environment. In excess of 90 percent of all nesting takes place on 6 small sand islands in the middle of the archipelago at French Frigate Shoals. Adults periodically undertake long-distance migrations to this location for reproduction. Hawaiian *Chelonia* exhibit the rare behavioral trait among sea turtles of coming ashore to bask or rest, but only at certain undisturbed sites in the Northwestern Hawaiian Islands. This includes both adult males and females and, to a lesser extent, immature members of the population (Balazs 1976, 1979b).

Although immature green turtles have, at various times, been tagged at 16 different foraging sites throughout the Hawaiian Archipelago, 7 representative study areas have been selected for repetitive and long-term sampling. The locations of these areas are shown in Figure 1 and described as follows.

Table 1. Growth rates of immature green turtles sampled at 7 study areas in the Hawaiian Archipelago

Location and tag number	Straight carapace length, cm	Interval in months	Growth rate cm per month	Mean growth rate cm per month
Midway Islands $N=8$				
Kau, Hawaii (19°08'N, 155°30'W)	47.6	1.75	.49	.44
2520	50.8	8.5	.52	—
2934	55.2	7.5	.38	—
2887	54.0	7.5	.38	—
Bellows, Oahu (21°10'N, 157°43'W)	44.1	13.5	.21	.20
2340	57.2	22	.19	—
2332	—	—	—	—
Necker Island (23°35'N, 166°42'W)	48.3	20	.14	.14
2391	—	—	—	—
French Frigate Shoals (23°45'N, 166°10'W)	36.5	10.5	.06	.08
2266	37.1	11.5	.11	—
1632	38.1	12.5	.08	—
2735	39.4	26	.09	—
1628	39.7	10	.06	—
2682	40.6	14	.09	—
2682	41.9	11.5	.08	—
1629	41.9	10	.03	—
1730	41.9	3	.11	—
3050	43.8	34	.04	—
3134	43.8	35.5	.08	—
2403	44.5	21	.01	—
1626	44.5	7.5	.13	—
1660	45.1	11.5	.03	—
1666	48.9	9	.11	—
1641	49.8	10	.10	—
1663	52.7	3	.11	—
1645	53.3	7	.09	—
1634	53.3	7	.05	—
Lisianski Island (26°02'N, 174°00'W)	35.9	2	.13	.13
2854	35.9	2	.13	—
2850	40.0	2	.13	—
2858	44.8	2	.13	—

ally through the water column. These nets are made of 2-mm diameter cotton or nylon line and measure 3.5 by 20 m with a square mesh of 23 cm. Multiple sections of net can be easily tied together to form different lengths. The nets are usually set from shore extending out perpendicular to the coastline. Most captures are made at night, frequently from 1 to 3 hours before sunrise during periods of incoming tides. Periodic monitoring of the net must take place as a precautionary measure to prevent the turtles from drowning once they have become entangled. Tangle nets have not been used at foraging areas in the Northwestern Hawaiian Islands due to the possibility of catching resident Hawaiian monk seals (*Monachus schauinslandi*).

**Diving.** At Kau, Midway, and Kure, captures have been made by hand while diving, both with and without the aid of scuba. Turtles are usually found resting on the bottom in partially sheltered areas of rock and calcareous substrate.

**Banding.** At Necker, French Frigate Shoals and Lisianski turtles have at times been captured when they come ashore to bask.

Morphometric data recorded for immature Hawaiian *Chelonia* have included straight and curved carapace length along the midline, straight and curved marginal, straight plastron-length along the midline, and body weight.

The identification tags that have been used since September of 1976 were specially manufactured by the National Band and Tag Company (Newport, Kentucky) from Inconel 625, an alloy consisting principally of nickel and cadmium (Balazs 1977). The change to Inconel was made following the determination that substantial corrosion was occurring in the Monel 400 (copper- and nickel-alloy) tags that had previously been in use. Both the Inconel and Monel tags were made in the manufacturer's series number 4-1005-681 self-piercing tag (8 by 29 mm, 3.5 g), which has a simplified locking mechanism and is suitable for use on both immature and adult turtles. Two tags have been applied to each turtle through the folds of flesh located proximal to the body on the trailing edges of the front flippers. Application is made so that some space remains between the end of the tag and the flipper to accommodate growth. No signs of corrosion have thus far been found in tags made of Inconel.

Sampling procedures have also included the recovery of food from the mouths of turtles captured while foraging and the retrieval of stomach contents using a flexible plastic tube inserted through the esophagus (Balazs in press). This has been carried out to identify food sources and to determine if differences that could influence growth exist between foraging areas.

A total of 629 immature *Chelonia* has thus far been

District consists of a lava rock coastline that lacks protective reefs and has numerous areas where fresh water enters the ocean from underground springs. Although a few partially sheltered bays are present, most foraging occurs close to shore under turbulent conditions resulting from exposure to tradewind-generated waves.

**Bellows Air Force Station, Oahu** (21°10'N, 157°43'W). Bellows Air Force Station has a sand beach coastline within Waimanalo Bay that is protected from large surf by subtidal reefs. Foraging occurs close to shore, particularly near the exits of 2 fresh-water streams.

**Necker Island** (23°35'N, 166°42'W). Necker is an uninhabited lava rock island consisting of 17 ha with a maximum elevation of 85 m. Foraging occurs at the base of the island's cliffs and at a partially sheltered reef area adjacent to a rock ledge where basking takes place.

**French Frigate Shoals** (23°45'N, 166°10'W). French Frigate Shoals is a 35-km long crescent-shaped atoll that has shallow foraging areas located near the islands of East (4.0 ha), Whale-Skate (6.8 ha), and Tern. Tern was enlarged from 4.5 to 23 ha by dredging and landfill in 1942 to serve as a U. S. Naval Air Station. The station was later abandoned, but from 1952 to 1979 a small U. S. Coast Guard Loran Station was located at this site.

**Lisianski Island** (26°02'N, 174°00'W). Lisianski is an uninhabited 182-ha sand island with protective reefs and shallow foraging areas located close to shore.

**Midway Islands** (28°13'N, 177°21'W). Midway is an atoll 11 km in diameter with 2 sand islands (Sand and Eastern) and a well defined fringing reef. Foraging areas exist throughout the lagoon and adjacent to the islands. A U. S. Naval Station is located at this site.

**Kure Atoll** (28°25'N, 178°10'W). Kure is an atoll 9.5 km in diameter with 2 sand islands (Green and Sand) and a well-defined fringing reef. Foraging areas exist throughout the lagoon but are mostly adjacent to Green Island. Kure is the world's northernmost atoll and, since 1960, the site of a small U. S. Coast Guard Loran Station.

**Sampling Methods**

Four basic methods have been employed to capture immature green turtles in the Hawaiian Archipelago.

**Scoop net.** At Necker, French Frigate Shoals, Lisianski, and Kure, a scoop net 1 m in diameter with a 3.5-m long handle has been used to catch turtles, both from a small boat and from shore by walking out into shallow foraging areas up to 1.3 m deep.

**Tangle nets.** At Kau on Hawaii and Bellows on Oahu, turtles have been captured with tangle nets set verti-

tagged throughout the archipelago, 524 of which were captured at the 7 study areas. These turtles range from 29.5 to 79.4 cm in straight carapace length. Prior to the initiation of my research program in 1973, 185 immature *Chelonia* had been tagged since 1967 by the Korral Kings Diving Club at Midway, using series 4-1005-49 self-piercing Monel tags (9 by 39 mm, 7 g) supplied by the U.S. Fish and Wildlife Service. Turtles tagged at Midway have often been released up to 6 km from the site of capture while at the other study areas the turtles have been released where they were captured.

**Results**

Thirty-five turtles, ranging from 35.9 to 59.4 cm in straight carapace length, have thus far been recaptured, in which growth could be detected after intervals of 2 to 37 months in the wild. Four of these turtles were recaptured on 2 occasions, thereby providing a total of 39 growth measurements. The rates of growth found at each of the 7 study areas were not dependent on the size of the turtles (Table 1). Thirty-four other turtles that were recaptured after intervals of 2 to 20 months showed no measurable growth. This included 1 turtle at Necker, 24 at French Frigate Shoals, 3 at Lisianski, and 6 at Midway. One of the turtles at French Frigate Shoals measured 68 cm and was recaptured after 20 months while the turtle at Necker measured 42 cm and was recaptured after 17 months. All of these turtles were vigorous and appeared to be in good health.

187  
 $\bar{x} = 1.1 \text{ cm/year}$   
 Range 0.4 cm/year - 2.5 cm/year

None of the recaptured turtles showed evidence of tail enlargement indicative of males.

The mean rates of growth found at the 7 study areas ranged from .08 to .44 cm/month in straight carapace length. Growth rates at the 2 study areas in the main islands (Kau and Bellows) were considerably greater than at the 5 study areas in the Northwestern Hawaiian Islands (Table 2). The most rapid growth was recorded at Kau (range .38 to .52 cm/month), and the slowest at French Frigate Shoals (range .02 to .13 cm/month), and Kure (range .04 to .12 cm/month).

The use of straight carapace length has been found to be the most reliable index of growth for Hawaiian turtles. Curved carapace length is subject to greater error from variability in positioning the flexible measuring tape along the carapace in comparison to the use of calipers for straight line measurement. The use of body weight has also been found to be of reduced value. This is probably due to differences in the amount of food material present at various times in the gastrointestinal tract, a component that can comprise up to 18 percent of the weight of immature Hawaiian *Chelonia*.

All 69 of the turtles that were recaptured and measured were found in the same resident areas where

they were originally tagged. Except at Midway, most of the turtles were either foraging or resting within 50 m of the original capture site. At French Frigate Shoals, no movements of tagged immature turtles were found between East, Whale-Skate, and Tern, even though the distance between any 2 of these islands is only 8 to 11 km.

Of the 629 immature turtles tagged in the Hawaiian Archipelago, only 2 long-distance movements have been reported, with 1 of these being of questionable validity. One recovery involved a 38-cm turtle tagged at Midway and found 6 months later at Wake Island (19°18'N, 166°36'E), a distance of 1,900 km. However, the weak and apparently pathological condition of this turtle, reported both at the time of original capture and at recovery, suggests that it may have passively drifted there with prevailing winds and currents. The other long-distance movement was a 40-cm turtle also tagged at Midway that was reported 7 months later by a fisherman as having been recaptured and released alive in Hilo Bay on the island of Hawaii. This involves a distance of 2,500 km against prevailing winds and currents present in the latitudes of the Hawaiian Archipelago. Although 2 Monel tags were originally placed on the turtle, only 1 tag was found at the time of recovery.

**Table 2. Summary of growth rates and projected number of years to maturity for immature green turtles sampled at 7 study areas in the Hawaiian Archipelago**

Location, number tagged and size range	Growth rate, cm per month		Interval in months	Years to maturity (35 to 81 cm)		Years to maturity (35 to 92 cm)		
	Mean	Range		Mean	Range	Mean	Range	
Kau, Hawaii N = 72 37.7-79.4 cm	.44	.38-.52	4	7.5-17.5	8.7	7.4-10.1	10.8	9.1-12.5
Bellows, Oahu N = 21 38.1-61.6 cm	.20	.19-.21	2	13.5-22	19.2	18.3-20.2	23.8	22.6-25.0
Necker N = 7 39.4-48.3 cm	.14	—	1	20	27.4	—	33.9	—
French Frigate Shoals N = 130 36.4-67.9 cm	.08	.02-.13	19	3-35.5	47.9	29.5-191.7	59.4	36.5-237.5
Lisianski N = 23 35.9-53.3 cm	.13	—	3	2	29.5	—	36.5	—
Midway N = 250 36.5-59.4 cm	.09	.03-.21	8	6-37	42.6	18.3-127.8	52.8	22.6-158.3
Kure N = 21 29.5-61.6 cm	.08	.04-.12	1 1/2	13-24	47.9	31.9-95.8	59.4	39.6-118.8

Growth Rates

The possibility therefore exists that the tag number may have been misread due to corrosion or other causes, and that this turtle was not the one tagged at Midway. The major food sources of immature green turtles that have been identified at each of the 7 study areas consist of the following benthic algae:

- Study area** Major food source
- Kau, Hawaii: *Pterocladia capillacea*
  - Bellows, Oahu: *Codium edule*, *Codium arabicum*, *Codium phasmaticum*, *Ulva fasciata*
  - Necker: *Caulerpa racemosa*
  - French Frigate Shoals: *Codium arabicum*, *Codium phasmaticum*, *Codium edule*, *Caulerpa racemosa*, *Ulva fasciata*, *Turbinaria ornata*
  - Lisianski: *Caulerpa racemosa*, *Turbinaria ornata*
  - Midway: *Codium edule*, *Spyridia filamentosa*
  - Kure: *Codium edule*

In the Northwestern Hawaiian Islands, particularly at Midway and Kure, immature turtles have also been recorded voraciously feeding on the invertebrates *Physalia physalia*, *Velella velella* and *Janthina exigua* that periodically drift into coastal areas.

**Discussion and Conclusions**

The growth rates of naturally occurring immature green turtles reported by workers in other areas have ranged from .05 to 5.26 cm per month (Table 3).

Using curved carapace length, Schmidt (1916) found a mean growth rate of .43 cm/month (range .10 to .69 cm/month) in the Virgin Islands, while Limpus (1979) reported growth rates ranging from .05 to .27 cm/month at Heron Island. These values are similar to the ones found at the 7 study areas in the Hawaiian Archipelago. Limpus (1979) also recaptured green turtles in which no growth could be detected. The apparent absence of growth over extended periods has also been found for some immature *Chelonia* in the Galapagos Islands (D. Green, *in litt.*). In contrast with the findings of other workers, Carr and Caldwell (1956) reported a growth rate estimated to be from .75 to 5.26 cm per month for a green turtle recaptured off the west coast of Florida (Table 3).

Estimates of the maturation age of green turtles that have appeared in the literature (summarized by Hirth 1971 and Rebel 1974) have ranged from 4 to 13 years. However, these values were based on growth rates obtained in captivity where conditions are substantially different from the natural environment. It is of interest

to note that none of the estimates for age at maturity have been based on the natural growth rates resulting from Schmidt's pioneering work published in 1916.

If the growth rates determined at the study areas in the Hawaiian Archipelago remain constant until maturity, as available data suggest, then turtles measuring 35 cm that are new recruits would require from 8.7 years (at Kau) to 47.9 years (at Kure and French Frigate Shoals) to reach 81 cm, the minimum size at which nesting takes place in the population. From 10.8 to 59.4 years would be required to grow from 35 to 92 cm, the mean size of nesting Hawaiian *Chelonia*. Table 2 presents similar projections for 35-cm turtles that establish residency at each of the foraging areas investigated. All of these estimates are based on the assumption that residency is maintained at the same general foraging area, and that the turtles do not at some point prior to maturity move long distances to other foraging areas where different growth rates result. Except for the 2 long-distance recoveries previously described, all evidence accumulated to date indicates that residency continues for extended periods, and may be permanent except for reproductive migrations undertaken as adults. This concept is supported by the 69 stationary tag recoveries that have thus far been made after intervals ranging up to 37 months and by the fact that all sizes of turtles from 35 cm to mature adults are present at most of the foraging areas in the Hawaiian Archipelago.

Green turtles are believed to mature at different sizes (Carr and Goodman 1970), therefore age at maturity would be expected to differ, even among individuals at the same foraging area where similar growth rates are taking place. Carr and Carr (1970) have found that after reaching maturity the growth rate of green turtles nesting at Tortugero, Costa Rica is only approximately .02 cm/month. A similar slow growth rate of .04 cm per month (range .01 to .12 cm/month) has been found for 17 females nesting at French Frigate Shoals after intervals of 24 to 75 months. Consequently, some females (and presumably males) appear to mature at a small size and then reach a large size after many years of slow growth while other females do not mature until reaching a large size. Turtles that mature at 81 cm in the Hawaiian Archipelago would require an additional 23 years to reach the mean size of 92 cm. However, the size of adult green turtles is believed to be more heavily influenced by differences in maturation size than by growth (Carr and Goodman 1970), and most Hawaiian *Chelonia* that are 92 cm (or larger than 81 cm) probably grew to that size before achieving maturity (Table 2).

The natural growth rates of immature Hawaiian *Chelonia* less than 35 cm cannot be determined at the present time due to an absence of human contact with this size category following the departure of hatchling

period prior to the turtle's disappearance, a growth rate of .71 cm per month was recorded. This is far greater than the growth rates recorded for turtles feeding on natural food sources at French Frigate Shoals and, in fact, the most rapid growth thus far documented for a Hawaiian green turtle living in the wild. In assessing the growth rates and adaptability of captive-raised turtles returned to the wild (headstarting) the need exists to determine if food sources other than those used by naturally occurring turtles are being exploited.

The toxic properties of corroding Monel tags on turtles did not appear to be a factor affecting growth rates at the study areas where they were applied. Both Monel and Inconel tags have been used at Kau, French Frigate Shoals, and Midway. No relationship has been found at these locations between the type of tag and rate of growth. Only Inconel tags have been used at Bellows, Necker, Lisianski, and Kure. Nevertheless, the introduction of heavy metals into a turtle's system from Monel tags corroding at the unhealed piercing site could result in long-term adverse effects, in addition to the eventual loss of the tag.

The slower growth rates, and in many cases apparent cessation of growth, found at the study areas in the Northwestern Hawaiian Islands could have far reaching implications with respect to mortality rates of immature turtles and recruitment to the breeding colony. Tiger sharks (*Galeocerdo cuvier*) are essentially the only known natural predators of Hawaiian *Chelonia* at resident foraging areas throughout the archipelago (Balazs 1979b). At the locations where slower growth takes place, immature turtles would be exposed to this predation as small turtles for longer periods of time, thereby resulting in comparatively higher mortality rates. This is assuming, of course, that an increase in predation from tiger shark predation is afforded as a turtle grows larger. While such an inherent protective mechanism seems plausible and has been widely accepted as fact (Hirth 1971), it should be noted that the remains of full-size adults, in addition to immature individuals, have been periodically found in tiger sharks captured at French Frigate Shoals. If higher mortality rates of immature turtles do in fact occur in areas where slower growth takes place, then lower rates of recruitment of adults to the breeding colony would be expected. Many years may therefore be required for some green turtle populations to build up large breeding colonies due to these low adult recruitment rates, and the protracted ages at maturity. Furthermore, these populations would be more susceptible to overexploitation and less able to undergo recovery once such declines have taken place.

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Table 3. Summary of growth rates reported by other workers for naturally occurring immature green turtles

Location and reference	Number tagged	Type of measurement	Growth rate		Size range, cm	Interval, in months
			Mean	Range		
Virgin Islands 18°20'N, 64°55'W Schmidt (1916)	65	curved carapace length	.43	.10-.69	29-57	3.5-11
West Florida 28°54'N, 82°35'W Carr and Caldwell (1956)	43	straight carapace length	—	.75-5.26*	44-58	3-3.5
Bermuda 32°20'N, 65°45'W Burnette-Herkes (1974)	19	straight carapace length	.04*	—	<50	12-17
Heron Island 23°27'S, 151°57'E Limpus (1979)	—	curved carapace length	—	.05-.27	40-90	<51

a. Range of possible growth rates — loss of tag prevented individual identification  
b. Mean includes two naturally occurring turtles and one headstarted turtle

from the nesting beaches at French Frigate Shoals. During this unknown time period, the turtles are thought to be living in the open ocean where they feed on invertebrates occurring at or near the surface. In pelagic waters surrounding the Hawaiian Archipelago this could include *Physalia*, *Velella*, *Jambsina*, the megalops stage of some portunid crabs, and immature individuals of certain oceanic squids that come to the surface at night in large numbers (*Symbototeuthis ovalensis*, *Ocyropsis*, *Hyaloteuthis pelagica*, for example). Carnivorous foraging habits of this nature should produce growth rates that exceed those found at coastal areas where mostly algal food sources are utilized. In captivity, Hawaiian *Chelonia* have been found to require at least 19 months to grow from hatchlings to 35 cm.

The differences in growth rates found between the study areas in the Hawaiian Archipelago are thought to be a function of the sources and abundance of acceptable food. At Kau, where the most rapid growth has been recorded, dense pastures of the principal food source, *Pterocladia capillacea*, are present along the coastline. In the Northwestern Hawaiian Islands this is a rare species known to occur only in small quantities at Lisianski. Three other algal species, *Caulerpa racemosa*, *Tarbinaria ornata*, and *Spyridia filamentosa*, identified as principal food sources in the Northwestern Hawaiian Islands, have never been found as dietary components in the main islands, even though they occur at a number of locations. This would suggest that green turtles in the Northwestern Hawaiian Islands feed on these 3 species out of necessity due to the absence or limited supply of other more desirable algae. The genus *Caulerpa* contains the toxic constituents

caulerpin and caulerpin. Caulerpin can produce symptoms in humans similar to ciguatera fish poisoning, and caulerpin is toxic to mice (Doty and Aguilars-Santos 1966, 1970). Both of these compounds can be transferred along the food chain and concentrated in the process by certain herbivores. However, the effects on green turtles, if any, are presently unknown. *Caulerpa* has also been reported as a food source of green turtles in the Galapagos Islands (Pritchard 1971), South Africa (Hughes 1974), Aldabra Atoll (Frazier 1971), and Rose Atoll (Girard 1858).

Seawater temperature would be expected to exert some influence on growth at the study areas, but this is not evident based on the available data. At Kure and Midway, and probably extending to the southeast as far as Lisianski, mean monthly sea-surface temperatures range from a low of 20.5° C during February to a high of 26.2° C during August and September (Seckel 1962). This is 2 to 3° C cooler than at French Frigate Shoals (range of monthly means 23.8-28.3° C) where similar slow growth rates have been recorded. In contrast, sea-surface temperatures at French Frigate Shoals closely resemble those in the main islands where considerably faster growth has been found at Kau and Bellows.

Further evidence that food is the limiting factor for growth at some study areas, rather than seawater temperature or other environmental factors, has resulted from the recapture of a 46-cm green turtle raised from a hatchling in captivity and released at French Frigate Shoals. This turtle established a home range near Tern Island where it was regularly fed fresh fish scraps (*Caranx ignobilis*, *Caranx melampygus*) by personnel of the U.S. Coast Guard Loran Station. Over an 8-month

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# The Pacific Adventures of John Cameron

by Hank Soboleski

John Cameron was born in Scotland in 1850, went to sea as a lad of 17 and, after sailing the Atlantic and Indian Oceans, he started his Pacific adventures in Honolulu in 1879 as second mate of the Pomare, bound for the South Seas on a labor-recruiting voyage for Hawaii's sugar plantations.

Labor-recruiting, or "black-birding," was dangerous business, since natives often were warlike and especially hostile toward recruiters for cruel treatment their fellows had received at plantations in Fiji, Samoa and Australia.

Accordingly, Cameron and his mates anticipated trouble at Tanna Island in the New Hebrides (today's Vanuatu), Pomare's first stop. And, at sea, when they stood on deck at night and saw the eerie glare of Tanna's volcano in the distance, it may have seemed to them as if the ship was entering into the domain of the damned. But, no mishaps occurred at Tanna and a native boat crew was hired and Pomare sailed on.

Action picked up soon after, however, at Mallicolo where about 400 men gathered on shore. Large numbers of men generally meant danger to be avoided, but the men gestured in friendly fashion and appeared unarmed as seen from Pomare's deck, so a decision was made to recruit them.

The ship's two shoreboats were lowered, with Cameron in charge of one of them. When they reached the shallows, the natives waded out to greet them.

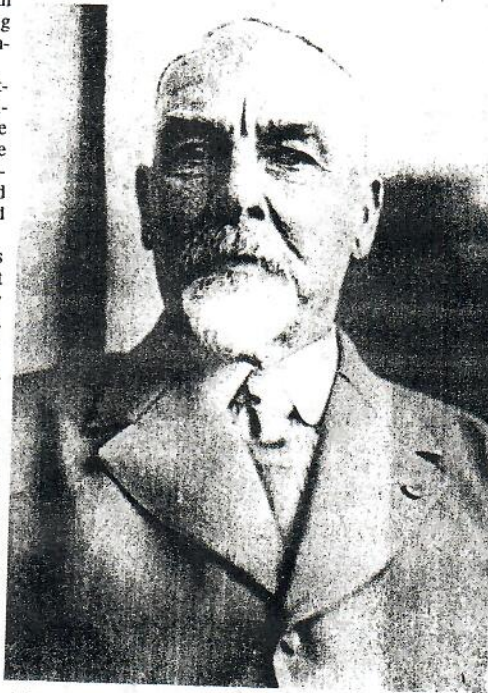
Then, without warning, they rushed the lead boat, attempting to seize it while Cameron's boat closed behind. Rifles and revolvers were fired, hatchets flew, knives were drawn and a fury of hand-to-hand combat ensued.

Incredibly, the natives were turned back by the outnumbered recruiters and Cameron received not a scratch, although a few of the crew were cut.

Later, at Pentecost Island, five canoes, each carrying about 100 warriors, were spotted two miles away being vigorously

paddled toward Pomare, which was becalmed inshore.

While the warriors paddled closer, yelling and waving their clubs and spears wildly, Cameron loaded his six-pounder and when they'd closed to 100 yards he fired the gun. Exploding shrapnel



John Cameron, a seafaring man who spent his last 25 years ashore. (Photos from John Cameron's Odyssey)

swamped two canoes, abruptly stopped the frenzy and the surviving warriors turned tail.

Similar adventures engaged Cameron before Pomare finally returned to Honolulu in 1881 with 87 laborers destined for the sugar cane fields. Cameron then took up more peaceful pursuits, serving as an officer on interisland steamships in Hawaiian waters for the next six years.

One of his most famous passengers was Princess Ruth Keelikolani, an alii (chief) of the highest rank and the wealthiest woman in Hawaii.

Cameron was first officer of the Iwalani in August 1881 when it transported Princess Ruth from Honolulu to the Big Is-

land so she could (amazing as this may seem) attempt to stop the lava flow that had advanced about 40 miles from its source at Mauna Loa and was endangering the town of Hilo.

Indeed, Princess Ruth seemed to be Hilo's last hope when she arrived to offer sacrifices to Pele, the volcano goddess, six decades, by the way, after missionaries had established Christianity in Hawaii.

It's a fact that the flow stopped immediately after she made burnt offerings of pigs and pigeons and no one could have persuaded the Hawaiians that her actions were merely coincidence.

Another famous that Cameron made the acquaintance of was King David Kalakaua, the "Merry Monarch." Kalakaua made frequent voyages to Kauai while Cameron was sailing as master in service to that island and the two became friends and drinking companions, tipping many a glass together in the king's home at Iolani Palace in Honolulu and at the jolliest of parties elsewhere.

Yet, in 1887, Cameron exchanged a steamship captaincy and a king's companionship for the promise of more adventure as first officer of the Wandering Minstrel and a shark-fishing voyage to Midway.

Cameron soon found the adventure he's sought, for when the ship reached Midway, a hurricane struck. Wandering

Minstrel was wrecked and Cameron and his shipmates found themselves castaways, living in shanties and subsisting mostly on a diet of birds' eggs, fish and water.

Weeks passed and hope of rescue dimmed. A boat was fitted for sea, but it vanished in a storm. Another boat, an open 21-footer, was made ready and, after eight months of being stranded on Midway, Cameron and two others wet sail for Hawaii.

Once at sea, three straight days of storms with teeth-rattling cold proved beyond endurance, forcing Cameron to change course for the Marshall Islands and warmer weather to the southwest.

Still, horrible weather persisted. Huge seas terrified the men. They bailed constantly for days on end. Rain provided plenty of drinking water, but food supplies dwindled. A speared dolphin sustained them, but a shark they'd snared with a rope and killed with a knife cause them severe abdominal pain after they's eaten its poisoned liver.

On the positive side, Cameron was a skilled navigator, able to reckon his position at sea with his compass and a damaged sextant to avoid being lost. At 33 days out of Midway, he estimated he was due east of Mili Atoll in the Marshalls.

Not long afterward, the dauntless Scot noticed coconut husks floating in the sea—a sign of land. Ten days later, they saw the tops of coconut palms at Mili.

That Cameron and his mates had survived a voyage of 43 days in an open boat in heavy seas over 1,700 miles of ocean devoid of land, with only the barest of navigational tools on hand, is remarkable. (The remaining survivors on Midway were finally rescued by the schooner Norma in March 1889.)

Cameron decided to stay in the Marshalls and soon was commanding the trading schooner Ebon, visiting trading stations in several island groups with supplies to exchange for copra and shells.

Never loathe to turn a profit

in this trade, he also once sold rifles and cartridges to natives in rebellion against Spanish occupation at Ponape (Pohnpei). This transaction, illegal under Spanish law, earned him a bos of gold, but an informant named Christian reported the sale to Spanish officials and Cameron was arrested, but not before he'd hidden his treasure.

If found guilty, Cameron would have faced execution, but the Spanish couldn't find the golden evidence they needed to validate Christian's charge. Meanwhile,

Cameron steadfastly maintained his innocence during his trial.

Yet, his fate remained doubtful, until a surprising and most welcome appearance at court by his friend, Dick Cole, saved the day, for Cole held some sort of influence over Christian that convinced the informant to withdraw the charge.

The cry of "not guilty!" was the sweetest sound to Cameron's ears. Later, at sea aboard Ebon, Cameron retrieved the gold he'd stashed away in a shipboard water tank.

Cameron met with many other adventures during his Pacific voyages. To mention a few:

His ship was grounded on the reef at Nikunau in the Gilberts; he sailed to Tahiti as master of a cattle vessel and he survived run-ins with pirates; he made a round-about, 9,000-mile, island-hopping voyage from Kusaie (Kosrae) to Kobe, Japan, and he delivered a yacht from Japan to Vladivostok, Russia, during a typhoon in 1887, his final year at sea.

He met the famous author, Robert Louis Stevenson, in 1890 in Tarawa on the deck of the latter's ship, the Janet Nicoll. His replies to the writer's questions about the wreck of the Wandering Minstrel on Midway helped inspire Stevenson to write The Wrecker with Lloyd Osbourne.

Cameron also met the notoriousing Tem Binoka of

Abemama, Kuria and Aranuka in the Gilberts and Binoka's constant companion, a retinue of 25 women.

He married the daughter of a Mejit Island chief and their daughter was born during a gale at sea.

Standard Oil Company hired Cameron at Kobe in 1899 and he held that shore job for 25 years. In 1925, he set sail on his final and eternal voyage.



Princess Ruth Keelikolani was one of John Cameron's most famous passengers.

75 years old

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## Species in the Spotlight..... Vol. 1 #1

Each edition of **The Gooney Gazette II** will feature one of the many species of wildlife that inhabit the land and waters of Midway Atoll. Since, in addition to the monk seals, dolphins and albatross that are so obvious to even the most casual Midway visitor, there are at least 14 other species of migratory birds and over 250 species of fish. So according to my math, we have material for at least 67 years of "Species in the Spotlight"! This edition will feature...

### Green Sea Turtles



There are about 250 species of turtles in the world. Some live only on land but others, like the Green Sea Turtle, spend almost their entire life in the sea. While many turtles live their entire lives close to where they were hatched, sea turtles migrate thousands of miles from their birthplace.

Turtles have been around for a long time. Evidence has been found indicating that turtles or turtle-like reptiles were on earth as far back as 200 million years ago, during the Triassic Period which is before the onset of dinosaurs!!

All turtles hatch from eggs that are laid on land. Female sea turtles may lay as many as 200 eggs at a time and one mating can result in the fertilization of all the eggs for several years! The warmth of the sun hatches the eggs and interestingly, the temperature at which the eggs are incubated determines the sex of the hatchlings.

Sea turtles are among the largest of the species and visitors to Midway can confirm that, indeed, they do surprisingly large. Sea turtles have legs shaped like long paddles, with flippers instead of feet. The Green Sea turtles are graceful swimmers and the fastest of all turtles. For brief periods they can swim at nearly 20 miles per hour, using their flippers much as a bird flaps its wings.

Though the Green Sea turtle is graceful and swift in water, they are almost completely helpless while they are on land.

Though most species of turtles can pull their head, legs and tail into their shell for protection, the sea turtles cannot withdraw into their shells and thus they depend on their size and swimming speed for defense.

Turtles have no teeth but use their sharp beak to tear their food into pieces. They have well-developed senses of sight and touch and scientific experiments indicate that they also have a good sense of smell, at least for nearby objects. A turtle can hear low-pitched sounds about as well as a human can. Turtle shells are turtles on surprisingly sensitive due to the many nerves imbedded in it.

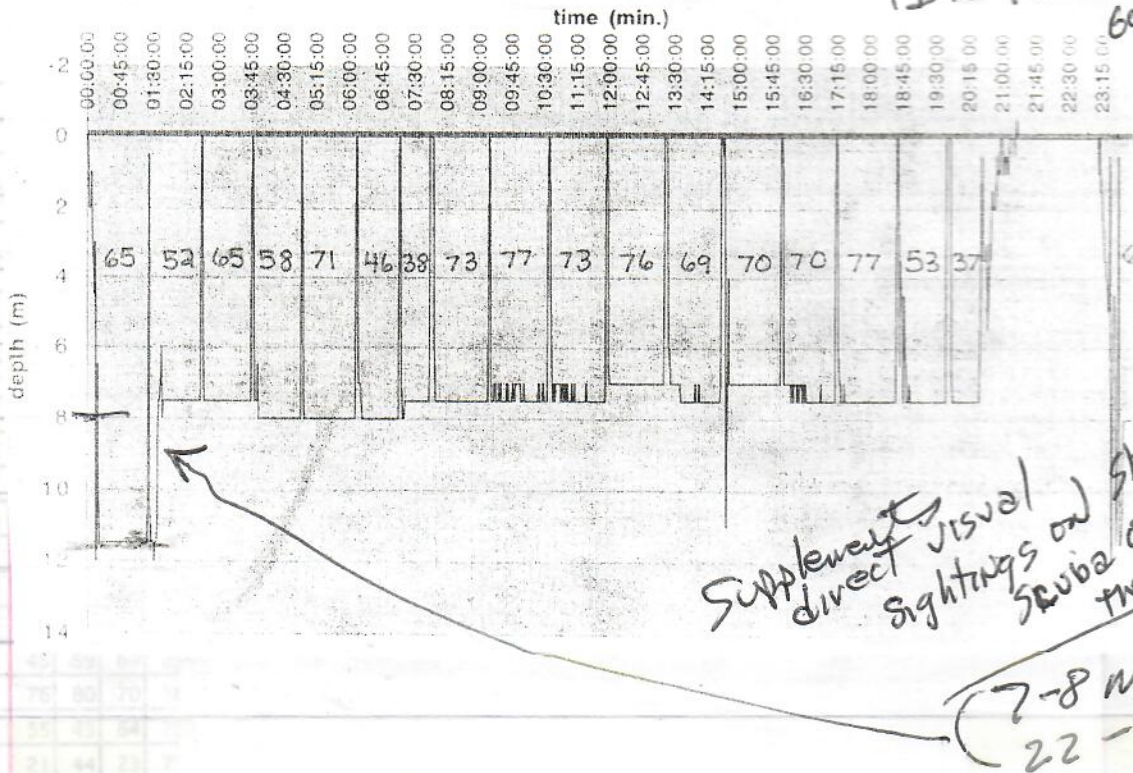
Many animals prey on turtle eggs and newborn turtles. Various birds and mammals eat baby sea turtles as they crawl toward the water and fish devour many as they enter the sea. Scientists believe turtles live longer than any other backboned animal. Most of the sea turtles are on the endangered species list. Diminishing nesting grounds and drowning of turtles in trawler nets are of serious concern to wildlife supporters.

Midway's lagoon is an important feeding area for green sea turtles and they are frequently seen resting on the beaches. There has been no nesting of these Midway for many years. It is hoped, however, that with continued protection of the beaches where turtles rest, females may begin to use Midway as a nesting ground.

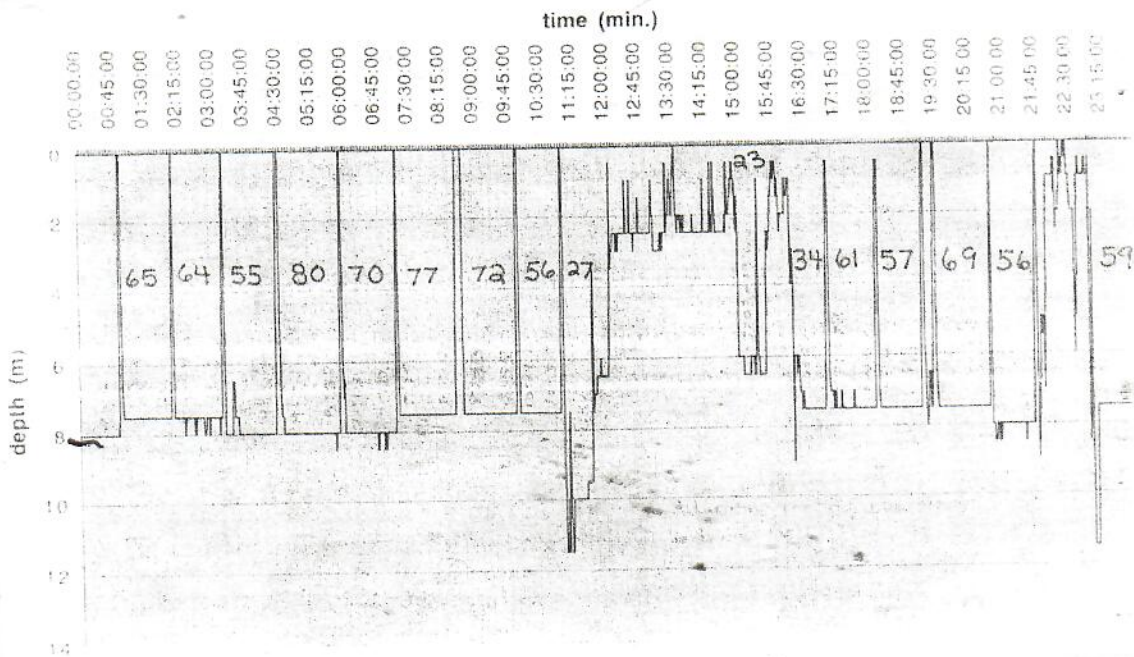


Midway #25 9/27/99 Graph 1

Seef. 179 193  
TDR 96-368  
60 days



Midway #25 9/28/99 Graph 1



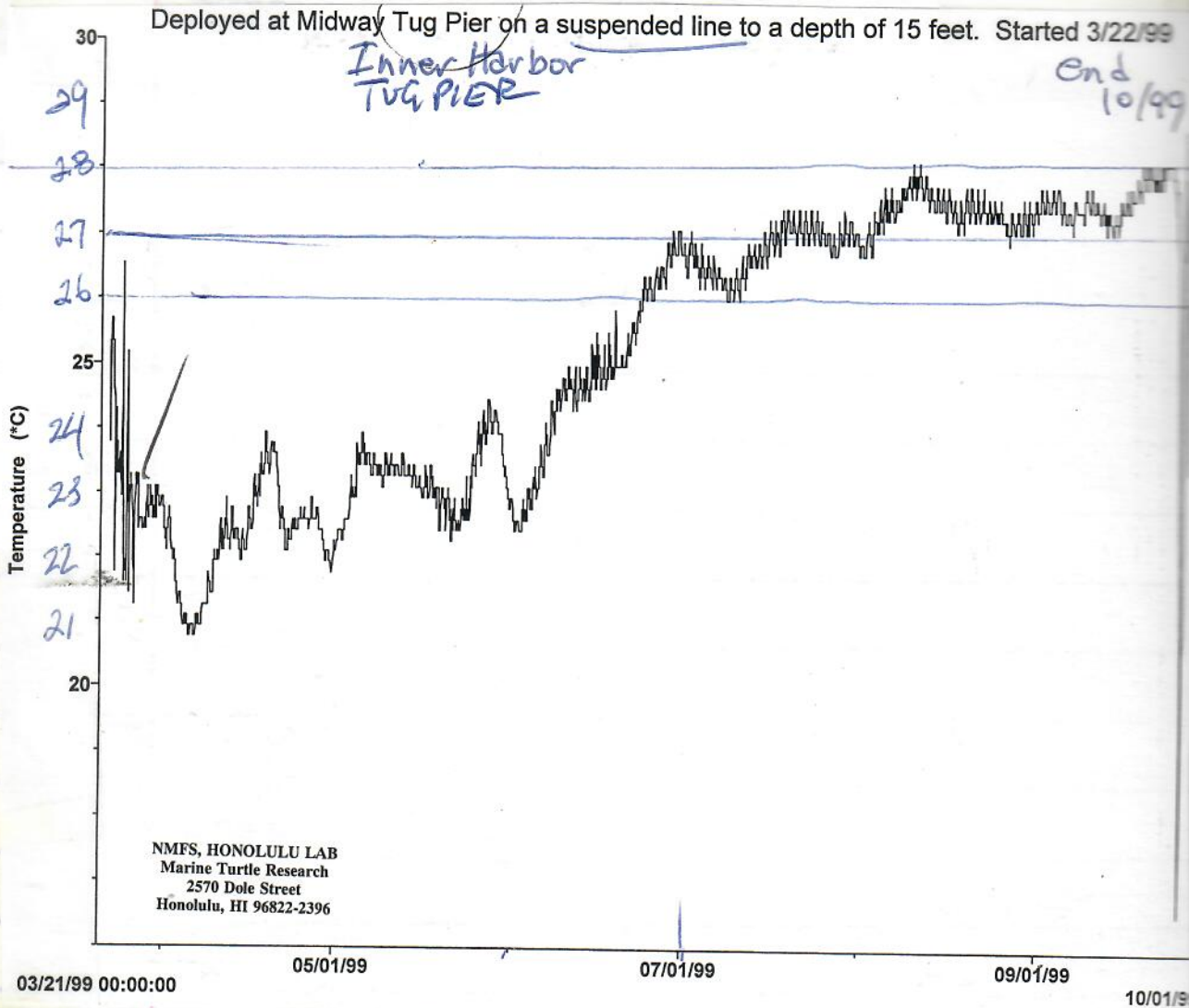
fliers 20-35 ft

10/28/99	70	37	87	83	86	83	84	91	33	48	41	48	59
10/29/99	68	71	73	76	81	67	84	21	50	14	48	33	15
10/30/99	94	92	85	85	70	90	76	83	40	42	53	65	46
10/31/99	89	83	89	80	85	93	82	78	71	79	78	73	85
11/1/99	95	74	81	75	74	27	92	89	94	58	61	55	55
11/2/99	70	73	91	56	25	47	60	57	57	54	53	59	72
11/3/99	79	83	91	79	106	107	91	96	44	24	62	62	55
11/4/99	18	73	85	87	87	67	26	97	95	104	36	46	55
11/5/99	89	96	102	100	49	69	106	97	27	18	56	59	52
11/6/99	77	77	90	88	85	26	70	93	92	44	51	60	53
11/7/99	69	94	80	78	90	86	100	95	103	52	65	52	48
11/8/99	86	97	92	103	100	100	20	55	45	56	56	47	49
11/9/99	95	96	90	84	86	95	95	83	28	15	82	35	50
11/10/99	86	98	80	70	29	86	97	87	36	46	60	51	52
11/11/99	76	73	92	92	71	86	87	29	59	19	76	76	80
11/12/99	92	91	84	88	73	90	90	95	85	100	97	104	101
11/13/99	101	99	93	87	84	99	81	47	37	57	54	39	51
11/14/99													
11/15/99	86	87	85	81	49	90	82	98	88	20	57	62	25
11/16/99	90	95	72	51	101	101	106	87	58	48	18	84	99
11/17/99	104	104	111	86	99	95	99	109	109	101	90	64	86
11/18/99	96	99	101	105	36	16	93	95	108	98	74	76	90
11/19/99													
11/20/99	97	99	97	97	109	118	91	92	64	108	105	107	95
11/21/99	114	119	111	102	81	40	42	17	70	65	68	114	98
11/22/99	106	118	120	96	101	111	101	113	103	92	103	119	96
11/23/99													

MT  
25

RE  
800  
100  
916

40	47	69	73	55	57	70									1261	20	63.05
35	42	19	27	66	80	75	69	75	78	91					1358	24	56.58
48	77	77	90												1213	17	71.35
81	82	75													1303	16	81.44
48	34														1012	15	67.47
65	77	79													995	16	62.19
39	42	50	64												1174	17	69.06
37	32	50	82	86	65										1228	19	64.63
49	86	77	69	78											1279	18	71.06
52	13	70	74	76	91										1282	19	67.47
54	76	77	77	66											1362	18	75.67
69	78	80	83	82											1298	18	72.11
57	86	85	65												1227	17	72.18
51	47	50	66	75	70	55	82								1374	21	65.43
90	76	88	86												1256	17	73.88
100	99														1389	15	92.6
23	42	76	75												1145	17	67.35
61	65	79	83	79											1277	18	70.94
75	76	15	35	84											1295	18	71.94
															1257	13	96.69
105															1192	14	85.14
															1279	13	98.38
104															1145	14	81.79
															1379	13	106.1



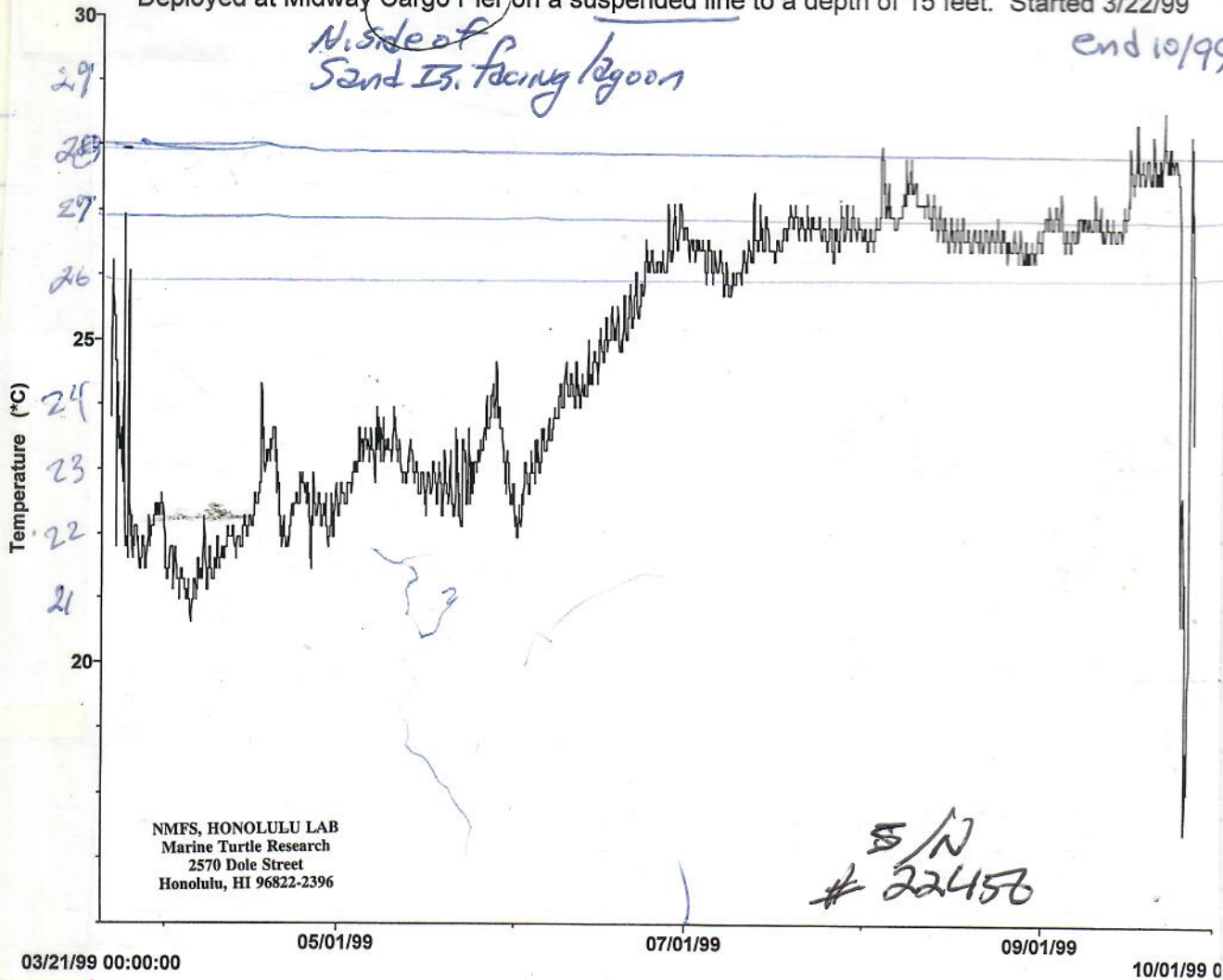
199

CARGO PIER

Deployed at Midway Cargo Pier on a suspended line to a depth of 15 feet. Started 3/22/99

North side of Sand Is. facing lagoon

end 10/99



NMFS, HONOLULU LAB  
Marine Turtle Research  
2570 Dole Street  
Honolulu, HI 96822-2396

S/N  
# 22456

200

Need TDPS  
if not already there

Date: Sat, 19 Jun 1999 14:09:14 EDT  
From: Hinwr@aol.com  
To: gbalazs@honlab.nmfs.hawaii.edu  
Subject: Turtle

See p. 65

Aloha George,

Tnx for the wine! This past eve we saw a turt. w  
(on both sides). Tags were N-21 LFL and N-20 RFL  
special?

MIDTP TD L  
Midway  
Assigned Turtle  
By Midway Beach  
"18" on her 3rd lat. scute  
Who is she? Is she

Our pit tag reader died. I guess seal was broken & when it fell out of turt.  
vest and got wet from a wave; water got inside. Tim says extra you sent with  
him doesn't read pit tags in the bag. We will send defunct reader back on  
the July 7 flight w/ a more detailed explanation.  
All else going well. My sub for Tim went well. Guess I am sorta doing  
turtle camp!

Vanessa (& Julie)

John Alexander  
Dylan Boyle  
Kelly Davis

Checklist

## MULTIPLICATION TABLE

1	2	3	4	5	6	7	8	9	10	11	12
2	4	6	8	10	12	14	16	18	20	22	24
3	6	9	12	15	18	21	24	27	30	33	36
4	8	12	16	20	24	28	32	36	40	44	48
5	10	15	20	25	30	35	40	45	50	55	60
6	12	18	24	30	36	42	48	54	60	66	72
7	14	21	28	35	42	49	56	63	70	77	84
8	16	24	32	40	48	56	64	72	80	88	96
9	18	27	36	45	54	63	72	81	90	99	108
10	20	30	40	50	60	70	80	90	100	110	120
11	22	33	44	55	66	77	88	99	110	121	132
12	24	36	48	60	72	84	96	108	120	132	144

## CONVERSION TABLE

### LENGTH

1 meter (m)	=	100 cm = 1,000 mm
1 millimeter (mm)	=	.001 m
1 centimeter (cm)	=	.01 m
1 decimeter (dm)	=	.1 m
1 decameter (dkm)	=	10 m
1 hectometer (hm)	=	100 m
1 kilometer (km)	=	1,000 m

### CAPACITY

1 liter (l)	=	100 cl = 1,000 ml
1 milliliter (ml)	=	.001 l
1 centiliter (cl)	=	.01 l
1 deciliter (dl)	=	.1 l
1 decaliter (dkl)	=	10 l
1 hectoliter (hl)	=	100 l
1 kiloliter (kl)	=	1,000 l

### WEIGHT

1 gram (g)	=	100 cg = 1,000 mg
1 milligram (mg)	=	.001 g
1 centigram (cg)	=	.01 g
1 decigram (dg)	=	.1 g
1 decagram (dkg)	=	10 g
1 hectogram (hg)	=	100 g
1 kilogram (kg)	=	1,000 g

## Straight carapace length

Straight carapace length (cm)	mL Liquamycin	
35-39.9	0.5	a noun a noun to another
40-44.9	1.0	words or ideas nation
45-49.9	1.7	
50-54.9	2.3	has". are".
55-59.9	3.0	
60-64.9	3.6	
65-69.9	4.3	is to recline.
70-74.9	4.9	is to cause.
75-79.9	5.6	

### • Punctuation

A **comma** is used to indicate a pause within a sentence, and to group words that belong together.

A **colon** is used prior to a list or long quotation.

A **semicolon** indicates a greater pause than that which is indicated by a comma; and is often used between groups of words separated by commas.

An **apostrophe** is used to indicate the possessive case of nouns as in *Jenny's pen*; to form a contraction as in *I've* or *they've*; and to form the plural of a letter or number as in the three *R's*, *7's* and *11's*.

An **hyphen** divides words in syllables such as compound words like *twenty-five*.

A **quotation mark** indicates the exact words someone spoke. Use with titles of songs, short stories, chapter titles, short plays, television programs, magazine articles and poems.

**Underlining** is used with the titles of books, movies, newspapers, magazines, long plays and poems.

