Hawaiian Turtles

G.H. BALAZS

MISCELLANEOUS FILE

Hawaii Institute of Marine Biology

The Hawaii Institute of Marine Biology is a research unit of the University of Hawaii which oversees and maintains facilities for faculty in several departments: Botany, Zoology, Oceanography, Microbiology, and Psychology. The primary laboratory site is Moku-o-Loe (Coconut Island) in Kaneohe Bay. Projects conducted at HIMB frequently accommodate undergraduates in MOP and provide an excellent training center for marine skill acquisition. In FY 77 Marie Wuerker and Alan Kam both pursued opportunities here. Although little used as a formal classroom-teaching facility, weekend field trips to HIMB are part of Oceanography 201, a course required of all MOP students.

ALAN KAM WITH A TURTLE AT A HAWAII INSTITUTE OF MARINE BIOLOGY HOLDING PEN

Alan Kam

Student Research Assistant

Alan Kam, a spring 1977 Marine Option Program graduate, has been working at HIMB with George Balazs as a research assistant on the green sea turtle project, which is funded by the MAC office and the UH Sea Grant College Program. Alan notes that the turtle population has been decreasing as the human population begins to infringe upon the turtle's habitat, with the result being that French Frigate Shoals has become the last viable reproductive population in the Hawaiian Archipelago.

Alan's work involved the capture, tagging, and release of turtles at Bellows Beach on the windward side of Oahu as well as on Kauai, the Big Island, and Midway Islands. He is currently continuing his work of tagging and recovering turtles, as well as doing a population study.

When asked to comment about MOP, Alan said, "The Marine Option Program is an organization that is able to develop individual talents with particular emphasis on our marine environment, namely Hawaii and the sea. Students from all over the mainland and Hawaii come to partake of an education that is relevant to their interests in marine activities." He added, "Through the leadership of the staff, MOP students are guided towards realizing their ideals and goals." He feels that since the ocean can be viewed from different perspectives, whether it be for recreational or commercial use, there is a vital need for understanding the potential of our marine resources, and to provide for better planning and management. "MOP," he says, "helps to build leaders, as students develop expertise in marine-related areas." Thus, in terms of the future, Alan feels that MOP students could readily apply their knowledge in situations which involve marine affairs decision-making.

ANNUAL REPORT 1977-78

Text by
Alan Okamoto and Laura Westbrook

MARINE OPTION PROGRAM UNIVERSITY OF HAWAII

John J. McMahon
Director

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Mortemore, J.A. (1974) Animals that live in the sea. Hilo, Hawaii 2000, Outdoor Education Center. 12 pp.

GREEN TURTLE

GREEN TURTLE

The green turtle is prized for its delicious meat as well as its shell. Many hotels and homes in Hawaii and elsewhere are adorned by brownish patterned shells hung on their walls. The shells must first be cleaned of flesh, barnacles, and other sea creatures before they are lacquered.

The green turtle is seen and caught frequently in Hawaiian waters. It is primarily a vegetarian, although it eats fish in captivity. It often swims close to rocky cliffs where it feeds upon plant material.

The green turtle is almost entirely aquatic, but may occasionally leave the water to bask in the sun. While in the water, it is an efficient swimmer. On land, however, it is rather awkward, since it crawls with a breast stroke. Other turtles walk on their legs.

The female must crawl ashore to lay her eggs in the sand. Using all four of her feet, she digs into the sand until she is buried level with the bottom of her shell. She then digs with only her rear feet until the rear of her body is lower than the front. She lays several hundred eggs which she covers with alternate layers of sand. The eggs look like soft ping-pong balls.

Many predators, including man, like to eat turtle eggs. When the young turtles hatch, they burrow out of the sand and head for the sea. Many types of birds prey upon them at this time.

Although it is not the largest sea turtle, the green turtle is large. An old one may weigh seven hundred pounds and reach five feet in length.

Today the green turtle is protected by law in Hawaiian waters.

TOWARD MANHOOD!

The boy, against his father's wishes, joined an expedition to Laysan Island, a remote Pacific atoll where five species of birds faced extinction.

There, amid the fascination of nature's outpost, the boy discovered both the bounty and the cruelty of nature. The creatures of the island—birds, seals, huge turtles, rabbits—are born, thrive, and die on the Pacific atoll. The boy grows, too. And in learning the lessons taught by nature the boy becomes a man.

"I couldn't put it down. . . There is a simplicity and sincerity to this writing which holds steady, and is truly reassuring in a crazy world." CATHERINE DRINKER BOWEN

Each of Robert Murphy's novels has been hailed as a classic of nature writing. In A CERTAIN ISLAND he has created one of the most memorable novels of boyhood and nature ever written.

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A CERTAIN ISLAND

by ROBERT MURPHY

author of THE POND

"Fascinating reading for anyone who loves wildlife and outdoor adventures."

JOHN KIERAN

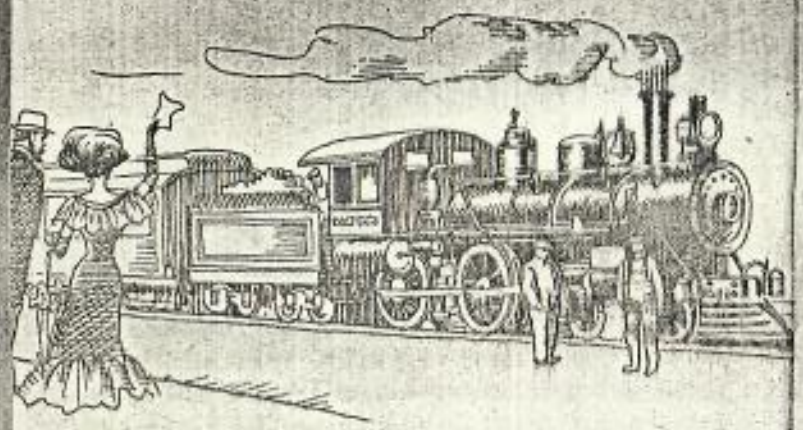
The small expedition to Laysan Island with which this novel is concerned actually took place. The island can be found on the map at the location given, and the background of history and birdlife is true. But the characters and events set forth are imaginary. The young man who made the trip bears some outward resemblance to Alfred M. Bailey, who is now the Director of the Denver Museum of Natural History. Dr. Bailey was born in Iowa and several of his boyhood adventures suggested a few of the things that occur in the book, but that is all. Dr. Bailey is not Geordie nor were Geordie's problems his, any more

than the other characters in the novel are the actual people who went to Laysan.

When I was first thinking of the book, I went to see Dr. Bailey. He and his family were most hospitable and generous in providing me with notes, diaries and museum publications, some of which are now out of print, containing Dr. Bailey's articles and pictures relative to the trip he had made so long ago. Without this help I doubt that the skeleton of A CERTAIN ISLAND would ever have been formed, and I am most grateful to them all.

Robert Murphy
Westtown, Pennsylvania

A CERTAIN ISLAND



THIRTEEN

The next morning Geordie hurried to Doc's office and forgot to knock before he pushed open the door. Doc was sitting surrounded with papers, and looked up. "I can go!" Geordie said. "My father's going to let me go!"

Doc stood up, and they shook hands. "Geordie, I'm delighted. I'll have a list for you in a day or two of the things you're to take. You and I will be leaving two weeks from tomorrow. We'll meet the rest of the crowd in San Francisco and go to Honolulu on an Army transport. You'd better go see Black." He smiled. "Oh," he said, and stuck his finger out. "You may be the camp

cook, and have to deal with turtles, fish, and whatever supplies they give us that will last ten weeks or so without refrigeration. It might be a good thing to have a conference with that Ingrid, and make up a list of spices and whatnot that you'll need. It will be a long swim to the nearest store."

"If you think I can cook well enough."

"No false modesty. You're a master chef, my boy. I still remember that stew on the opening day. In fact, that's what got me interested in you—that and the fact that you skin birds well. You'll work like the deuce, poor fellow."

"I sure worried about that stew. I wanted you to be impressed."

"You were scheming even then?"

"Yes, sir."

"It seems to run in the family," Doc said obscurely. "Well, off you go. I'll see you later."

Geordie went along to see Dr. Black, whom he found skinning a beautifully marked snowy owl.

"Thought I'd better attend to it myself," Dr. Black said, straightening up and putting his scalpel down. "It's the handsomest one I've ever seen. Came from up around the northern end of the state somewhere. You look pleased with yourself this morning."

"I'm going to Laysan," Geordie said. "My father told me last night I could go."

Dr. Black solemnly shook hands with him. "Congratulations," he said. "May it be the first of a lifetime of expeditions. I had heard that this was in the wind, but I didn't want to speak prematurely. I think that I'll give you a copy of the order for materials that should meet you in San Francisco. You can double check Sat. If he doesn't lose his list, that is."

the beach among the black-footed albatrosses—black gonies—that were scattered about. It was still strange to Geordie to have birds calmly move off only a few steps and watch him go by. Many of them didn't move at all. One that they stopped in front of had apparently just laid its egg, and when they stooped before it the bird got up, bent over, and touched the egg with its beak as though to point with pride to what it had accomplished.

They took pictures of it and went on to the little freshwater pond in the island's southwest corner. There was bunch grass in this vicinity and a few Laysan rails were running about in it; two ducks, dusky, with dark faces and white patches around their eyes, were swimming in the middle of the pond. They didn't fly and only moved a little further toward the far shore.

"They're awfully tame," Geordie said, and then recognized them. "They're Laysan teal! Now I've seen all five species of Laysan's birds! Doc, do you think that these are all that's left of them? They can't be down to two."

"I certainly hope not. There were less than a hundred when I was here before, and we were worried then. Even at that, they were the rarest duck in the world. But only two . . . . I can't believe it. You'd better make a project of getting here frequently to see if you can see more."

"Yes, sir."

"John was intending to collect a pair or two, but I'll have to call him off that. We have a few skins back home, and we'll give him a couple of those."

"Last night, when I said something about his being seasick all the time he didn't like it. I guess I shouldn't have said it."

"You were certainly within your rights," Doc said, "but as closely associated as we are, and will be for six weeks or so, I think you'd better go easy with him. He was always a difficult fellow, and seemed to think he was

better than anyone else and up on a little pedestal, but this time he's worse than usual. I don't think he's well, and being shaken up on the trip and not eating enough to keep a snake alive hasn't been good for him. Be patient, and offer to help him if the chance comes up. You'll probably be rebuffed, but just let it go."

"I'm sorry I talked back to him."

"Don't be sorry. Think no more about it."

They started to walk again, and came out on the wide south beach. The gray-backed terns were preparing to nest there soon, and there were legions of them; presently there would be more coming in from the sea. They swooped and dove at Doc and Geordie, tame and noisy; there were one or two pretty fairy terns among them, for they also liked that beach, and the two men moved through them as through a playful, living storm. A little further to the east, where the number of terns thinned out and the offshore reef ended, they came upon a sea turtle that must have weighed three hundred pounds. They hauled it out on the beach and grunted and heaved until they had turned it over on its back, where it lay waving its flippers.

"We'll come back later and collect some steaks," Doc said. "The tide's going out, and the old girl won't be able to get on her feet until it comes in again." He pointed north, up the beach. "There will be a lot of black gonies up there, but let's cut over to the lagoon now."

They started up the little rise behind the beach and as they got into the thin vegetation and scattered low scaevola brush they began to run into rabbits again. They were everywhere, seemingly as thick on the ground as the birds were in the air, and Doc and Geordie shot until their guns were almost too hot to hold and they had to stop for awhile.

A few more steps took them high enough to see the

their demolished tunnels with him, and after a good deal of dusty rolling about he got back onto solid footing and watched where he was going thereafter.

"So that's where they go in the daytime," he said, when he got his breath back. "They've scared me at night, but I didn't expect they'd try to bury me during the day."

"You'll fall into their burrows once in awhile," Doc said. "Everybody does. You can't always be sure where they are, and you'll have your mind on something else and down you'll go. They'll start to lay pretty soon and be quieter at night, and then the shearwaters will get here and make even more noise. I must admit that birds that live in holes during the day and raise the devil at night seem very queer to me. I can't get used to it."

They went on, shooting rabbits along the way, and finally found Cap on the island's highest point near the northern beach. It was only about twenty-five feet high, but it gave a fine view over the sea where the surf was the most beautiful; Cap was sitting pensively on top of the little hill watching it, and started when they joined him.

"I had gotten to feeling that I was the only man here," he said. "Robinson Crusoe facing the empty sea. Ships practically never come this way. I doubt we'll see one while we're here, except KITTIWAKE when she stops back."

Geordie didn't know that KITTIWAKE was coming back. "She's coming here? he asked. "I thought she went home."

"She was going to Midway to have a look, and she'll stop in on her way back to Honolulu. But she won't stay more than an hour or so. After that we'll be marooned. Want to go home on her?"

"No, sir," Geordie said. "I like being marooned here."

"We might as well start back," Doc said. "We've got a

turtle turned over on the east side, and it will take a while to butcher it. Have you seen John?"

"He went by here an hour or two ago. I guess he's gone back to skin his bird."

As they started out Doc said: "Do you think we'd better ask him if he feels well enough to stay? I was saying to Geordie awhile ago that he didn't seem very well."

"He'd take it as a criticism," Cap said. "He doesn't seem well to me either, but maybe it was the trip. Anyhow, how do you ask him? He'll say for sure that we're trying to get rid of him, and steal all the glory."

Doc threw up his hands, and they went on around the beach to the east, passing the big colony of black gonies and the area of great boulders at the edge of the beach that Doc said harbored crayfish, and came to the turtle again. They were bloodied to the elbows when they'd finished, and took a swim to get clean once more before they cut around the edge of the lagoon to cross the island to the cottage with their steaks. When they were nearly home Geordie discovered that he was still carrying the flying fish that the frigate bird had contributed. They were dried out and seemed very unappetizing; Geordie decided that he would get more some other time, when he was coming straight back from the lagoon, and buried these in the sand. When they reached the cottage they all wrote down the number of rabbits they had shot on the board that Cap had hung up that morning. The total added up to one hundred eighty-six.

The turtle steaks were delicious, and even Catton complimented Geordie on them. "Really quite good, I must say."

"Thank you," Geordie said, surprised, and recalling Doc's advice added: "I'd like to help you skin some of the birds you collected today, if you want me to."

Catton's face took on a look of suspicion. "Why?" he

SEVENTEEN

The sun was shining when Geordie awoke the next morning; he dressed, and when he went into the living room there were several miller birds, finches, and a single honey eater busily flitting about. It was such a cheerful scene, so lively and normal, that the air of gloom at bedtime the night before seemed far away. Doc was sitting at the table with a piece of paper before him, drawing what appeared to be a plan; a miller bird landed on his shoulder and began to sing, and he looked up and grinned.

"Merry Christmas!" he said.

Geordie stared at him. "What?" he asked.

"Merry Christmas!" Doc repeated. "Did you forget what day it is?"

"I guess I did for the moment," Geordie said. "It still doesn't seem like that time of year."

"Cap brought a bottle of wine along for Christmas dinner. We'll have to do something special."

"I ought to make a cake," Geordie said. "I would if I had enough eggs."

"We'll have plenty of eggs later, when the terns nest. They nest on the south beach and an unusually high tide always washes their eggs away. When they lay again all the eggs are fresh, but I wouldn't know how to find fresh eggs anywhere now. I guess we'll have to settle for more turtle steaks."

"They were good. I'll go around the island this morning and see if I can find a turtle."

"Do that," Doc said. "The rest of us are going to plant the rest of the trees. We'll excuse you."

Geordie went around to the kitchen, and in company with two rails that ran about his feet cooked breakfast; after it was eaten he started for the freshwater pond. The air was full of birds coming in from the sea, for they fed early upon the squid that left the surface a little after dawn. He shot ten rabbits on the way and found eight ducks on the pond. Three of them were mallards, and flew off; he was surprised to see them there, and they reminded him of home. The other five were Laysan teal. He was very pleased to know that there were at least three more of them, and they seemed so tame that he decided to see if he could get them closer, remembering from his reading that they were inquisitive birds and recalled a trick Possum had once showed him, to entice them closer. He lay down on his belly in the bunch grass with his camera in front of him, and waved his feet in the air.

The teal swam back and forth and craned their necks; soon they began to move in. They came closer and closer, while Geordie held his breath. When he finally took several pictures of them they were only a few feet away. He stood up and moved off, quite pleased with himself, for he doubted that anyone had ever been so close to them before. He could develop the pictures after dinner and they would be a fine Christmas present to Doc.

As he walked toward the south beach he fell to thinking of home again and the activities of the season, the presents and the Christmas tree and people coming in rosy from the cold and the house fragrant with Ingrid's cooking, and of his mother and father. For a long moment he felt very lonely for all the things that were so far away, and then he came into the great cloud of terns and was so engaged by their airy multitude that he cheered up again. He decided to make a day of it alone even if he did find a turtle quickly, and went on.

As luck would have it, he found a medium-sized turtle before he had gone very far. He turned it over and butchered it because the tide was coming in, cut out his steaks, and carrying them up the crest of the beach buried them deep in the sand to be picked up again later. He had a pleasant swim to clean himself up and went along the beach until he came to a big nesting colony of black gonies. This was their favorite nesting beach, which they liked more than the lagoon. There were thousands of them gathered there, many sitting on eggs, others without eggs sitting or wandering about. They were noisy, as usual, and some of them were dozing with their heads on their backs. Geordie sat down several feet from one of them, which looked at him calmly with its dark eyes, and he thought of them all, after the young had grown large enough to learn to take care of themselves, wandering on their narrow seven-foot wings over the trackless ocean as far as the Aleutians and back to find their island again.

The life of the colony went on around him. Birds took off for the sea, running and flapping for long distances before they were airborne, and others came in; there wasn't much wind, and most of these made clumsy landings, sometimes pitching forward and falling all over themselves. When they did this they would get up, collect themselves, look rather embarrassed, and waddle off; beautiful in the air, they were quite awkward on land. Presently another bird came in and waddled over to the one Geordie was near. It was the other one of the pair, come to relieve its mate after several days at sea. They made a ceremony of the changeover, touching beaks and talking to each other. The one on the egg was reluctant to leave, putting its head down mournfully; it was finally gently pushed off by the other, waddled away, and took to the air. Now that it had finally given up the egg, it might not return for eighteen or twenty days, during which time the bird on the egg would neither eat nor drink.

Geordie had lost track of the time, but the sun was getting higher and he decided to move on and spend some time with the Laysan albatrosses and other birds before going back to the cottage. He stood up, and turning away from the beach climbed the slight rise toward the middle of the island. The stunted bushes began and there seemed to be rabbits under all of them; he started to shoot them again. The little flightless rails ran about, he had to be careful not to break through into the numerous petrel burrows, and high over his head the rakish frigate birds were soaring on the warming air; they usually robbed the boobies in the early mornings and late afternoons. He decided to visit their roosting section later, on the way back, to collect some flying fish as an extra course at dinner, and went on to the portulaca flats around the lagoon.

The Laysan albatrosses, which outnumbered the black-

footed ones, were nested in droves on the western side of the lagoon. There was a flock of a hundred or so golden plover, which nested on the Alaskan tundra and spent the winter on Laysan, on the open beach near the water; they didn't trust him and flew at his approach, whistling their lonely cries. There were a few bristle-thighed curlews too, also northern nesters, birds with long, down-curved bills, that were tamer. He came among the albatrosses and sat down again.

Unlike the black gonies, which only made slight depressions in the sand, the white birds built up their nests a little. Occasionally one of them would reach out, pick up a beakful of sand, and then pat it into the low walls with the side of the beak. The one nearest Geordie had a few weatherbeaten old bones around it, all that remained of a bird or two that had been killed long ago by the feather hunters. Many of them napped, and the unmated wandered idly about; presently, thirty or forty yards away, two of them began to dance.

They drew close together with great solemnity, bowing and almost stamping their feet, and circled facing each other, continuing to bow. They fenced a little with their beaks, whetting them upon each other; one of them raised a wing and nibbled at the feathers beneath it. The other bird stood like a statue while this was going on, and snapped its long hooked beak five or six times. The first bird stopped its nibbling, pointed its beak at the sky, rose up on its toes, puffed itself up, and gave a long, ridiculous, nasal groan; the other snapped its beak loudly and repeatedly. They both paused for a moment and began to bow rapidly to each other again.

It seemed as though they were going to go through the performance again and Geordie remembered his camera. He got up and approached them for a picture, but they didn't want their picture taken; they broke off their dance and separated and wandered away. Geordie was

disappointed and waited for a time for another pair to begin, but none of them did; he finally decided that he would have to wait for another day. He threaded his way between them, pausing to pat one particularly benign-looking one, and continued around the north end of the lagoon to the frigate bird roost.

A number of these black pirates were sitting about on the stunted bushes and they looked at him calmly; Geordie was surprised to see several boobies nested on the ground immediately beneath them, and then decided that was the safest place for the boobies' young. The frigates couldn't get down through the bushes at them to pick the young boobies up when they hatched. Several of the frigates had big crops, and following Doc's procedure of the day before he found a stick and tapped them. As before, they regurgitated their fish, and Geordie collected a dozen good-sized ones, strung them on a stick, and walked back to the east beach and started along it for the cottage.

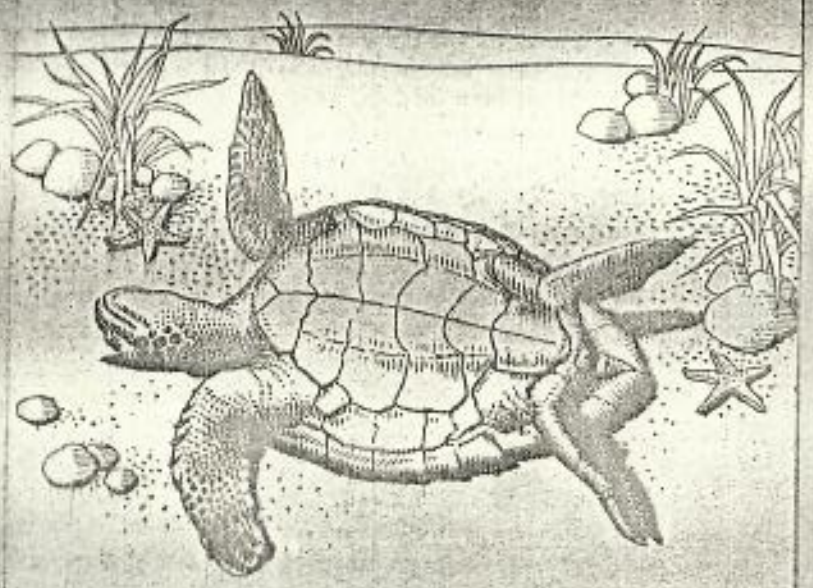
A fairy tern appeared above him and hovered, its wings translucent against the brilliant sky, the very picture of airiness and grace; then it dropped down in front of his face and hung staring at him with its big dark eyes, so close that he dropped his fish and raised his hand and caught it. It didn't struggle but lay quietly in his hand for a moment, a lovely bit of life, and as it rested there its mate came and hovered above Geordie's head and he let his captive go. He thought that they might be nested somewhere nearby, and decided that he would come back some day soon to see if he could find the nest.

He went along a little below the top of the ridge on the lagoon side, shooting rabbits as he went, recovered the turtle steaks, and cut around the end of the lagoon to the cottage. The surf on the reef and the changing colors of the ocean as the water deepened were beautiful. As he stood for a long moment looking out toward the empty

omous look and the fact that Catton had been trailing him about and watching him, as well as the man's accusation that he had been brought along as an accomplice to underhand maneuvers, upset him a good deal. The accusation was so false as to be unbalanced, and Geordie had never had any dealings with unbalanced people; he didn't know how to estimate them or what they might do.

He and Doc sat on the front steps until Cap and Catton came back. Catton went into the house without looking at anyone; Cap sat down with them.

"There were five teal there," Cap said, "so I think we've got that business quieted down." He looked at Geordie for a moment, thoughtfully. "We'll have to . . ." he began, and broke off and turned to Doc. "I'd like to talk to you a little about all this later."



NINETEEN

In the morning, Doc and Geordie went off to the fairy tern's nest, to get more pictures. Geordie was rather silent; he had thought a good deal about Catton in the night, and had gotten nowhere. As they walked along the western beach Doc, who had been rather quiet too, finally broke the silence.

"Cap and I took a walk after you'd gone to your room," he said. "We're both disturbed about that affair yesterday, for John got you involved in it."

"He doesn't like me,' Geordie said. "He hasn't liked me from the first."

male's green scapulars rose like bristles, and both birds puffed themselves up, trembled, and finally mated on the nest.

Geordie turned away presently and started back. He hoped that now the frigates had started nesting he would be able to get pictures of their antics. To make better time he went out onto the beach. The tide was very low, lower than he had ever seen it, and he went out and poked about the boulders that were usually awash; in the deep pools around them he could see many big crayfish moving around but had no way to catch them; he thought of rigging up a long-handled net to be ready if the tide fell so low again. Further south he saw a flock of red phalaropes come in off the sea and head for the lagoon. All of the migrating birds should be increasing now, and more of the terns, both graybacks and noddies, should be coming in to nest. He turned over a big turtle on the beach near the end of the lagoon, and not having his knife with him cut across the island to get it and return.

Doc was sitting on the steps, with his rifle beside him; he'd been out shooting rabbits. "We've got him in bed," he said, to Geordie's inquiring look. "When we got him undressed we found his arms and legs all broken out. It's arsenical poisoning as sure as the devil. Cap's with him now; we're going to take turns."

"I'll take a turn too," Geordie said. "At least, I can holler if I need help or don't know what to do."

"No need for you to do it," Doc said. "I think we can keep you busy enough. Cap and I talked it over awhile ago. If John is laid up for long, or if he . . . doesn't make it, his collection will have to be filled. Cap can't skin a bird, and that will leave it up to you and me to collect and work up all the skins for John's university, the ones

we want, and the ones for the National Museum. We have rails to catch, pictures to take, some sets of eggs to collect, and rabbits to shoot. I looked on the board awhile ago, and to date we've shot close to three thousand of them and they're getting wilder all the time, so our average will probably go down from now on. We're a long, long way from cleaning them out, and we've only got about five more weeks to go. I'll be out of circulation part of the time and Cap can help with the rabbits when he's free, but you can see that you'll be doing a lot of work. I'm sorry, Geordie. It won't be quite as leisurely for any of us as we thought it would."

"It's been pretty easy so far," Geordie said. "It's been sort of like a vacation, with plenty of time to look around. I don't mind working a lot harder, Doc. I'd like to do it. I hope I can fix the skins well enough."

"You'll do," Doc said. "Let's go out and shoot some more rabbits."

"I have a turtle on the east beach. I've got to go butcher him."

"Get your rifle and put the plover away," Doc said. "I'll go along."

When they returned they found Cap sitting on the steps, and he got up and walked toward them. They all stopped a few yards from the cottage.

"He's very sick," Cap said. "We didn't always have a doctor handy on destroyers, so I had to know a little medicine, and we'll just have to do the best we can. I've been thinking about the situation and I've decided it would be best if you, Geordie, stayed away from him. It would be unpleasant for you to help us nurse him, and unnecessary, and it might stir him up. From one or two things he's mumbled I take it he still thinks about that business of the teal once in awhile. He's pretty confused

another four in July 1956, all normal-coloured. Then, one of the female cubs of the second litter was mated with her father, the white tiger, Mohan, and on 30th October 1958, four white cubs were born. Three more were born in June 1960, but in this litter one was a normal-coloured female. In the next litter there were only two cubs, the animals now at Bristol Zoo.

The few white tigers that have been seen in the wild have all seemed to be big animals and the signs are that the male at the Bristol Zoo will be a large animal too.

HAWAIIAN MONK SEALS
Monachus schauinslandi
AND GREEN TURTLES
Chelonia mydas
AT WAIKIKI AQUARIUM

*by Louis S. Mowbray**
Director,
Bermuda Government Aquarium,
Bermuda

MONK seals are warm-water seals and today represented by three species: the Mediterranean monk seal, *Monachus monachus*, the Caribbean monk seal, *M. tropicalis* and the Hawaiian monk seal, *M. schauinslandi*. All three species are rare and the Caribbean monk seal is thought to be almost extinct (Scheffer, 1958). The Hawaiian species is found on a number of the small islands of the Hawaiian Chain as far as Kure Atol, about 1,200 miles north-west of Honolulu, Oahu. There is evidence of considerable inter-island migration, verified by a tagging programme. Four seals tagged on Laysan Island were recovered on Pearl and Hermes Reef, more than 300 miles distant. The Hawaii State Fish and Game Department and the Smithsonian Institution have recently carried out a survey on the populations of the Hawaiian monk seal. In 1957 the estimated population was 1,000 animals. The 1964 survey indicates that a more realistic figure is 1,500 seals; and the estimate may be somewhat on the conservative side.

The Waikiki Aquarium in Hawaii has had several of these interesting seals during the past few years, and one lived as long as two years in captivity; another lived only about six months. Post-mortem examination indicated that death was caused by heavy infestations of tape-worm and round-worm, resulting in heavy ulceration of the stomach and the intestine. Post-mortem examination by Smithsonian Institution workers of a dead Hawaiian monk seal found on Kure indicated that death had been caused by the same worms.

On 13th December 1963, a fine immature male, weighing about 150 lb., was obtained by the Waikiki Aquarium. It was captured on Kure Atol. After it had been in captivity for one month and had learned to eat dead fish, the animal was treated for intestinal worms (Vermiflex, and Caricide, which had been recommended by the Curator of Marineland of the Pacific, California). The recommended dose is 10 mg. per pound of body weight; this can be repeated if necessary after a period of three or four weeks. Results were good and the seal has progressed well. At the time of writing (June 1964) it weighs about 220 lb. and is about two-and-a-half years old.

We had hoped to obtain a female monk seal at the same time but it was not possible. However, one was obtained on 22nd March 1964. This animal refused food for twelve days and lost much weight until it weighed only 100 lb. After twelve days, it started to accept food and it began to gain weight. It was de-wormed after one month in captivity and at the time of writing it weighs at least 200 lb. and is about one-and-a-half years old.

The monk seal's habit of lying for hours on sandy beaches, throughout their habitat, indicates that they are primarily nocturnal feeders. The large eye would tend to substantiate this. Their natural food consists of littoral fishes, morays and conger eels. Earlier specimens kept at the aquarium had to be fed on live fish of similar species, and taught gradually to accept dead fish, such as herring or smelt. They now thrive on this diet and have not received live food since they have been in captivity.

The two monk seals at the Waikiki Aquarium are kept in an outdoor pool with a capacity of approximately 90,000 gallons of

*During 1963–4 Mr L. S. Mowbray was Acting Director of the Waikiki Aquarium; while Mr S. Tinker, the Waikiki Aquarium director, was Acting Director of the Bermuda Government Aquarium.

seawater. The pool is shared without compatibility problems with four Harbour seals, *Phoca vitulina*, and about a dozen large sea turtles, *Chelonia*, *Caretta* and *Eretmochelys*. There is an island in the pool on which the seals rest. It is beneficial if the monk seals can have a sand-box or beach on which to lie as they prefer sand to the hard rock. There is a continuous flow of seawater through the pool, though it is drained and scrubbed once a week to control the growth of algae.

GREEN TURTLE EXHIBIT

The Pacific green turtle, *Chelonia mydas*, mate regularly in the big pool at the aquarium, and later deposit eggs on the bottom of the pool (in the water). As far as is known, this is the only record of this happening in captivity. With the provision of a suitable ramp and sand pit, these sea turtles would surely lay their eggs in the proper medium and these would hatch as the result of normal incubation by the heat of the sun. Provision of such facilities for the turtles is proposed for 1964–5.

REFERENCE

Scheffer, V. B. (1958): *Seals, sea lions and walruses; a review of the Pinnipedia*. Stanford.

WHITE BOTTLE-NOSED DOLPHIN

Tursiops truncatus

AT MIAMI SEAQUARIUM

by William B. Gray

Director of Collections and Exhibits, Miami Seaquarium, USA

AS far as we know, the white Bottle-nosed dolphin at Miami Seaquarium is the only true albino of this species that has ever been caught. Our specimen, 'Carolina Snowball', is 8 ft. long, weighs 400 lb. and is estimated to be between twelve and fifteen years old.

In 1961 we heard that a dolphin as 'white as snow' was reported to have been seen several times in the St Helena sound area of South Carolina's coastal waters. It was said to have been seen in there over a period of seven or eight years. Our chief specimen collector, Captain Emil Hanson, went to the area and did indeed see a ghost-like dolphin in the company of a large school of dark-skinned Bottle-nosed dolphins. As a result of his report we arranged an expedition to try and catch the white dolphin. After cruising about the area, we came across the gleaming white animal cavorting with a large group of normal-coloured dolphins. After fifteen days attempting to capture it, we realized that our ordinary dolphin nets were unsuitable for the deep waters of the sound. In January 1962, we returned with a special longer and deeper nylon net, three-quarters of a mile in length. But once again we failed, this time because the rough weather made it impossible to find any dolphins, let alone a white one. In July, we returned once more and again found the white dolphin. As before, there was a small grey dolphin swimming by its side. They seemed to be inseparable. It was obvious that the white dolphin was a female and the little one was her baby. After three weeks, we finally caught both of them and returned to the Seaquarium on 4th August 1963, with both specimens in perfect condition. We estimated the baby, a male, to be about two years old for he was just about ready to be weaned (baby dolphins live entirely on their mother's milk for the first eighteen months of their lives).

From the moment she was captured, the white dolphin was friendlier, more placid in temperament and less skittish and nervous than other dolphins I have known. She keeps her pink eyes half-closed because they are extremely sensitive to light, as are the eyes of all albinos.

Dr Clyde Keeler, a mammalian geneticist and professor at Georgia State College for Women, has been studying the white dolphin and her son. We were interested to find that his studies tallied with our observations. He believes the albino is characteristically gentle and friendly because of a low basal metabolism. He disagrees with those who hold that lower intelligence accompanies albinism. (He has made detailed studies of the San Blas Indians, a Central American tribe with the highest incidence of albinism in the world. From these studies of San Blas 'moon-children' he is of the opinion that the albino is just as intelligent as his fellows with normally coloured skins, and may learn more readily because of a less nervous temperament.)

As the young dolphin carries one gene for

34pp

UNIVERSITY OF HAWAII MARINE OPTION PROGRAM

ANNUAL REPORT 1976-77

by

John J. McMahon

Report on program activities of Sea Grant project, Marine Option Program (E/MO-01); John P. Craven, Principal Investigator, Sea Grant Year 08; John J. McMahon, Principal Investigator, Sea Grant Year 09.

Sea Grant Miscellaneous Report
UNIHI-SEAGRANT-MR-78-02

December 1977

This annual report describes the program sponsored in part by NOAA Office of Sea Grant, Department of Commerce, under Grant Nos. 04-5-158-44026 and 04-6-158-44114, the Office of Naval Research, the University of Hawaii, and the State Office of the Marine Affairs Coordinator. The US Government is authorized to produce and distribute reprints for governmental purposes notwithstanding any copyright notations that may appear hereon.

students in Hawaii. Manoa MOP and Hilo MOP each offered a regular marine film series. Both series were, of course, well received. Specific dates and titles are shown in Appendix A.

In addition to the traditional academic activities already described, some Marine Option Program students originated and participated in research projects related to expressed state needs in marine affairs.

Cynthia Baldwin and Miles Nagata of Hilo MOP completed the Kauai Coastal Zone Resource Survey which was begun in 1975. This study obtained biological and physical baseline data from selected sites on Kauai and integrated it with a sociological survey of the coastal zone activities of Kauai residents. This study was nominated for the Arthur L. Dean Prize in social science by the Dean of Marine Programs.

Hilo MOP students Robert Wright and Michael Lay assisted in the assessment of Hawaii's green sea turtle population by studying the distribution, abundance, and behavior of sub-adult turtles near the island of Hawaii. This study complemented the green sea turtle research of Mr. George Balazs at the Hawaii Institute of Marine Biology. Mr. Balazs provided substantial assistance throughout the study period.

Guy Anzai, a Manoa MOP student, led a team of students who performed biological baseline studies off Papohaku Beach, Molokai and Molokini Island. The results of the Papohaku Beach study document the changes in the marine environment concurrent with changes in the adjacent terrestrial environment (primarily the Sheraton-Molokai hotel development complex) between the June 1974 MOP baseline study (Oishi, 1975) and June 1976.

Mr. Anzai's team study of Molokini Island was done in response to a resolution of the Eighth Legislature of the State of Hawaii. The results were submitted to the Department of Land and Natural Resources for consideration in developing regulations to preserve Molokini's unique environment. DLNR regulations became effective in July 1977. The report by Anzai et al. has been reviewed and accepted for publication by the UH Sea Grant College Program and is currently in final preparation. It was also nominated for the Arthur L. Dean Prize in science by the Dean of Marine Programs.

The same team of Manoa MOP students conducted a baseline study of Honolua Bay off Maui for Kapalua Land Company, Ltd. The final report, authored by MOP student Leonard Torricer, has also been reviewed and accepted for publication by the UH Sea Grant College Program.

Ms. Linda Ward of Manoa MOP completed a study of larval polychaetes in Hawaiian waters and developed a taxonomic key for them. This study has direct application to various pollution studies in Hawaii. It has been accepted for publication by the UH Sea Grant College Program.

Manoa MOPer Matthew James received the Arthur L. Dean Prize in science for his honors thesis on scanning electron microscopy of cone shell radulae.

Although no separate MOP report will be written, six Manoa MOPers assisted the Department of Planning and Economic Development in its

Treasure Islands of Wildlife

(See Map on Page 154)

A biologist lands by Navy helicopter in Hawaiian National Wildlife Refuge to observe birds found nowhere else

BY DAVID B. MARSHALL

With photographs by the author

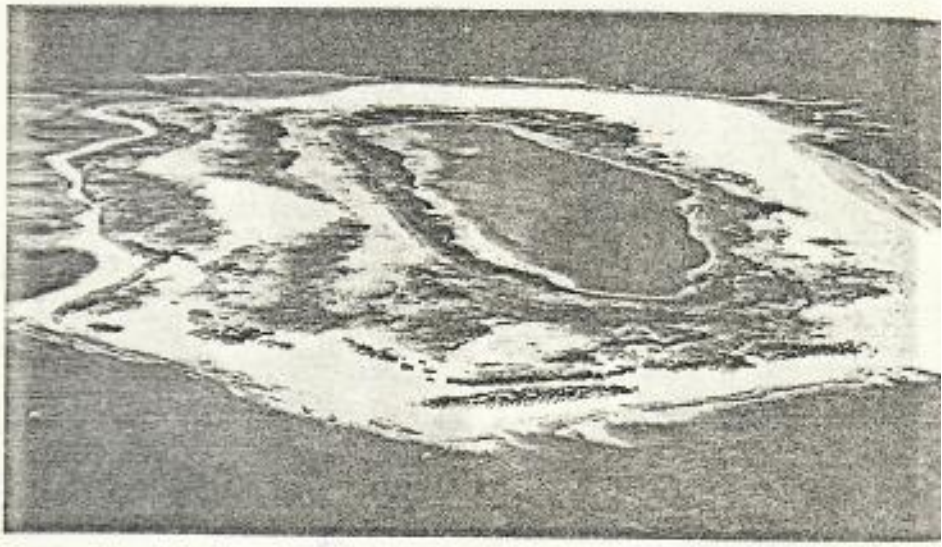
There is—in the mid-Pacific—a land richly endowed with rare and unusual birds that can be picked up in the hands and photographed without a telephoto lens.

This wildlife wonderland is part of the United States.

Unknown to most Americans—outside of Hawaii—the Hawaiian Islands National Wildlife Refuge sprawls for more than 1,000 miles between the main islands and Midway Islands. This chain of sandy reefs and rocky promontories, known to Hawaiians as the Leeward Islands, provides the sole habitat for several species of birds.

Trips to the refuge are difficult and infrequent. When Paul T. Quick, re-

Once a valuable nesting habitat, Tern Island now resembles a giant aircraft carrier.



Laysan Island, designated a refuge in 1909 by President Theodore Roosevelt, has the world's largest Laysan albatross colony—260,000 adults. The rare Laysan duck, down to 12 birds in 1912, now numbers more than 400.

Steep terrain makes travel slow on Nihoa, first stop of the author's expedition. Wildlife Biologist Raymond Kramer, Hawaiian Division of Fish and Game, works along cliffs inhabited by blue-gray noddy terns.

The Author—*David B. Marshall is regional refuge biologist of the Bureau of Sport Fisheries and Wildlife, U. S. Fish and Wildlife Service, Portland, Oregon.*

gional director of the Bureau of Sport Fisheries and Wildlife, invited me to make an inspection tour in June of 1962, I quickly accepted. Inspection trips were being made twice a year at that time by state biologists under a contract between the bureau and the state of Hawaii's Division of Fish and Game.

This remoteness of the islands is fortunate since it has permitted a minimum of tampering with their wildlife and fragile ecology.

Through courtesy of the U. S. Navy I left Pearl Harbor aboard an LST (Landing Ship-Tank), the USS *Stone County*, commanded by Capt. P. R. Walker. Accompanying me were David H. Woodside and Raymond J. Kramer, biologists with the state Division of Fish and Game, and Jack W. Beardsley, an entomologist with the Hawaii Sugar Planters' Association. A helicopter—almost indispensable for our task—flew aboard as our ship moved out.

We made our first stop at the island of Nihoa, the top of a volcanic mountain largely under water. The 'copter put us down on 900-foot Miller's Peak, the higher of two summits on the 146-acre island.

Before the sound of its engine had faded, we found ourselves alone in an eerie atmosphere of dampness and semidarkness, enveloped with bloodcurdling moaning and groaning sounds. We could appreciate why sailors refer to the shearwaters and petrels as "the moaning birds."

Conspicuous were Christmas Island shearwaters. Their burrows extended under rocks along talus slopes thick with waist-high vegetation—mainly a *Chenopodium* similar to the familiar lamb's-quarters. Wedge-tailed shearwaters and Bonin petrels were also visible.

As the sun emerged and rain ceased, "the moaning birds" became quiet. Since a cliff forms the north side of the island, we turned southward down the more gentle, but still difficult, slopes of West Palm Valley to a small beach. This had been used by past expeditions not so fortunate as to have a helicopter.

The air and ground were full of sooty terns, noncolonial nesting gray-backed terns, brown noddies and blue-gray noddies—the latter in holes carved out by weather along rocky prominences. Several races of this exquisite pearl-gray tern are found throughout the Pacific; this race is sometimes called the Necker Island tern.

Nihoa's endemic fan palms, appropriately named *Pritchardia remota*, provided nesting platforms for a colony of squawking red-footed boobies. Overhead were those pirates of the sky, the man-o-war or frigate birds. On occasion they would dive with tremendous speed, sounding like a jet plane, to take food brought from the sea by incoming terns or boobies. In the rocky cliffs of a canyon were thousands of white or fairy terns.

Two passerines are found exclusively on Nihoa: The Nihoa race of the Laysan finch was visible at every rocky outcrop and there was an extra thrill in discovering a Nihoa millerbird nest on Miller's Peak. We had seen perhaps 20 of these birds dart from bush to bush during the course of the walk up and down the valley, but the nest was a rare find. Two birds took turns incubating a single, brown-splotched, pale blue egg.

The Nihoa millerbird was found in 1923 by the Tanager Expedition, which made the first ornithological trip to this island. In the dim geological past this small, sparrow-sized species apparently originated at this very spot or on islands in this general area. Today Nihoa's 146 acres stand between the bird and extinction.

Photographing the millerbirds allowed us no time to visit some of

Navy helicopter (below) lands biologists on Necker Island from USS Stone County *(inset). Without 'copters it is a difficult sea feat to land in refuge.*

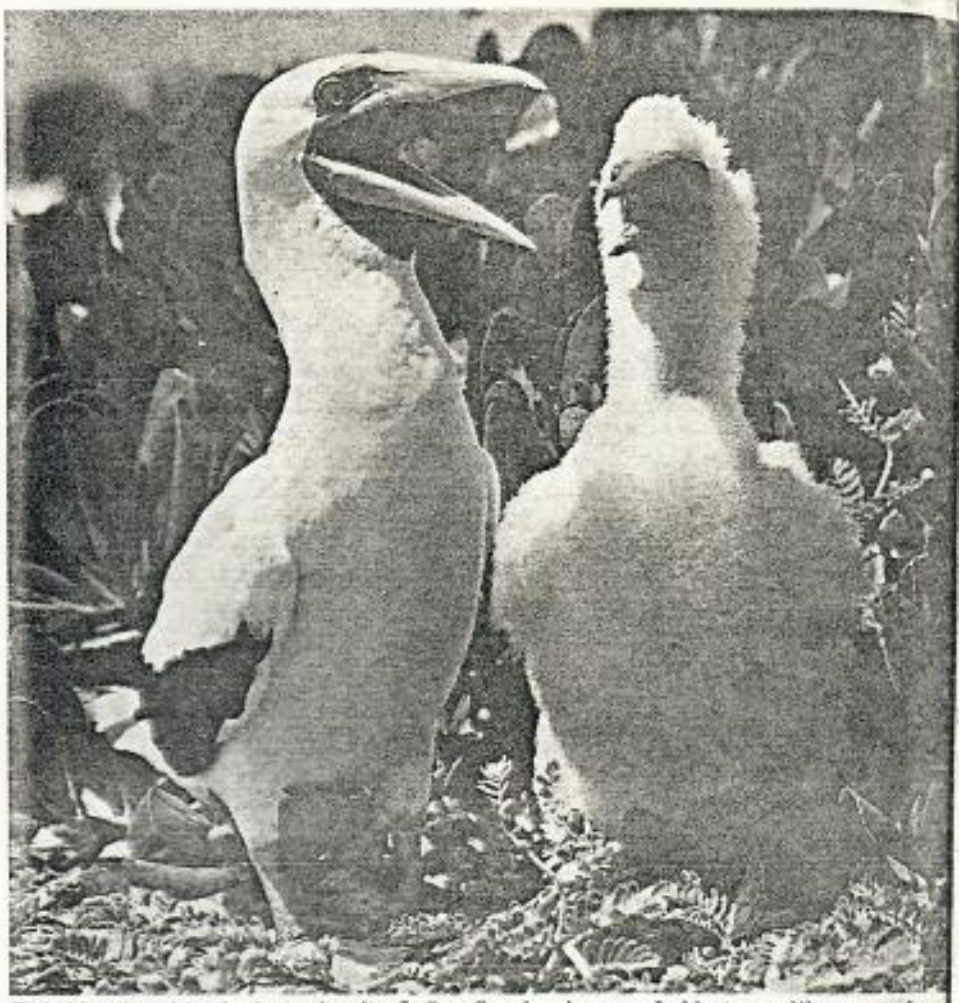
the exquisite monuments left by ancient Polynesians who once had miraculously inhabited the steep slopes.

At the 'copter landing site, where small groups of military personnel regularly camp, we found a patch of sandbur and paspalum grass. These no doubt sprouted from seeds dropped from a serviceman's equipment. If these plants spread, control measures may be necessary should they pose a menace to native plants on which such species as the millerbird are dependent.

Our next stop was Necker Island —a 41-acre rocky ridge which is actually another volcanic peak. Although supporting thousands of sea birds and resembling Nihoa, this island has no land birds. We wondered if the millerbird might survive there if introduced; Necker could serve as a sort of safety valve should some catastrophe come to Nihoa.

From Necker our tour took us past French Frigate Shoals and Gardiner Pinnacles to the jewel of this area, the island of Laysan. As in the case of Nihoa and Necker, we shuttled from ship to shore via helicopter.

From the air Laysan presented a picture of vivid color contrasts. A shore of nearly white coral sand bordered the deep blue of the Pacific with accompanying blue-green coral shoals. On the island a patchy rim of deep emerald vegetation flourished where the sand was stabilized. In Laysan's center a brackish lagoon matched the ocean's hue. In contrast to Necker and Nihoa, Laysan's 700 acres rise barely 50 feet.



This blue-faced booby lecturing its fluffy offspring is remarkably tame, like most of the other birds in the Hawaiian Islands National Wildlife Refuge.

The Laysan finch—abundant on Laysan Island—is found nowhere else in the world.

It was difficult to know what to look at first—the plant life or the teeming flocks of birds. The vegetation was especially exquisite. Prominent was the fleshy-leaved bush scaevola, a bunch grass (*Eragrostis variabilis*), and beach morning glory.

Our helicopter came down adjacent to a sooty tern colony. The screaming birds would hover six feet over our heads, making ideal subjects for flight photographs against the dark blue sky. Mile-long colonies of these terns stretched the full length of the island. Their noise was almost too loud for comfort.

We camped near one of these colonies for five nights. After dark the moaning of tens of thousands of wedge-tailed shearwaters added to the

clamor of the terns and the belching grunts and snorts of almost fearless Hawaiian monk seals, moving into the scaevola from the beach.

Laysan has long been of major ornithological interest. Prior to occupancy by guano diggers early in the century, it had supported five birds found nowhere else. Three of these, the Laysan rail,[1] a miniature flightless species; the Laysan honeyeater, a form of the apapane; and the Laysan millerbird, similar to the one at Nihoa, are gone forever. They failed to survive the well-meaning introduction of rabbits by the guano workers.

The rabbits turned the island into a barren land, destroying the food chain and other habitat requirements of the birds. The Tanager Expedition dispatched the last of the rabbits in 1923. Surviving endemic birds are the Laysan duck, also called Laysan teal, and the Laysan finch.

At the time of Alfred M. Bailey's[2] visit in 1912–13, when the rabbits were going strong, only 12 Laysan ducks could be found. Today, there are 400 to 600. The vegetation again resembles its former appearance although without some endemic species. Some foreign plants, including tobacco, also appear.

The sea birds are back to their one-time number and the Laysan finches cover every grass-covered area. All that can be seen of the guano miners' settlement is a pile of twisted sheet metal and a rusted-out track on which the workers pushed their mining carts.

Prior to the guano workers,[3] feather hunters had ravaged Laysan. It was their wanton destruction that prompted President Theodore Roosevelt to establish this refuge in 1909.

The largest colonies of Laysan albatrosses anywhere—over 260,000 adults—occupy all barren areas on Laysan. There are smaller populations of black-footed albatrosses. The other species nest in or near vegetation, except the petrels and shearwaters. They use most underground portions, the summer-nesting wedge-tailed shearwaters taking turns with the winter-nesting Bonin petrels.

Nesting of the albatrosses requires most of the year so both the surface and underground portions of the island are occupied with nesting birds

Author finds this female Hawaiian monk seal, with her black velvet pup, in a belligerent mood on Laysan Island.

The Nihoa millerbird, one of the world's rarest birds, is found only on Nihoa's 156 acres and is not very abundant there. This photograph, made on June 10, 1962, may be the first ever made of a nesting millerbird.

VIGILANCE STILL NEEDED TO PREVENT REFUGE GIVEAWAY

A proposal advanced by the director of the U. S. Bureau of the Budget to give away the Hawaiian Islands National Wildlife Refuge has been headed off—at least for the present.

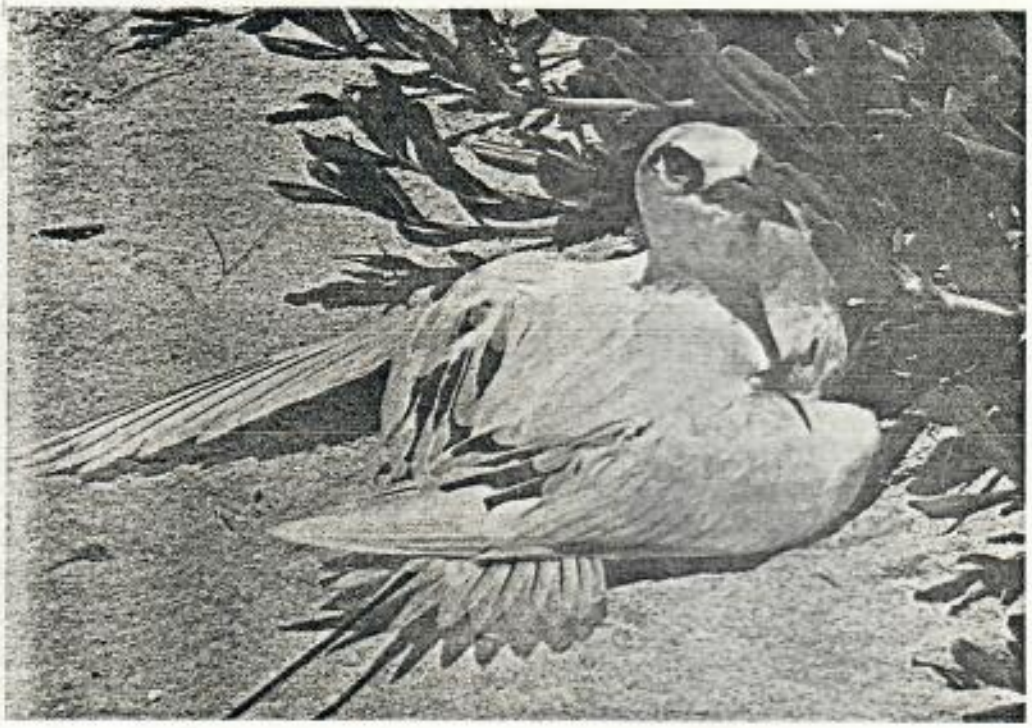
The threat arose because a provision of the Hawaiian Statehood Act said a final decision as to which federal lands would be transferred to the state had to be made by August 21, 1964. The refuge was on the giveaway list.

The National Audubon Society led a protest by conservationists because the state legislature could not be counted on to resist the pressure of powerful interests that would like to grab choice islands for private development.

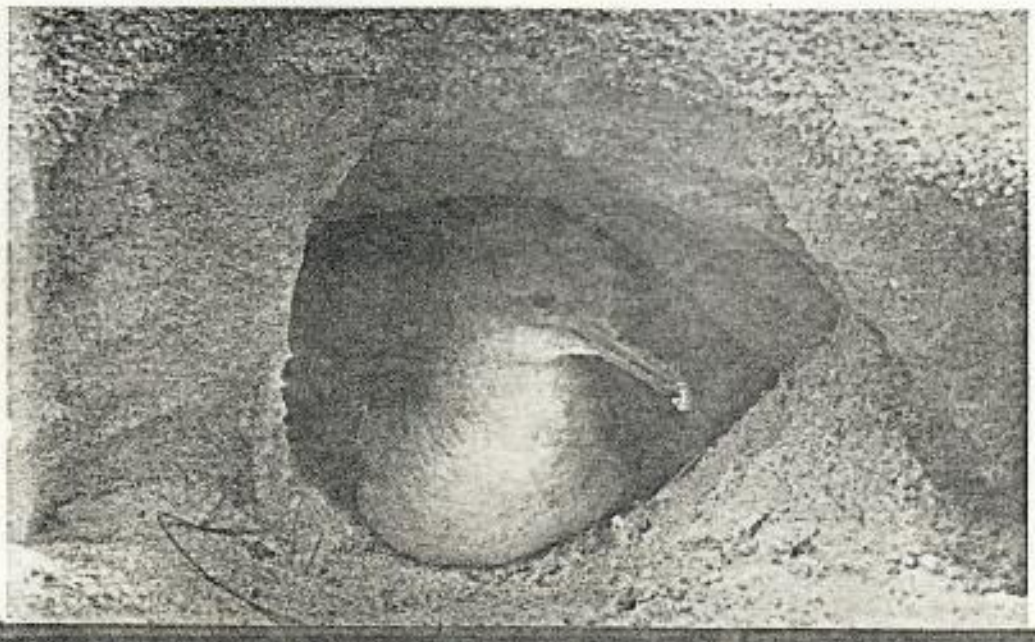
When the protests mounted, Congress hurriedly passed a bill last December that amended the Statehood Act to remove the August 21 deadline. It also provided, in effect, that no such giveaway could take place in the future unless the Secretary of the Interior gave his approval.

The issue is almost certain to arise again. A future Secretary of the Interior may not have as stiff a backbone as Stewart Udall. As Carl W. Buchheister, our Society President, said in *Audubon Magazine* (January-February 1964), conservationists must keep an attentive eye on this 1,000-mile string of Pacific islands. David B. Marshall's article will help you understand why.

Aptly named for its long tail of bright red, this red-tailed tropicbird is almost helpless on Laysan's sands. In the air it is a skillful flier. Seamen know it as the "boatswain's bird."



Inquisitive nature photographers are no disturbance to most of the birds in the Hawaiian Refuge. This wedge-tailed shearwater sits snugly in its Laysan Island burrow for its portrait.



throughout most seasons. The wedgetails dig like dogs. One kicked a sizable quantity of sand into my pack containing photographic equipment. Their long burrows cave in when walked over, making our travel over the island somewhat meddlesome to the birds.

On our visit in June the young albatrosses were adult sized and struck at our legs. One youngster claimed the shade under the awning of our tent entrance as his home, and vigorously defended it against all, including biologists. A pair of Laysan ducks lived with us part of the time, attracted to the fresh water in our wash pan which they used for swimming.

It is easy to approach within three or four feet of such species as the brown noddy, blue-faced or masked booby, brown booby, and the great frigate bird for pictures. More wary are the gray-backed terns and white-capped noddies, or Hawaiian terns. The red-tailed tropicbird with vivid red tail streamers could be picked up and thrown into the air for flight pictures.

Probably the most beautiful species on these islands is the dainty fairy tern which frequents the Laysan shorelines. Nudged from its resting spots in the scaevola, it curiously flutters overhead, making a soft "oink" sound.

Bristle-thighed curlews, which nest in Alaska, American golden plovers, and other shore birds rest or winter at Laysan and other sandy islands of the chain.

The irreparable damage brought about by man's unwise activities, including the near loss of the Laysan duck, should serve as a valuable lesson. Introduced mammals such as

rabbits, dogs and rats play havoc with such fearless birds or destroy delicate ecological balances.

The prevention of exotic plant introductions also is a constant problem. We destroyed a patch of potatoes and onions which no doubt originated from visitors' garbage.

Insects pose problems, too. Introduction of foreign varieties without their natural predators threaten native plants. It is this phase that our entomologist was studying. Every attempt is now being made to prevent new threats to surviving species through a program of education and cooperation between the Bureau of Sport Fisheries and Wildlife and the Department of Defense. Special permits are required for entry to the refuge.

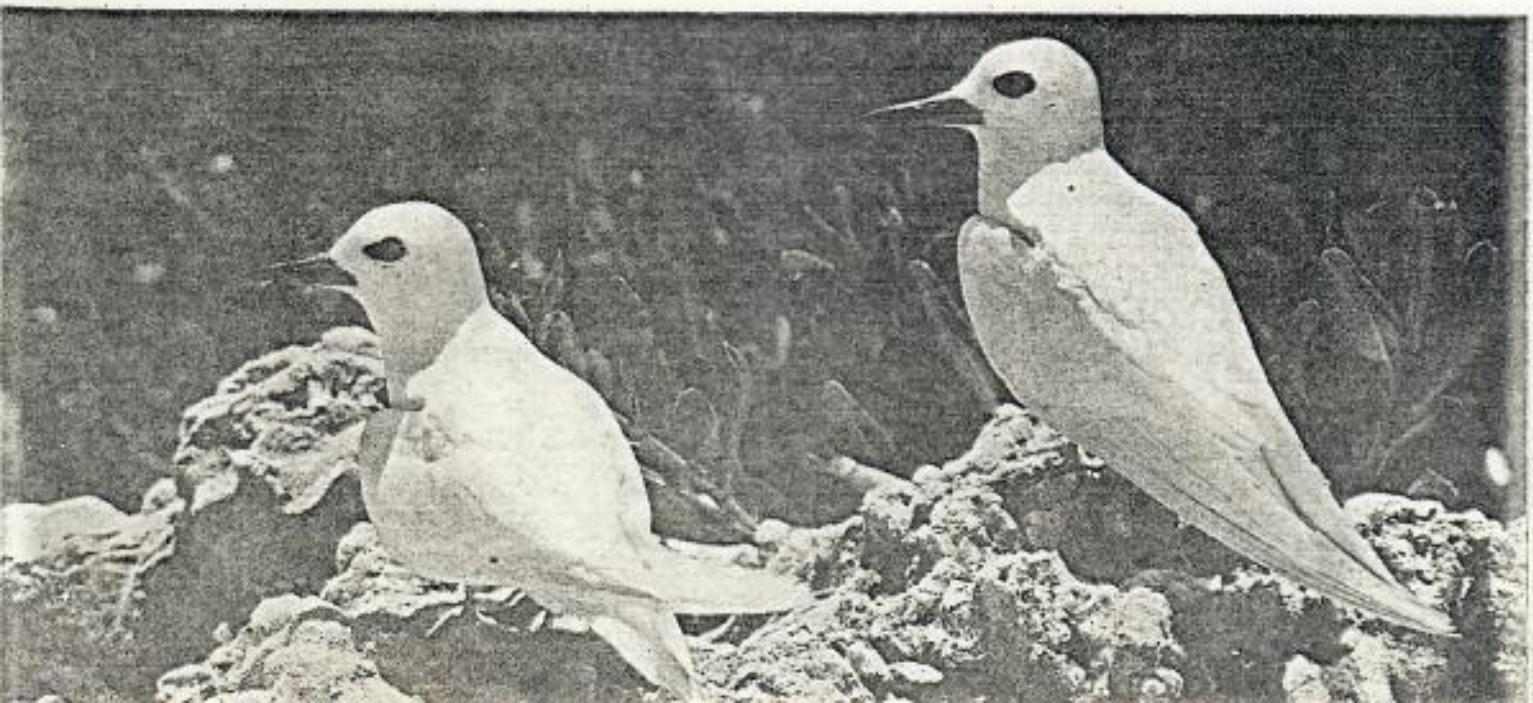
We weren't able to visit other islands of the chain, such as Pearl and Hermes Reef and Lisianski. On our return, however, we stopped at Tern Island of French Frigate Shoals. It resembles a giant aircraft carrier and no longer serves the birds, having been turned into a military base during World War II. Only a handful of albatrosses and other birds remains from what was once a vast colony.

This is a sad reminder of what could happen to other islands of the Hawaiian Islands Refuge if they are not carefully guarded. THE END

[1] See "Fate of the Laysan Rail," by Paul H. Baldwin (*Audubon Magazine*, Nov.-Dec. 1945)
[2] See "The Portulaca Flats of Laysan," by Alfred M. Bailey (*Audubon Magazine*, May-June 1942)
[3] See Executive Department Report (*Bird-Lore*, March-April, 1910)

Beauty is as sooty does, and this sooty tern demonstrates it at Laysan Island for the alert author's sky-turned camera.

One good tern deserves another and these fairy terns at Laysan Island show why they are often called the most beautiful birds in the Pacific in flight or afoot.



perhaps only one to several hundred of the other varieties. There is no season on crabbing in Hawaii except in the case of the Kona crab, which cannot be taken during June, July and August. But there is a minimum size for the Samoan crab which must measure five inches between the last two points on the carapace. The pincers of the Samoan crab are extremely powerful and dangerous, so a forked stick is used to hold the creature to the ground while its legs are tied against its body.

At night, crabs may be caught by dazzling them with a strong light as they perch along the rocks. They hold so still, staring at the light, that they may be quickly snatched with the hands. Hosaka recommends snaring them by catching the crab's eyestalk in a noose made of thread, while the crab is staring at the light. When the eyestalk is drawn inward, the thread is held fast. Another way to catch them is to tie a piece of meat on a string and drop it near the crab. When the crab grasps it, the string is moved about loosely until the legs become snarled.

Turtle Hunting

A turtle is always an impressive prize. The shell makes a fine trophy when highly varnished and many a fisherman's home has one proudly hanging on the wall, a pleasant reminder of the feast of turtle steaks that came with it. Turtle meat is much like veal and is a regular item at some Honolulu restaurants.'

Catching a turtle can be as daring an adventure as one wishes. There are a variety of ways to capture the great beast, ranging from picking it up entangled in an overnight stand net, to riding it to its doom. Only the best

of swimmers should try this latter bare-handed technique of the Hawaiians. When a turtle is seen loafing along on the surface of the water, they dive down under it and, approaching from behind, flip it over on its back. This renders the creature helpless as it cannot use its flippers to dive under water. Then it is placed on its back in the canoe where it remains immobilized, waving its flippers foolishly.

The act of subduing the turtle is completed in an instant, but everything depends on that instant, on the perfect timing and adroitness of the hunter. The only real danger in this would come from exposing one's self to the head of the turtle. While not a fierce animal, it does possess a powerful beak, something like that of a parrot enlarged five or ten times, and one snap could be disastrous. Otherwise, the only alternative to success would be losing the turtle, for if the flip-over were not quickly maneuvered, it would dive for the bottom. Hanging on would be useless, for turtles can go to depths impossible for a human, and there would be no other opportunity to attempt the flip-over technique again. There have been stories of turtle hunters who rode on their backs and directed them toward shore by pulling upwards on the shell. But the only stories which were authenticated in Hawaii have involved spear fishermen who first wounded the turtle, then held on or rode it as it tried to swim away.

Turtles are also taken with a kind of harpoon spear which is thrown when the turtles come into coves to eat seaweed. Sometimes turtles are snagged with a line which has a weight and three hooks attached to it. This is thrown at the turtle so as to catch on its flippers.

When turtles are caught unwounded, as in the flip-over technique, they may be kept alive but helpless by

leaving them on their backs. Fishermen have kept them in their yards this way for days, until they were ready to eat them.

There are two kinds of turtles in Hawaii, the *honu*, which is edible, and the *e-a* which is poisonous, but from which commercial tortoise-shell articles are made.

Shrimping

Shrimps, like crabs, are sometimes caught to eat, although they are used chiefly as bait. They are found in brackish water four or five feet deep and are caught in a net which resembles the crab net but is of a finer mesh. The net is baited with meat or fish and lowered into water which is clear enough to permit seeing the shrimps below. After a half hour or more, the net is brought up and the entangled shrimps are removed. If there is a good catch, the net is replaced in the same spot. If not, the fisherman moves on in hopes of finding better grounds. Kuapa bay and stream, just a few miles from Honolulu, is a favorite spot for gathering shrimp. Early in the morning, particularly on weekends, the area is alive with fishermen obtaining bait.

Ina, Wana and Limu Gathering

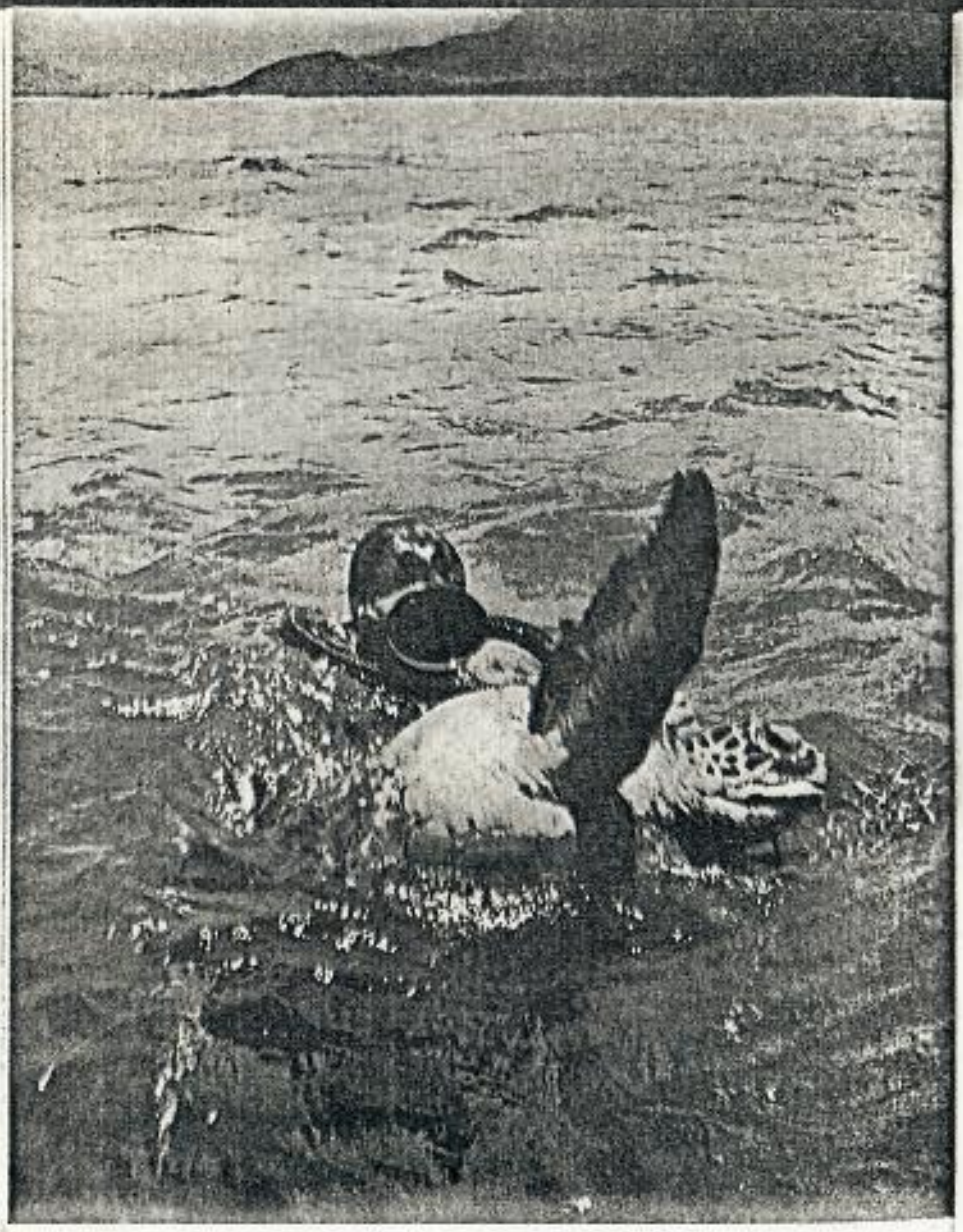
Although the gathering of such sea life as *wana* and *ina*, two kinds of sea urchins, and *limu*, which is seaweed, cannot properly be called a sport, it was included in the general term for fishing by the ancient Hawaiians. All products of the ocean, whether they moved or not, were called *i'a* or fish. And perhaps with generosity,

these activities can be admitted here on the same grounds that clam-digging expeditions are considered good sport in New England. For the obtaining of these sea-forms takes on an air of festivity and diversion, particularly when related to an impending *luau* or feast, that removes it from the class of hard-bitten work. The Hawaiians have always enjoyed the things they found to do at the seashore, and this was one more excuse to linger there. Let anyone who doubts the truth of this ask a Hawaiian which he'd rather do, plant taro or gather *limu*.

Wana looks like a sea hedgehog. It has long sharp spines and lives in the holes near the outer edge of the reef, while *ina* lives in shallow tidal pools where the surf washes freely. Stepping on *wana* is a very painful experience for the spines are brittle and break off inside the foot. Once embedded they cannot be dug out, as they break at the touch of a needle. The injured person can only wait until they melt away, absorbed by the flesh.

Once at a beach in the country a young *haole* mother was panic-stricken when her child got a number of the spines in his foot. An old Hawaiian woman who was near and saw the situation told the mother that the best thing to do was to soak the foot in vinegar, and offered to get some for her. The mother thanked the Hawaiian woman but, preferring an M.D.'s treatment to such a dubious household remedy, whisked her child back to the city and roused her family doctor on his day off. At the office he took one look at the foot and said, "I can't do anything for that. Just soak it in vinegar. The acid will neutralize the spines and lessen the pain."

Both *wana* and *ina* are dug out of their holes with a piece of stiff wire. Then they are thrown in a sack and shaken against one another until the spines break off. The meat within the smoothed shell is yellow and



AN EXCITING PRIZE,
THE HAWAIIAN TURTLE

Dan Wallace Photo

HAWAIIAN LOBSTERS ARE
SPINY BUT HAVE NO CLAWS

perhaps only one to several hundred of the other varieties. There is no season on crabbing in Hawaii except in the case of the Kona crab, which cannot be taken during June, July and August. But there is a minimum size for the Samoan crab which must measure five inches between the last two points on the carapace. The pincers of the Samoan crab are extremely powerful and dangerous, so a forked stick is used to hold the creature to the ground while its legs are tied against its body.

At night, crabs may be caught by dazzling them with a strong light as they perch along the rocks. They hold so still, staring at the light, that they may be quickly snatched with the hands. Hosaka recommends snaring them by catching the crab's eyestalk in a noose made of thread, while the crab is staring at the light. When the eyestalk is drawn inward, the thread is held fast. Another way to catch them is to tie a piece of meat on a string and drop it near the crab. When the crab grasps it, the string is moved about loosely until the legs become snarled.

Turtle Hunting

A turtle is always an impressive prize. The shell makes a fine trophy when highly varnished and many a fisherman's home has one proudly hanging on the wall, a pleasant reminder of the feast of turtle steaks that came with it. Turtle meat is much like veal and is a regular item at some Honolulu restaurants.

Catching a turtle can be as daring an adventure as one wishes. There are a variety of ways to capture the great beast, ranging from picking it up entangled in an overnight stand net, to riding it to its doom. Only the best

of swimmers should try this latter bare-handed technique of the Hawaiians. When a turtle is seen loafing along on the surface of the water, they dive down under it and, approaching from behind, flip it over on its back. This renders the creature helpless as it cannot use its flippers to dive under water. Then it is placed on its back in the canoe where it remains immobilized, waving its flippers foolishly.

The act of subduing the turtle is completed in an instant, but everything depends on that instant, on the perfect timing and adroitness of the hunter. The only real danger in this would come from exposing one's self to the head of the turtle. While not a fierce animal, it does possess a powerful beak, something like that of a parrot enlarged five or ten times, and one snap could be disastrous. Otherwise, the only alternative to success would be losing the turtle, for if the flip-over were not quickly maneuvered, it would dive for the bottom. Hanging on would be useless, for turtles can go to depths impossible for a human, and there would be no other opportunity to attempt the flip-over technique again. There have been stories of turtle hunters who rode on their backs and directed them toward shore by pulling upwards on the shell. But the only stories which were authenticated in Hawaii have involved spear fishermen who first wounded the turtle, then held on or rode it as it tried to swim away.

Turtles are also taken with a kind of harpoon spear which is thrown when the turtles come into coves to eat seaweed. Sometimes turtles are snagged with a line which has a weight and three hooks attached to it. This is thrown at the turtle so as to catch on its flippers.

When turtles are caught unwounded, as in the flip-over technique, they may be kept alive but helpless by

leaving them on their backs. Fishermen have kept them in their yards this way for days, until they were ready to eat them.

There are two kinds of turtles in Hawaii, the *honu*, which is edible, and the *e-a* which is poisonous, but from which commercial tortoise-shell articles are made.

Shrimping

Shrimps, like crabs, are sometimes caught to eat, although they are used chiefly as bait. They are found in brackish water four or five feet deep and are caught in a net which resembles the crab net but is of a finer mesh. The net is baited with meat or fish and lowered into water which is clear enough to permit seeing the shrimps below. After a half hour or more, the net is brought up and the entangled shrimps are removed. If there is a good catch, the net is replaced in the same spot. If not, the fisherman moves on in hopes of finding better grounds. Kuapa bay and stream, just a few miles from Honolulu, is a favorite spot for gathering shrimp. Early in the morning, particularly on weekends, the area is alive with fishermen obtaining bait.

Ina, Wana and Limu Gathering

Although the gathering of such sea life as *wana* and *ina*, two kinds of sea urchins, and *limu*, which is seaweed, cannot properly be called a sport, it was included in the general term for fishing by the ancient Hawaiians. All products of the ocean, whether they moved or not, were called *i'a* or fish. And perhaps with generosity,

these activities can be admitted here on the same grounds that clam-digging expeditions are considered good sport in New England. For the obtaining of these sea-forms takes on an air of festivity and diversion, particularly when related to an impending *luau* or feast, that removes it from the class of hard-bitten work. The Hawaiians have always enjoyed the things they found to do at the seashore, and this was one more excuse to linger there. Let anyone who doubts the truth of this ask a Hawaiian which he'd rather do, plant taro or gather *limu*.

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BARNACLE BILL THE DRIFTER

BY GLENN MCKINNEY

Nora and Dia

About eight miles out, where the waters of the Kolohi and Kaiwi Channels meet, we spotted a large round object floating in the mirrowlike sea. We immediately thought there might be mahimahi under it. As we drew closer, it started moving towards us, and we realized it was a huge turtle of about two hundred pounds!

We stopped the "Kamalii Kai Too" and drifted. Instead of swimming away, this turtle kept coming, heading steadily in our direction. He would duck his head from time to time, but only go down when he came right up to the stern of the boat. Each time he went under, we would pull away for a few feet and stop again. Up he would come, swimming back to the stern again.

Finally we realized that he was tired and simply looking for a ledge to rest on. As he was miles away from shore, it had probably been a long time between meals. Then we saw what was bothing him . . . he only had one front flipper! No wonder he was looking for a home base. A shark must have attacked him!

Sam and Jim tried to play cowboy and rope the slippery beast. Finally they had him snug, but it took Doc, Sam and Jim to raise him up. As soon as they had him set, they all lifted together and hauled the big sea creature up over the side onto the backdeck. He hung onto one of the ropes with his beak until we had him situated comfortably in a corner, where he settled down and made himself at home.

Upon closer inspection, he was missing not only one flipper, but also his tail. He even had a bite along the side of his jaw. All of the wounds looked as if they were several days old. Upon his rought domed back perched two pointed white barnacles shaped like little volcanoes. The animals within kept sticking out their noses. We set up a salt water hose to keep him cool while we were traveling as we were still some eight hours from Pokai Bay.

This turtle must really have been exhausted. Diana and Nora took turns running water over burlap bags, covering him up and wiping out his eyes. He never put up any kind of a fuss. Sam even scrubbed his back with a brush. Although he moved around a bit, he appeared quite tame. We named him Barnacle Bill after his two hitchhikers.

It was well past dark when we came around the breakwall at Pokai Bay. Barnacle Bill was going to have to spend a night in Sam's front yard, while Doc phoned around to find a home for him. He peacefully spent the time on the grass with Sam's granddaughters, Roxanne and Gina, caring for him, keeping him cool and damp.

Doc finally reached Dr. Ed Schallenberger of Sea Life Park who said they would be delighted to take Barnacle Bill. So Bill started off on another ride, this time in the back of a pickup across the island with many watering stops along the way. Can you imagine what passing motorists must have thought when they looked down into the back of that pickup and found a big burlap-covered turtle staring back at them?

Once at Sea Life Park, Dr. Schallenberger checked Bill over and pronounced him fairly healthy, although thin, in spite of all he had been through. he was lifted into an isolation tank containing copper sulfate in the water to kill any parasites he might have. When George H. Balazs, the turtle authority and biologist from the University of Hawaii, looked him over, it was discovered that Bill was an Atlantic loggerhead turtle! How he ever negotiated his way through the Panama Canal is anybody's guess. However, these loggerheads are occasionally seen near Baja, California and may have drifted off course. The only other loggerhead found here visited us 27 years ago.

Bill is being fed squid by hand and is so tame, scientists are wondering if he might have escaped from another facility. He is eating great amounts of food and is putting on weight. As soon as he is in shape, he will be put into the Turtle Lagoon with others of his kind. Bill must think he has taken a ride to Turtle Heaven.

Sam Kapoi s
on back.

Nora and Diana keep turtle watered down during trip back.

Sam Kapoi scrubbing turtles shell. Note two large barnacles on back.

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Veterinarian Doc McKinney examining turtle. Note missing left flipper.

Untying "Barnacle Bill" after being lowered into isolation tank at Sea Life Park.

(1)

ut 1,000 feet altitude, below the Koa and above the Wiliwili Zone. Prob- he tree occurred on the lower, dry of nearly every secondary ridge lead- om the Waianae Mountains and on leading from the leeward side and the end of the Koolau Range. The north- d southern slopes of the Schofield sad- pparently had much more extensive of sandalwood, from Waimano to iliuli, and from Pupukea to Makaleha. s a deduction from various types of ce here assembled, which, for the first give an indication of the location of incipal stands of sandalwood on Oahu. ough decimated by the sandalwood the tree persisted on Oahu, survived ergrazing and forest recession, and is ommon and widespread at its former limit, now the lower forest line on the le of the Koolau Range and on both of the Waianae Mountains. Most of resent stations are protected from r destructive exploitation by their sit- within the Territorial Forest Reserves.

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The Tsunami of April 1, 1946, in the Hawaiian Islands

G. A. MACDONALD, F. P. SHEPARD, and D. C. COX[1]

INTRODUCTION

THE TSUNAMI WHICH STRUCK the shores of the Hawaiian Islands on the morning of April 1, 1946, was the most destructive, and one of the most violent, in the history of the islands. More than 150 persons were killed, principally by drowning, and at least 161 others were injured. Property damage reached about $25,000,000.

The wave attack on Hawaiian shores was far from uniform. The height and violence of the waves at adjacent points varied greatly, and not always in the manner which would have been expected from superficial inspection and a study of the existing literature on tsunamis. Therefore, a detailed study of the effects of the tsunami has been made, in an effort to understand the observed variations, and in the hope that the principles established may help lessen the loss of life and property in future tsunamis. Space is not available in the present short paper to discuss findings in detail, or even to present all the evidence for all the conclusions. These matters will be treated in detail in a longer paper (Shepard, Cox, and Macdonald, in preparation).

Acknowledgments: We wish to thank the many persons who furnished information during the course of the field study. We are also especially grateful to M. H. Carson, H. S. Leak, H. W. Beardin, and W. K. Sproat, who supplied measurements of the high-water level in areas not visited by us; H. W. Iversen and J. D. Isaacs, who supplied additional measurements on Oahu; A. F. Robinson and Dexter Fraser, who furnished descriptions of the wave effects on Niihau and Lanai, respectively; the Hawaii County Engineer's Office, which supplied a map showing the extent of flooding in Hilo; and the U. S. Coast and Geodetic Survey, which supplied data on the earthquake and the record of the Honolulu tide gage, and permitted the use, in advance of publication, of C. K. Green's manuscript on the tsunami along the shores of North and South America. Howard A. Powers, Seismologist of the Volcano Observatory at Hawaii National Park, aided greatly in the investigation on the island of Hawaii. Miss Maude Jones, Archivist of the Territory of Hawaii, and Miss Margaret Titcomb, Librarian of the Bishop Museum, aided in locating records of past waves. C. K. Wentworth and H. S. Palmer aided greatly in discussions. Wentworth and Walter Munk read and criticized the manuscript. J. Y. Nitta prepared the illustrations.

DEFINITION OF "TSUNAMI"

The name "tsunami"[2] is applied to a long-period gravity wave in the ocean caused by a sudden large displacement of the sea bottom or shores. A tsunami is accompanied by a severe earthquake, but the earthquake does not cause the tsunami. Rather, both are caused by the same sudden crustal displacement. The waves of a tsunami have a period

[1] U. S. Geological Survey, Scripps Institution of Oceanography, and Hawaiian Sugar Planters' Association Experiment Station, respectively. This paper is published by permission of the Director, Geological Survey, U. S. Department of the Interior.

[2] Also spelled "tunami," the Japanese equivalent of the letter *t* being pronounced *ts* in English. It appears preferable, however, to use the phonetic spelling in English, avoiding thereby much incorrect pronunciation.

near the coast of South America and one in the Aleutian area, and one was of local origin. One tsunami of moderate intensity came from near Kamchatka, and another probably from South America.

GENERAL FEATURES OF THE APRIL, 1946, TSUNAMI: ORIGIN AND NATURE OF THE WAVES

The tsunami of April 1, 1946, was caused by a movement of the sea bottom on the northern slope of the Aleutian Deep, south of Unimak Island. The same crustal movement gave rise to a violent earthquake, recorded on seismographs all over the world. In Hawaii, it was recorded on the instrument of the U. S. Coast and Geodetic Survey located on the campus of the University of Hawaii in Honolulu, and on those of the Hawaiian Volcano Observatory at Kilauea on Hawaii. The epicenter of the earthquake has been located by the Coast and Geodetic Survey at latitude 53.5° N. and longitude 163° W., and the time established as 1ʰ 59ᵐ A.M. Hawaiian time (12ʰ29ᵐ Greenwich time) (Bodle, 1946: 464). It may be assumed that the tsunami originated at the same place and time as the earthquake. The place of origin was thus 2,241 miles N. 8.5° W. of Honolulu, and 2,375 miles N. 12° W. of Hilo (Fig. 1).

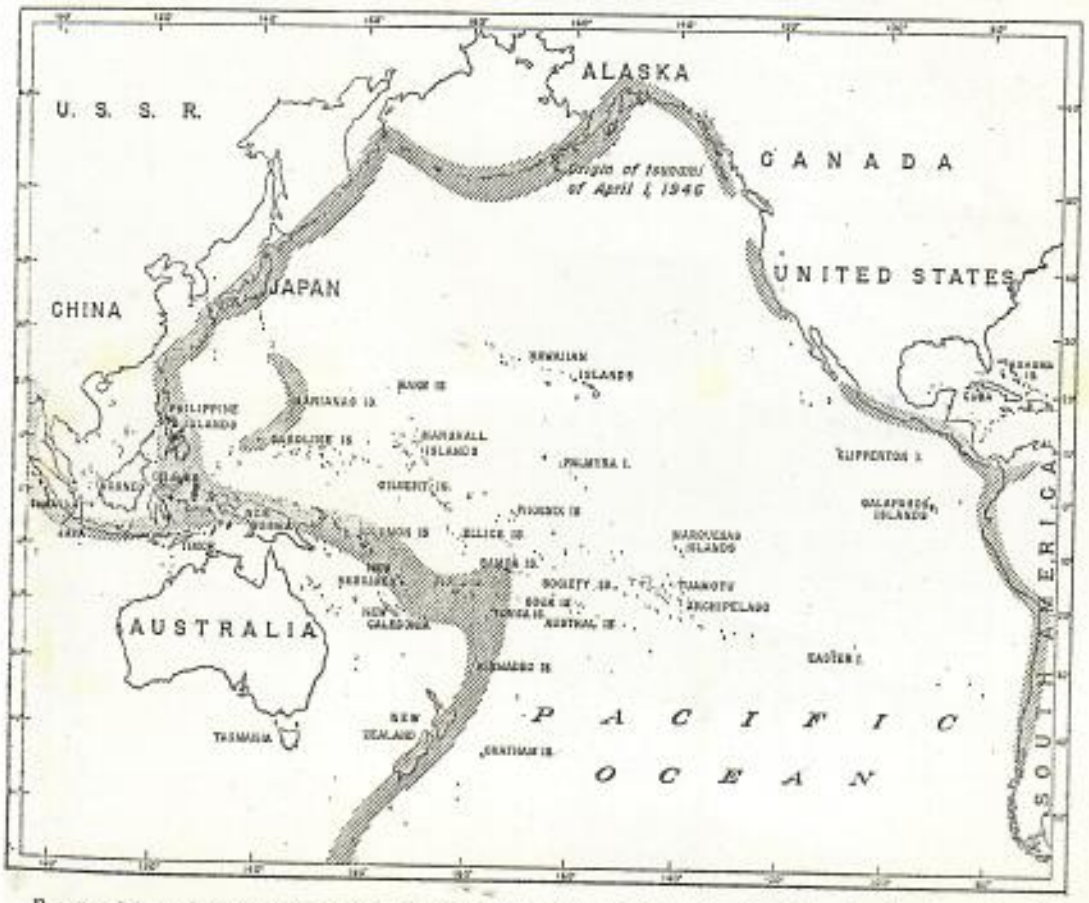

FIG. 1. Map of the Pacific basin, showing the position of the Hawaiian Islands, the place of origin of the tsunami of April 1, 1946, and the distribution of seismically active belts around the Pacific in which tsunamis are likely to originate.

of several minutes to an hour as contrasted with several seconds for ordinary storm waves caused by wind, a wave length of scores of miles as contrasted with less than 500 feet for wind waves, and a speed of hundreds of miles an hour as contrasted with less than 60 miles an hour for wind waves. Tsunamis are also sometimes termed "seismic sea waves," and are popularly known as "tidal waves." The latter term is patently undesirable, as the waves have no connection whatever with the tides. "Tsunami" is used herein in preference to "seismic sea wave" because of its greater brevity, and because the etymological correctness of the term "seismic sea wave" appears open to question.[3]

HISTORY OF TSUNAMIS IN HAWAII

Tsunamis probably reach Hawaiian shores on an average of more than one a year. Most of these are small, however, and generally escape notice except when their record is recognized on tide gages. Earlier tsunamis in Hawaii have been discussed by Jaggar (1931: 1–3) and Powers (1946: 3). The accompanying table lists all the tsunamis noticed on Hawaiian shores, in the period of written history, of which record could be found, together with their sources if known. A total of 27 are listed, or an average of one every 4.7 years since 1819. Most of them, however, did little damage. During the same interval there are listed five severe tsunamis which caused extensive damage, an average of one every 25.6 years.

Other violent waves have been termed "tidal waves" in the newspapers, but were more probably storm waves. Such were the wave which hit Maliko, Maui, on January 28, 1895, and those which struck Kaumalapau on Lanai, and Nawiliwili on Kauai, on May 30, 1924.

It will be noted that only two of the 27 tsunamis listed in the table were of local origin. With the exception of the numerous volcanic earthquakes on the island of Hawaii, which seldom cause tsunamis, the Hawaiian region is only moderately active seismically (Gutenberg and Richter, 1941: 84–85). The great majority of the tsunamis reaching Hawaii originate in the highly seismic border zone of the Pacific. Of the 22 tsunamis from known sources listed in the table, five came from near South America, one from near Central America, one from near California, three from near Alaska and the Aleutian Islands, five from near Kamchatka, three from the Japanese area, and one from near the Solomon Islands. Of the five severe tsunamis, three originated

TABLE 1

HAWAIIAN TSUNAMIS

DATE	SOURCE	DAMAGE IN HAWAII	AVERAGE SPEED OF WAVES
	nearest coast		mi. per h
1819 Apr. 12	Unknown	Unknown	—
1837 Nov. 7	South America	Severe	—
1841 May 17	Kamchatka	Small	—
1868 Apr. 2	Hawaii	Severe	—
1868 Aug. 13	South America	Severe	—
1869 July 25	South America (?)	Moderate	—
1872 Aug. 23	Hawaii	Small	—
1877 May 10	South America	Severe	—
1883 Aug. 26	East Indies	Small	—
1896 June 15	Japan	None	478
1901 Aug. 9	Japan (?)	None	—
1906 Jan. 31	Unknown	None	—
1906 Aug. 16	South America	Small	—
1918 Sept. 7	Kamchatka	Small	456
1919 Apr. 30	Unknown (distant)	None	—
1922 Nov. 11	South America	None	450
1923 Feb. 3	Kamchatka	Moderate	432
1923 Apr. 13	Kamchatka	None	438
1927 Nov. 4	California	None	462
1927 Dec. 28	Kamchatka	None	438
1928 June 16	Mexico	None	462
1929 Mar. 6	Aleutian Is.	None	492
1931 Oct. 3	Solomon Is.	None	447
1933 Mar. 2	Japan	Small	477
1938 Nov. 10	Alaska	None	496
1944 Dec. 7	Japan	None	425
1946 Apr. 1	Aleutian Is.	Severe	490

[3] The adjective "seismic" is derived from the Greek root *seismos*, meaning earthquake, and is defined as pertaining to, produced by, or characteristic of an earthquake. The waves in question are not, however, characteristic of most earthquakes, even those of submarine origin, and are not produced by earthquakes.

The time of arrival of the waves in the Hawaiian Islands is known with certainty only at Honolulu. The record of the Honolulu tide gage (Fig. 2) shows that the first rise started at about 6:33 A.M. (Green, C. K., 1946: 491), though the exact time cannot be stated closer than 2 or 3 minutes. The drum of the water-stage recorder at the Waimea River, on Kauai, revolves too slowly to give an accurate indication of time, but the first rise appears to have started there at about 5:55. At Hilo, electric clocks were stopped at 7:06, and a brief power failure occurred at 7:18. These have been interpreted by Powers (1946: 2), probably correctly, as the time of arrival of two wave crests at Hilo. From other considerations, discussed briefly elsewhere (Shepard, Macdonald, and Cox, in preparation), it appears probable, however, that the crest at 7:06 was the second wave at Hilo, not the first. If so, allowing for the observed 15-minute interval between later waves, the first rise at Hilo probably started at about 6:45. Computed from these times of arrival, the approximate average speed of the tsunami from its origin to Honolulu and Hilo was, respectively, 490 and 498 miles an hour. On entering shallow water the waves decreased greatly in speed. The waves moving up Kawela Bay, on Oahu, were estimated by Shepard to be moving only about 15 miles an hour. Similar low speeds near shore were reported by other observers, and are comparable to the speed of 20 miles an hour recorded in San Francisco Bay (Green, C. K., 1946: 492).

The interval between the first and third wave crests, as recorded on the Honolulu tide gage (Fig. 2), was about 25 minutes, indi

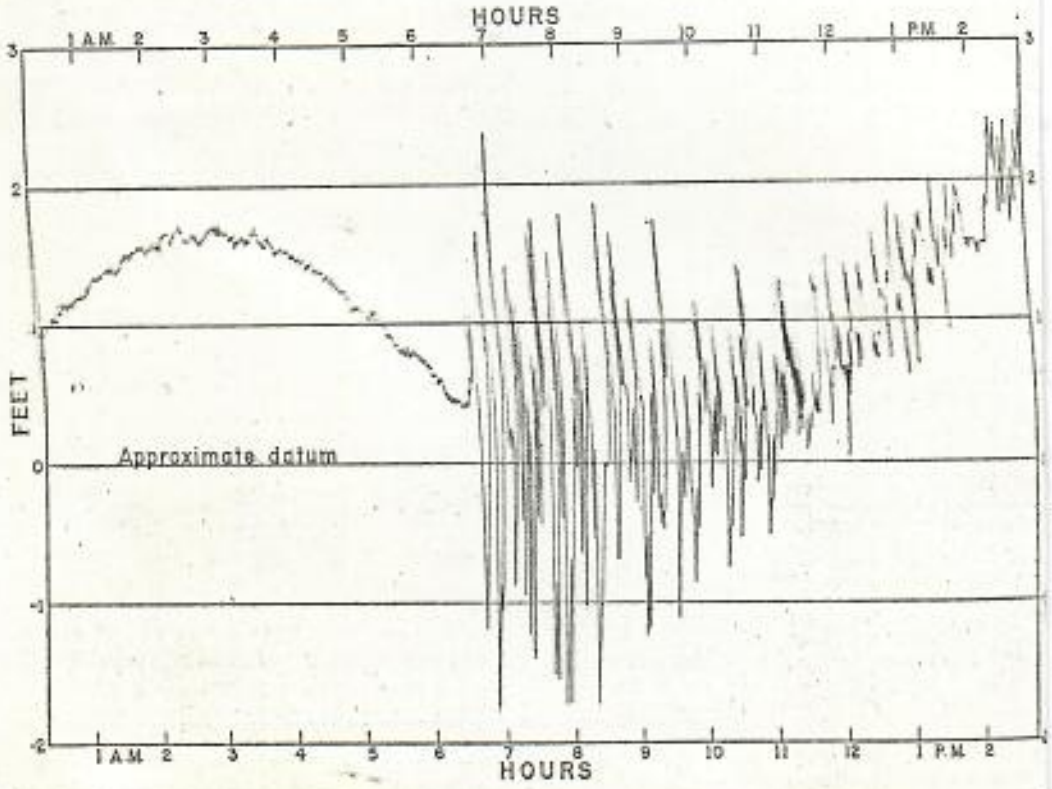

FIG. 2. Record produced on the tide gage in Honolulu Harbor by the tsunami of April 1, 1946.

cating an average interval between early wave crests of approximately 12.5 minutes. The interval between the first wave crest and the succeeding trough was 7.5 minutes, however, indicating a wave period of 15 minutes at the beginning of the disturbance. This corresponds with the mean wave period of 15.6 minutes found by Green (1946: 499) at Honolulu and eight other stations on the coasts of North and South America. At the mouth of Nuuanu Stream in Honolulu, C. K. Wentworth observed an interval of approximately 15 minutes between successive bores ascending the stream, and a wave period of about 15 minutes was observed by J. B. Cox and D. C. Cox at Waikiki at about 7:45 A.M. Observations elsewhere were poor, but in general indicated an interval not far from 15 minutes between the early waves of the series. The interval between later waves at Honolulu (Fig. 2) and elsewhere was shorter and less regular, probably because of the arrival of chains of waves traveling by somewhat different routes, refracted around different sides of islands, and reflected at various points, as well as traveling by the most direct route. Probably contributing to the irregularity of later waves were wind waves and also the free-period oscillations, in harbors and channels, known as "seiches." If the period of the waves is assumed to be 15 minutes, and the average speed to be about 489 miles an hour, the average wave length from crest to crest was about 122 miles.

Direct observations on the height of the waves in the open sea are lacking, but theoretical considerations indicate that the height probably did not exceed 2 feet from crest to trough.[4] If so, the small height combined with the very great wave length should have made the waves imperceptible to ships at sea. That such was indeed the case is indicated by the fact that the master of a ship lying offshore near Hilo could feel no unusual waves, although he could see the great waves breaking onshore. Crews of fishing boats in the Hawaiian area also reported no unusual conditions at the time of the tsunami, although heavy storm waves were running. The few reports of violent waves of great height from ships at sea were probably occasioned by storm waves, together with the knowledge that a tsunami was taking place.

The nature of the waves sweeping up on to Hawaiian shores varied greatly from place to place. At some places the water rose gently, flooding over the coastal lands without the development of any steep wave front. At such places most of the damage resulted from the violent run-back of the water to the sea. At some localities, although the general water surface rose gently, ordinary storm waves moved in over the top of the broad swells of the tsunami, and there at least part of the damage was caused by the storm waves. At most places, however, the waves of the tsunami swept toward shore with steep fronts and great turbulence, causing a loud roaring and hissing noise. Locally, the wave closely resembled a tidal bore, the steep front rolling in over comparatively quiet water in front of it. Behind the steep front, the wave crest was broad and nearly flat, with smaller storm waves superimposed upon it. Such bores were best developed in bays and estuaries, but waves of closely similar form were observed crossing shallowly submerged reefs upon otherwise open coasts.

At many places the violence of the waves moving shoreward was sufficiently great to tear loose heads of coral and algae, up to 4 feet across, and toss them onto the beach as much as 15 feet above sea level. Locally, blocks of reef rock weighing several tons were quarried at the outer edge of the reef and thrown onto the reef surface.

Between crests, the water withdrew from shore, exposing reefs, coastal mud flats, and

[4] Based on the assumption of a 10-foot wave in 10 feet of water, and the variation of the wave height inversely as the fourth root of the depth.

harbor bottoms for distances up to 500 feet or more from the normal strand line. The outflow of the water was rapid and turbulent, making a loud hissing, roaring, and rattling noise. At several places houses were carried out to sea, and in some areas even large rocks and blocks of concrete were carried out onto the reefs. Sand beaches were strongly eroded by the outgoing water. People and their belongings were swept to sea, some being rescued hours later by boats and life rafts dropped from planes.

At a few places, generally but not exclusively on the sides of the islands away from the wave origin, the first wave was reported to have been the highest. At those places, the rise was generally of the quiet sort. There are, however, no instrumental records showing the first wave to have been the highest, and it is possible that at places reporting the first wave as the highest, earlier waves may have been overlooked. Much more generally the third or fourth wave was reported to have been the highest and most violent. The third crest was the largest at the Honolulu tide gage (Fig. 2). At other localities the sixth, seventh, or eighth waves were said to have been the highest. At Waimea River, Kauai, the sixth crest was higher than any other, both in absolute level and in its height above the preceding and succeeding troughs.

In general, if not everywhere, the size and violence of the waves increased to a maximum with the third to eighth waves. The oscillations then gradually decreased in amplitude over a period of at least 2 days, but with occasional waves which were larger than those just before and after them. Such temporary increases in wave height probably resulted from mutual reinforcement by the essentially simultaneous arrival, in phase, of waves which had traveled different paths, or from the coincidence of tsunami waves with storm waves or seiche oscillations.

Measures of the height of the waves approaching shore in shallow water, but before they dashed up on shore, are poor. At Kawela Bay, Oahu, Shepard estimated the height of the waves advancing across the reef to have been as much as 18 feet, and observers estimated the height of the waves crossing the reef off Lanikai, on Oahu, to have been about 7 feet. Photographs taken at Hilo show the top of the breakers to have been 2 feet above the normal bay surface where they struck Cocoanut Island, but the waves may have increased considerably in height in crossing the breakwater, and the effect of dashing up on the shore was probably already present, further exaggerating the height. Photographs of some of the late waves at the mouth of the Wailuku River, in Hilo, show them to have been 6 to 8 feet high (Plate 8), and early waves undoubtedly were higher. In general, these heights correspond fairly closely with the measured heights to which the water dashed on the shore at those localities. At any rate it appears clear that the waves not only slowed down, but increased in height on entering shallow water. George Green (1838: 457–462) states that the wave height varies inversely as the fourth root of the depth of the water.

Most observers reported the first movement on Hawaiian shores to have been a withdrawal of the water. However, the only available instrumental records, at Honolulu and Waimea, both indicate the first movement to have been a rise. The instrumental records are probably more reliable than the reports of untrained observers. The initial rise at Honolulu was small (Fig. 2), and a similar small rise at other localities may easily have been overlooked. Certainly it would have been less impressive than the large withdrawal of the water from shore as the succeeding trough approached. It is interesting to note that the records of tide gages along the coasts of North and South America obtained by C. K. Green (1946: 497) all show the initial movement to have been a

rise, with amplitude of about one third that of the ensuing trough.

HEIGHTS REACHED BY THE WAVES ON HAWAIIAN SHORES

Measurements of high-water marks have been made around the shores of all five major islands of the Hawaiian group. The measured heights are shown on Fig. 3 to 7. All heights are stated in feet above lower low water. At each point sea level was estimated, the height of the high-water mark above that level was measured by means of hand level or steel tape, and the measurement reduced by means of tide tables to height above lower low water. Some inaccuracy undoubtedly has entered in the estimation of mean sea level, but it is believed that the heights are probably accurate to within 1 foot. The levels measured include: points indicated by eyewitnesses as the upper limit of the water, lines of flotsam or swash marks, the upper limits of soil and vegetation scouring, levels of consistent scratching and barking on trees, and the upper level of staining on the walls of buildings.

The measured heights of high-water marks range from 55 feet at Pololu Valley

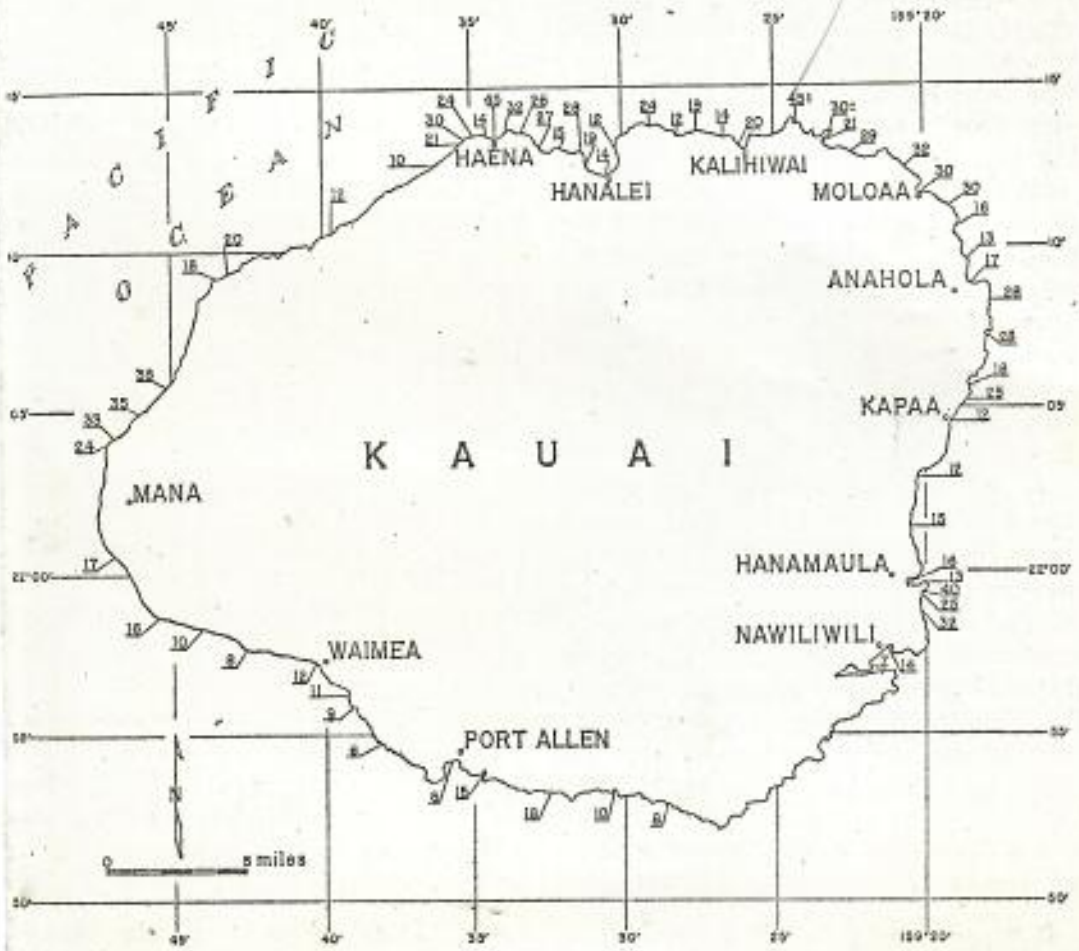

FIG. 3. Map of the island of Kauai, showing heights reached by the water during the tsunami of April 1, 1946. Heights are in feet above lower low water.

on Hawaii, 54 feet at Waikolu Valley on Molokai, and 45 feet at Haena and Kilauea Point on Kauai, to 2 feet at Kaunakakai on Molokai, 2 feet at Mililii and Hoopuloa on Hawaii, and less than 2 feet at the head of Kaneohe Bay on Oahu. Causes of the variations in height will be discussed in a later section.

Most of the heights measured are, of course, not the heights of the actual waves, but rather the heights to which the water was driven on shore. On a vertical cliff directly across the path of the wave, this height may theoretically amount to twice the height of the actual wave. On slopes less than vertical, or on cliffs at an angle to the direction of wave advance, it should be somewhat less than twice the wave height. This measure represents the height of dash of solid water, but very abundant spray may be thrown much higher. Moreover, storm waves riding on the crest of the broader swells of the tsunami undoubtedly added in places to the height to which water dashed on shore. There are places where normal trade-wind waves are flung to a height nearly as great as that reached by the tsunami, and many places, particularly on shores facing away from the origin of the tsunami, where waves of heavy storms reached appreciably higher than did the waves of the tsunami.

It is not possible to make reliable estimates of the magnitudes of these complicating factors, as there are too many unknown elements involved. However, it is probable that most of the water heights recorded for the tsunami on the northern and eastern sides of the islands were appreciably increased by these factors.

FACTORS INFLUENCING THE HEIGHTS AND INTENSITIES OF THE WAVES

It may be assumed that the size and speed of the waves approaching the islands from the open ocean to the north were essentially the same throughout the length of the Hawaiian Archipelago. Differences in height reached by the water and in violence of wave attack along Hawaiian shores must be attributed to local influences modifying the size and behavior of the waves.

The factors found to have affected the height and intensity of the waves during the tsunami of April 1, 1946, are:

1. Orientation of the coast line with respect to the point of origin of the tsunami.
2. Shape of the island.
3. Exposure to storm waves.
4. Submarine topography.
5. Presence or absence of reefs.
6. Configuration of the coast line.
7. Merging of waves from different directions, or of different types.

Orientation of the coast line with respect to the point of origin of the tsunami.—In general, the heights reached by the water were greatest on the sides of the islands facing the origin of the waves, and lowest on the sides away from the wave origin. This is evident from even a cursory inspection of the maps (Fig. 3 to 7). Heights average consistently greater on the northern than on the southern sides of the islands. All the extreme heights were measured on the northern or northeastern sides. Conversely, most of the lowest figures were found on the southern and southwestern sides. It appears almost self-evident that this should be so. Waves striking northern shores retain their full force, whereas the refracted waves striking southern shores suffer a diminution in force and height. This effect is discussed for wind waves in *Breakers and surf* (U. S. Navy Hydrographic Office, 1944: 12–13). No wave can be refracted or reflected without losing some of its force.

Shape of the island.—Waves were refracted around circular or nearly circular islands much more effectively than around angular or elongate islands. This fact had a marked effect on the height and violence of waves on

the southern shores. Thus the water reached considerably greater heights along the southern coast of the nearly round island of Kauai (Fig. 3) than along the southern coast of the angular and elongate island of Molokai (Fig. 5), even though the heights along the northern coast of Molokai were on the average perhaps a little greater than those on the northern coast of Kauai. The contrast between the very high average height on the northern coast of Molokai and the very low average height on the southern coast is greater than that between the two sides of any other island, although the difference between the extreme highs and lows is almost exactly the same as on the island of Hawaii (Fig. 7).

Exposure to storm waves.—At the time of the tsunami, large storm waves had been running for several days. As already pointed out, these storm waves riding in on the backs of the broad swells of the tsunami in places undoubtedly increased the height to which the water dashed on shore. Moreover, in other places, where the rise in water level due to the tsunami was gentle, storm waves on top of the tsunami were responsible for much of the damage. The generally greater violence of the waves on the windward (northern and northeastern) coasts as compared to that on the leeward coasts may have been in considerable part the result of the large storm waves which were driving in on the windward coasts. Places on the wind-

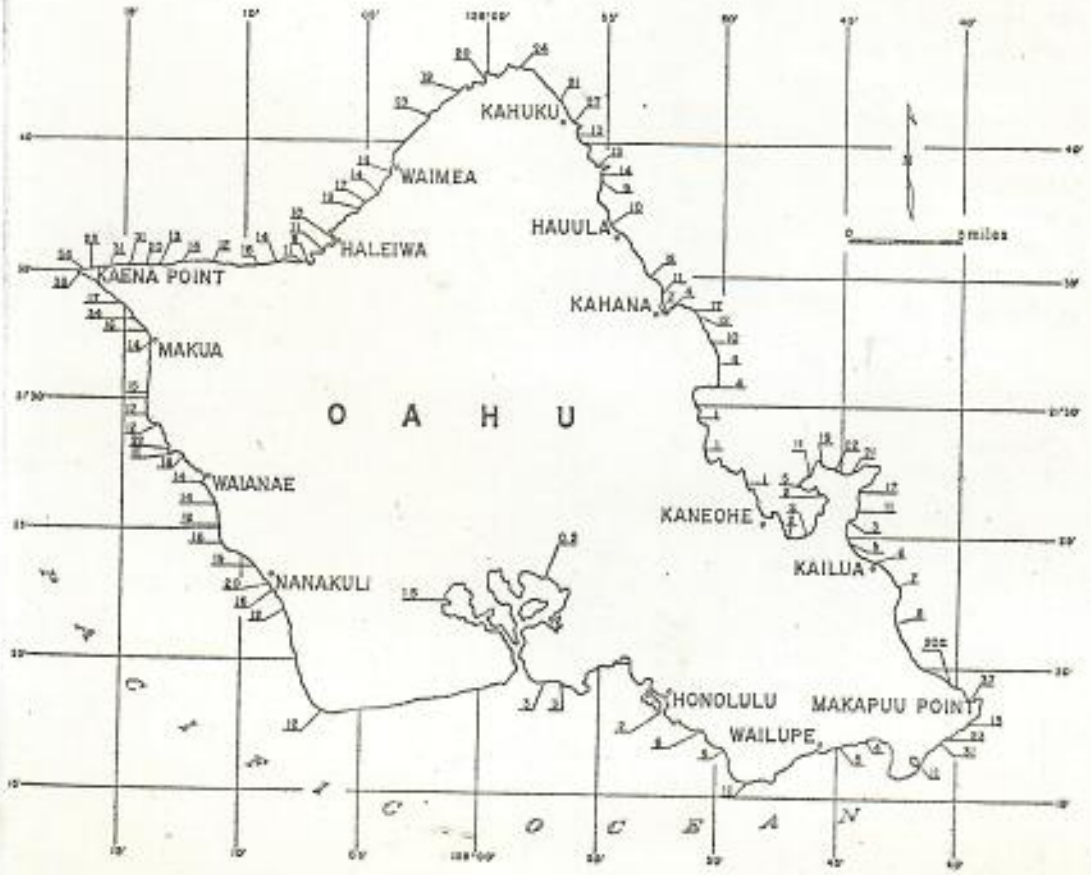

FIG. 4. Map of the island of Oahu, showing the heights reached by the water during the tsunami of April 1, 1946. Heights are in feet above lower low water.

ward coasts which were sheltered from the storm waves also experienced less violent waves. Thus at Kalaupapa, on the sheltered side of the peninsula on the windward side of Molokai, both photographs and the testimony of observers indicate that the rise of 25 feet caused by the tsunami was not violent. On the windward coasts, much of the rapid variation in intensity of wave attack may have resulted from the caprice of storm waves.

Submarine topography. — Owing to their great wave length, the waves were somewhat affected by the ocean bottom throughout their course. However, the effect of the bottom increased greatly as the waves moved into shallow water, and caused a slowing of the wave, an increase in its height, and a steepening of its front. A direct evidence of the increase in height of the waves in shallow water was afforded by the lesser heights reached by the water at the ends of certain peninsulas projecting into deep water and not prolonged seaward by pronounced ridges, as compared with the heights on adjacent shores rising from shoal water. Thus at the end of Kalaupapa Peninsula, on the northern coast of Molokai (Fig. 5), the water dashed only 7 feet above normal sea level, distinctly less than do the waves of ordinary storms; whereas on the coasts rising from shoal water both east and west of the peninsula, the water swept up to heights of 30 to 54 feet. At the end of Keanae Peninsula, on the northern coast of Maui (Fig. 6), the tsunami reached heights only a little greater than large trade-wind waves.

Submarine ridges and valleys, particularly those pointing toward the wave source, were of great importance in their effect on the strength of the waves. The best examples of the effect of ridges are found on the northern coast of Kauai. A long ridge extends in a direction slightly west of north from Haena, to a depth of about 8,000 feet (Plate 2). Another extends northeastward from Kilauea Point, to even greater depths. The greatest heights (45 feet) reached by the water on the shores of Kauai were at the heads of these two ridges (Fig. 3). Another ridge extending northwestward from the western coast of Kauai is probably responsible for heights of 35 to 38 feet at its head. Long ridges projecting from Kaena and Kahuku Points on Oahu similarly caused an increase in wave heights there as compared to the heights on both sides (Fig. 4). The ridges projecting eastward north of Hilo Bay and at Cape Kumukahi on Hawaii had, on the other hand, no such pronounced

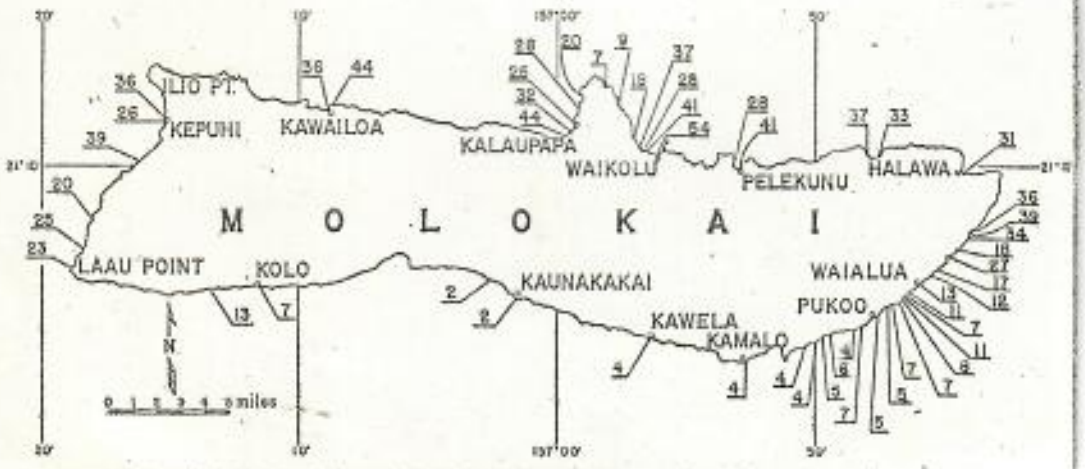

FIG. 5. Map of the island of Molokai, showing heights (in feet above lower low water) reached by the water during the tsunami of April 1, 1946.

effect on the heights at their heads; but it should be noted that they extend across the general direction of wave advance, not toward it.

The greater heights reached by the water at the heads of submarine ridges are not difficult to explain. The ridge has a greater effect in limiting the movement of water particles in the advancing wave than does the deeper water alongside it. Consequently the portion of the wave over the ridge is retarded more than that away from the ridge, and the wave front becomes bent, with its concavity directed toward the ridge head. The result is a focusing of wave force on the shore at the head of the ridge (U. S. Navy Hydrographic Office, 1944: 13).

Similarly, in moving toward shore along the axis of a submarine valley, the part of the wave in the deep water along the valley axis moves faster than that in shallower water on the two sides. In consequence the wave front becomes bent, with its convexity toward the valley head. In the vicinity of the valley head the force lines (orthogonals) of the wave are diffused or spread apart, and over any unit area the force of the waves striking shore is greatly decreased.

An example of the effect of a submarine valley in lessening the force of the waves at its head is found at Kahana Bay, on Oahu (Fig. 4). There the waves dashed to heights of 11 to 17 feet on the coasts north and south of the bay, but reached heights of only 4 to 7 feet in the bay itself. A small submarine valley extends 2 miles northeastward from the bay, to a depth of 150 feet. An example on a much larger scale is af-

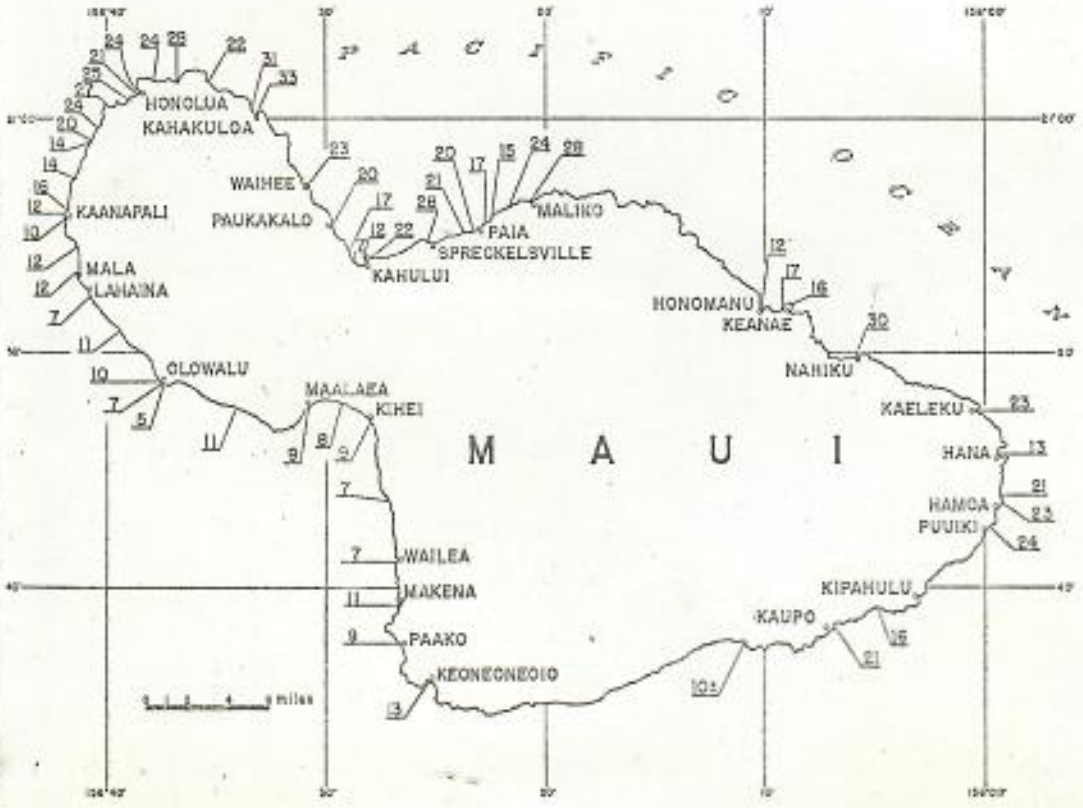

FIG. 6. Map of the island of Maui, showing heights (in feet above lower low water) reached by the water during the tsunami of April 1, 1946.

forded by the zone of small heights along the northwestern shore of Kauai (Fig. 3), at the head of a broad swale extending outward to oceanic depths. The broad valley-like depression off the eastern coast of Hawaii south of Hilo Bay probably also was somewhat effective in reducing the heights reached by the water along that coast. Although fairly great, ranging from 16 to 19 feet, the heights there are not much greater than those reached by ordinary storm waves.

Presence or absence of reefs.—The presence of a well-developed fringing reef appears to have had a decided effect in reducing the intensity of wave onslaught. Along the reef-protected northern coast of Oahu the heights reached on shore by the waves were on the average decidedly less than on the unprotected northern coasts of Molokai and Hawaii, or on the less protected northern coast of Kauai. The best-developed coral reef in the Hawaiian Islands fills Kaneohe Bay on Oahu, where it has a width of about 3 miles. Despite the fact that the broad mouth of Kaneohe Bay is open to the north and northeast, the tsunami produced a rise in water level at the bay head which was so small as to be hardly perceptible to observers, and, so far as could be determined, nowhere exceeded 2 feet. Along the shore north of the bay the heights ranged from 4 to 10 feet, and on the end of Mokapu Peninsula southeast of the bay the heights reached more than 20 feet (Fig. 4).

The lesser heights along the southern shore of Molokai were probably partly due to the wide protecting reef. The effect of the reef in reducing wave violence along that shore is well shown at places where channels cross the reef. There the waves striking the shore at the heads of the channels were distinctly larger than those reaching shore on each side of the channel. Thus at the head of a small channel which crosses the reef just west of the mouth of Kainalu Stream the water rose 11 feet, damaging houses, whereas just east and west of this channel the water rose only 7 to 8 feet.

Configuration of the coast line.—It is generally considered that the effects of tsunamis should be intensified near the heads of V-shaped embayments. Such embayments greatly increase tidal fluctuations, as in the Bay of Fundy, and might be expected to act likewise on the similarly long waves of a tsunami. Imamura (1937: 125–127) states that as such a wave rolls up a V-shaped embayment its height increases in inverse ratio to the width and depth of the bay, and cites examples of such increases in height of the waves toward the bay head during Japanese tsunamis. Consequently, special search was made for this phenomenon in funnel-shaped bays on Hawaiian shores. No good examples could be found. Hilo Bay would appear to be an almost ideal site for such funneling, but measurements around its shores show no systematic increase in heights toward its head (Fig. 7 and Plate 1). Similarly there was a lack of increase in heights toward the head of the broad V-shaped embayment on the northern coast of Maui. Possibly the extreme height of 54 feet at Waikolu Valley on the northern shore of Molokai, may have been partly the result of funneling between Kalaupapa Peninsula and the point and small islands just east of the mouth of the valley. At both Pololu Valley on Hawaii and Pelekunu Valley on Molokai, the water level was higher at the bay head than on the walls of the bay part way out. However, at Pololu Valley, and probably also at Pelekunu, this level was the result of a local upsurge where the waves crossed the beach. Conversely, several bays were found in which the heights reached by the water were less at the bay head than near its mouth.

Several small steep valleys, debouching into small bays, were found in which the water rose to appreciably greater heights along the valley axis than on the sides near the bay mouth or opposite the beach. Thus

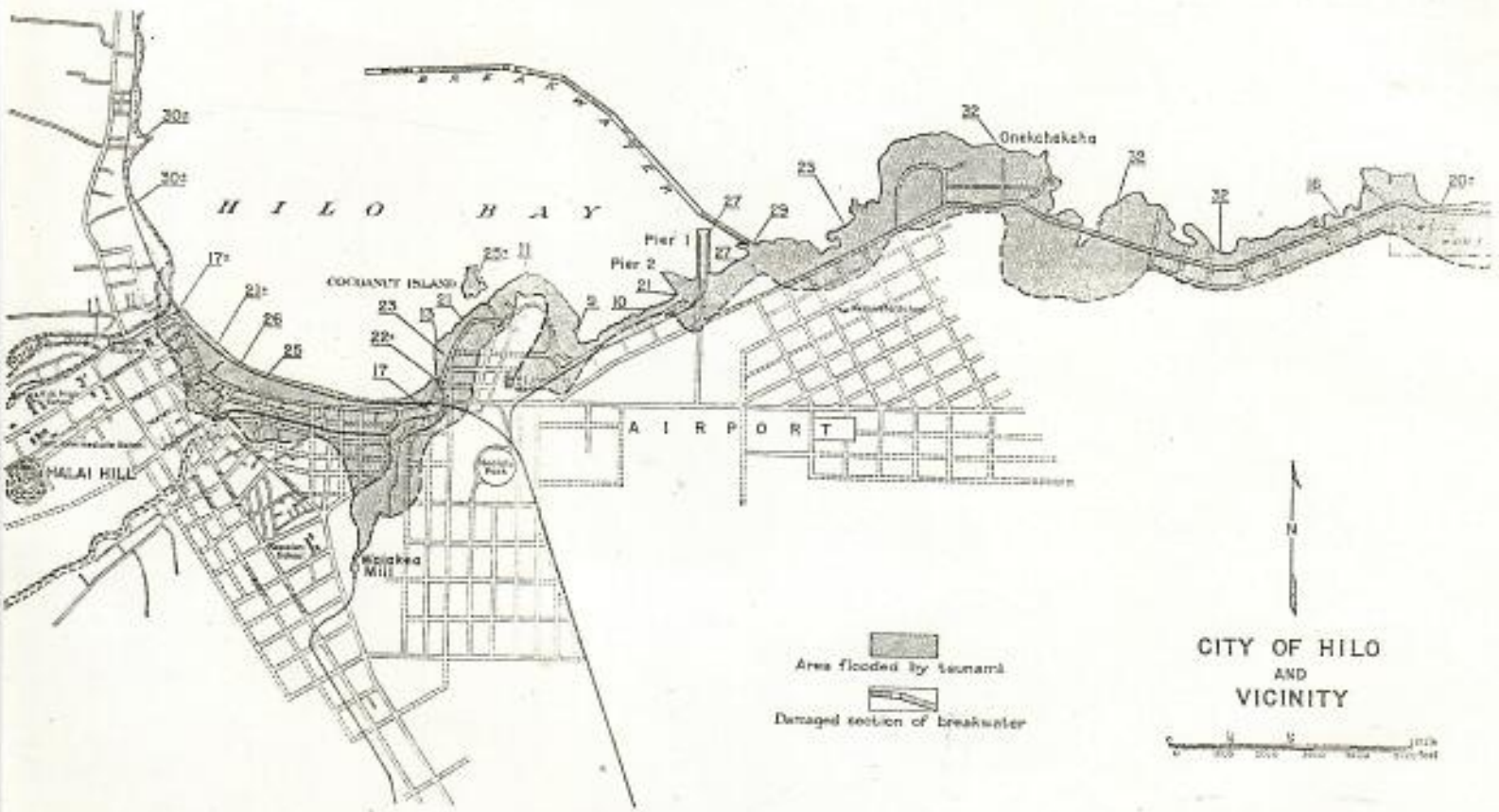

PLATE 1. Map of the Hilo area on the island of Hawaii, showing the heights reached by the water, the area of flooding, and the portion of the breakwater destroyed (shaded portions) during the tsunami of April 1, 1946. Heights are in feet above lower low water.

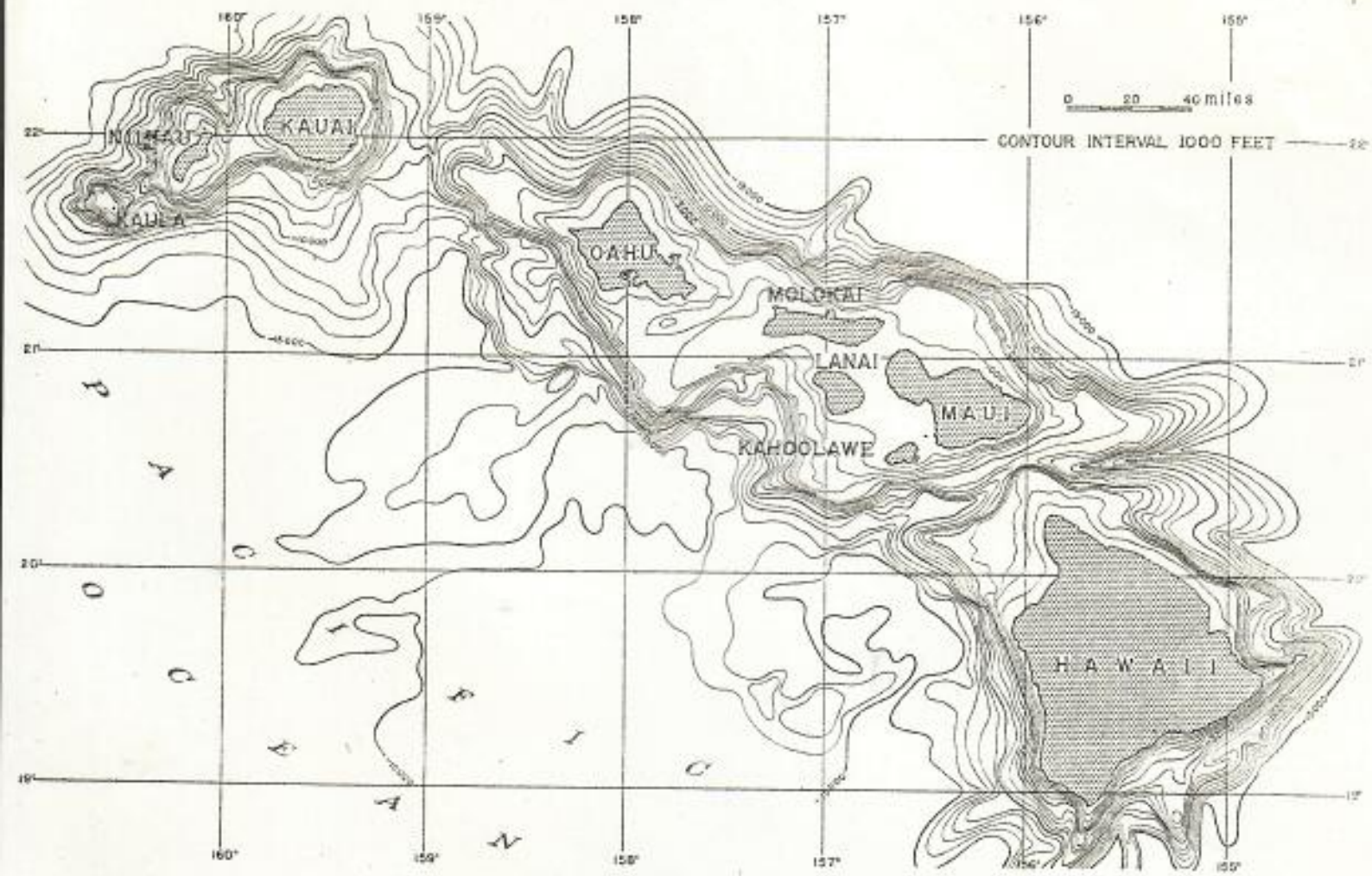

PLATE 2. Map of the Hawaiian Islands, showing submarine topography (after H. T. Stearns).

PLATE 3A. Wreckage left by the tsunami along Kamehameha Avenue, Hilo. Buildings on the left-hand (seaward) side of the street have been pushed into the street, some more or less intact, others as heaps of debris. Photo by Francis Lyman.

PLATE 3B. House in Keaukaha, east of Hilo, carried inland about 100 feet by the waves. The

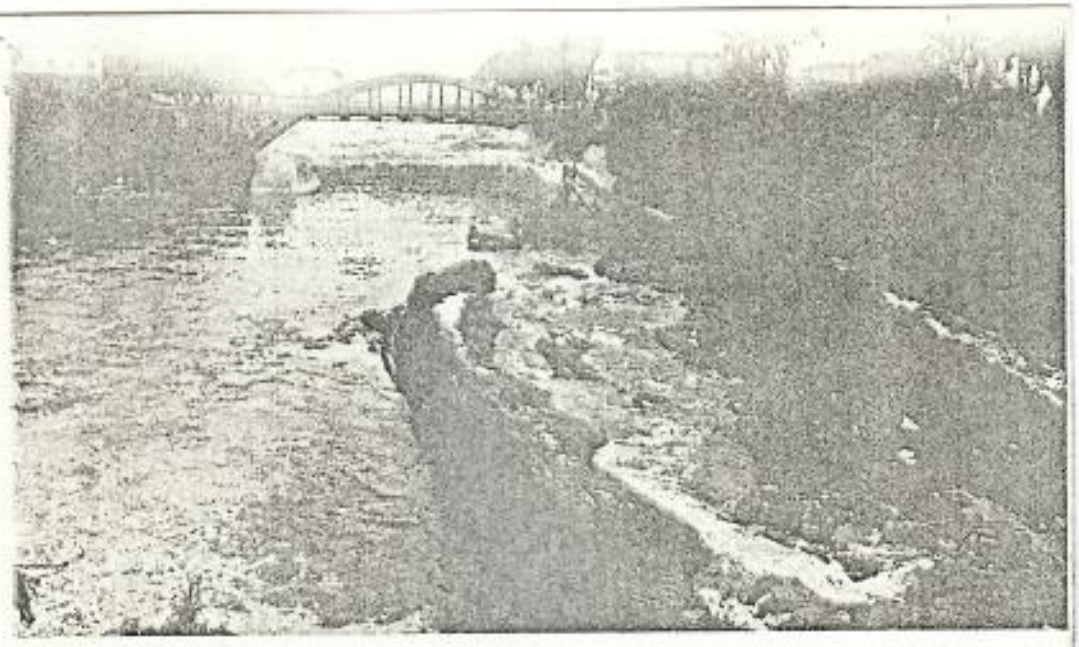

PLATE 4A. Mouth of the Wailuku River at Hilo, showing the advance of one of the later waves into the river mouth. Photo taken near the trough between two waves, showing very low water, and the waves starting up the river as the next crest approaches. The steel span from the distant railroad bridge is visible in the middle distance. Photo by Francis Lyman.

PLATE 4B. A minute or so later, the waves are sweeping turbulently up the river. Photo by Francis Lyman.

PLATE 5A. The very high stage of the water, in Wailuku River at Hilo, reached 3 or 4 minutes later than the stage shown in Plate 4B. Photo by Warren Flagg.

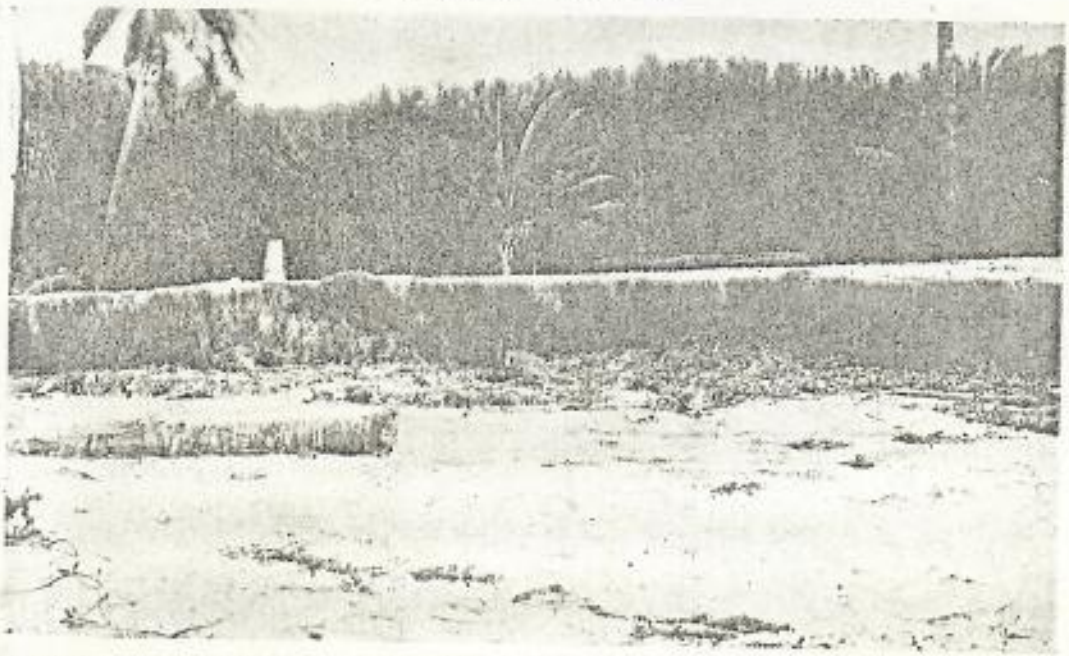

PLATE 5B. Scarp 5 feet high cut by the tsunami at the head of the beach at Moloaa, Kauai. The roots were exposed by removal of the enclosing soil. Photo by G. A. Macdonald.

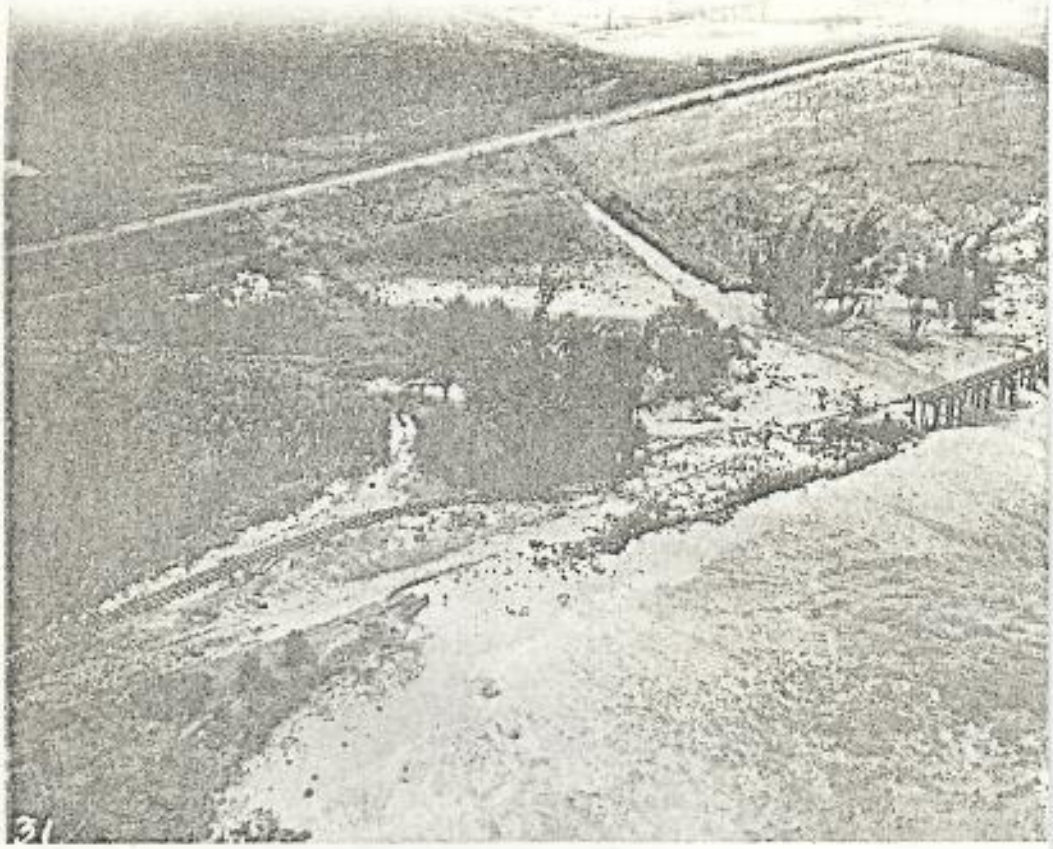

PLATE 6A. Railroad track swept inland from its bed at Waialee, Oahu. Photo by U. S. Navy.

PLATE 6B. Coral heads thrown up on the beach at Kaaawa, Oahu, by the tsunami. Photo by G. A. Macdonald.

PLATE 7A. Grove of pandanus trees pushed over, and blocks of coral thrown up on the shore platform by the tsunami near Haena, Kauai. Photo by F. P. Shepard.

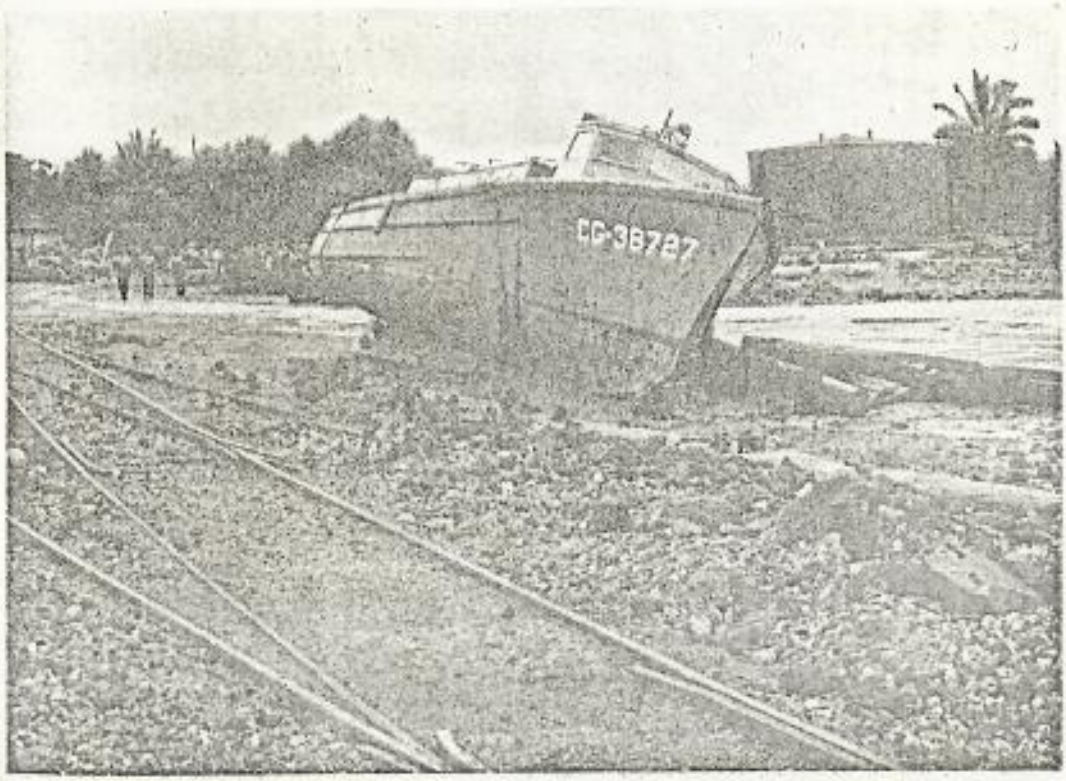

PLATE 7B. Small boat washed inland and left stranded by the tsunami near Pier 1, Hilo. Photo

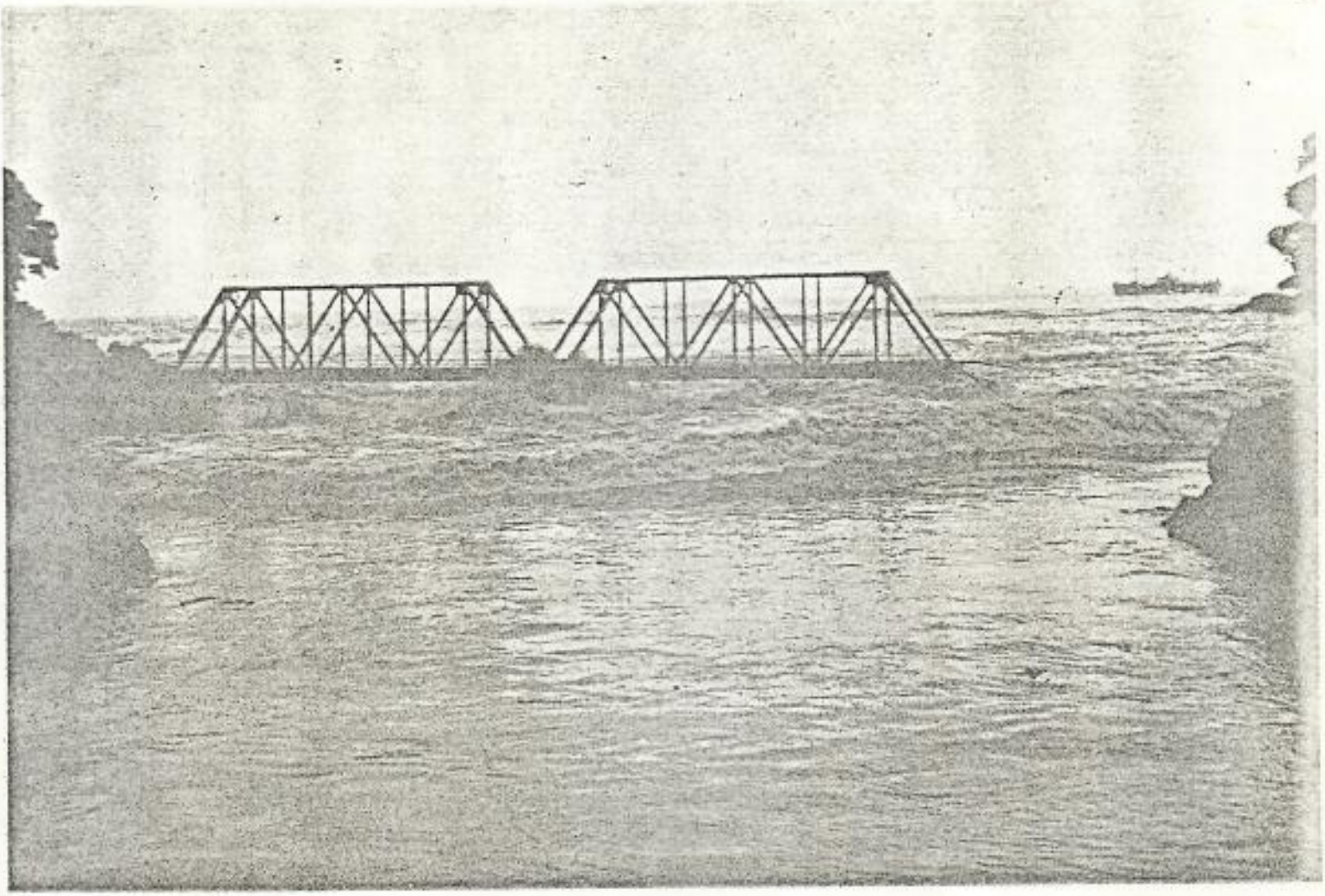

PLATE 8. Bore advancing past the railroad bridge at the mouth of the Wailuku River, Hilo. Note the steep front, the turbulence of the water

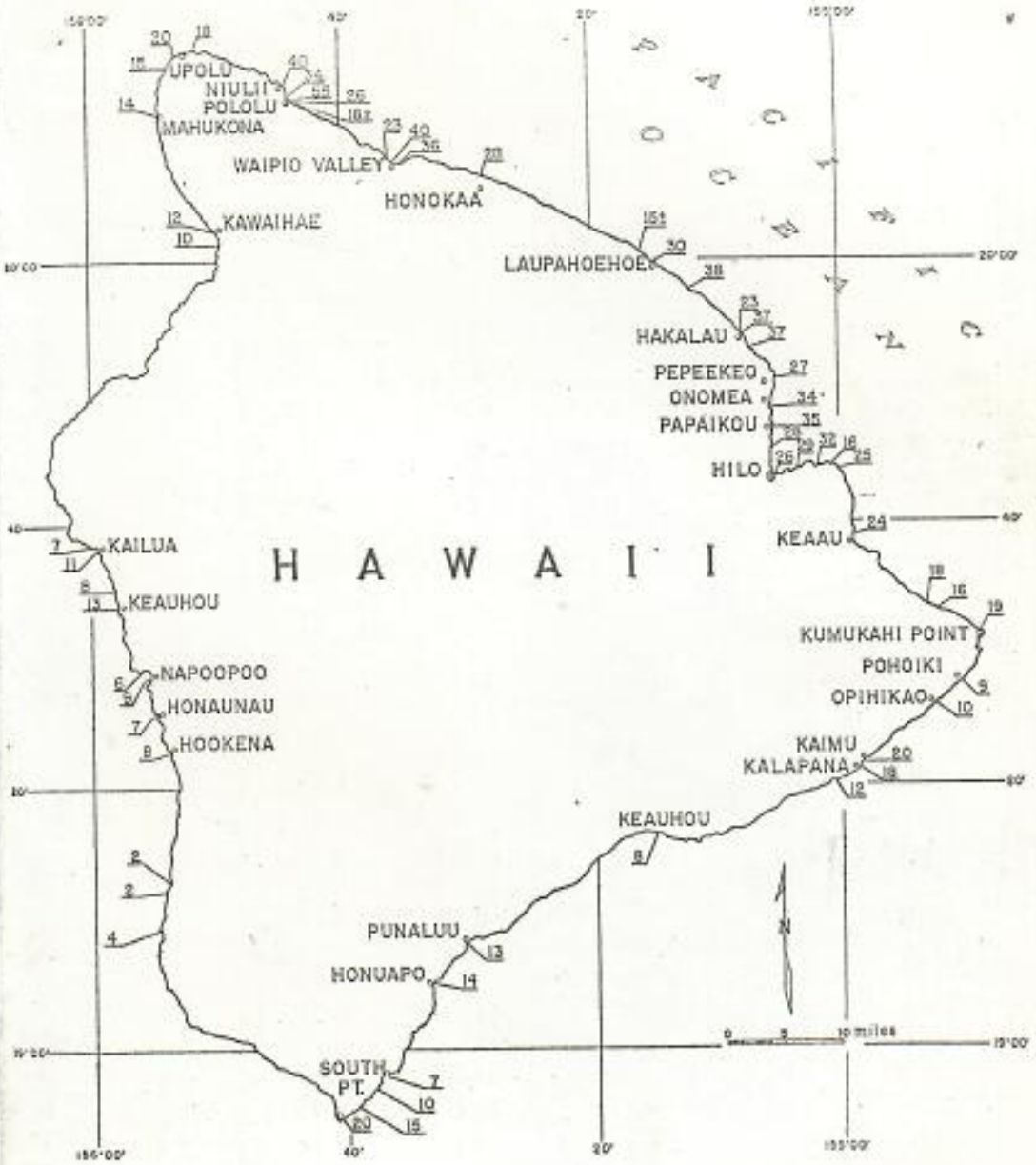

FIG. 7. Map of the island of Hawaii, showing heights (in feet above lower low water) reached by the water during the tsunami of April 1, 1946.

in the small bay just south of Hanamaulu Bay, on the eastern shore of Kauai, the water rose only 25 feet on the bay sides, but swept up the small valley at its head to a height of 40 feet. At Moloaa, on Kauai, the water reached an altitude of 40 feet in the axis of the valley, but only 30 to 35 feet on the bay walls. Again, at Honouliwai, on Molokai, the water reached a height of 27 feet opposite the beach, but went 6 feet higher up the valley. These are merely specialized examples of effect, upon the rush of water up on shore, of a topography above sea level which served to concentrate the inrushing water.

Merging of waves from different directions.—Wave crests traveling by different routes may arrive at a given locality simultaneously, giving rise to a wave of greater size than either. Likewise, the simultaneous arrival by different routes of a wave crest and a wave trough may effectually cancel out both. Thus, variations in the size and intensity of waves, particularly on the sides of the islands away from the wave origin, may result from the arrival, either in or out of phase, of two wave trains. During the tsunami of 1946 several examples of the formation of a large wave by the juncture of two smaller ones were observed. Thus, in the Keaukaha area east of Hilo, witnesses described the arrival of a wave from the north simultaneously with one from the northeast, which built up a very high crest at the place of juncture. At the head of Maunalua Bay, on the southeastern shore of Oahu, two waves were seen to advance up channels across the wide reef, move toward each other parallel with the shore, and meet, throwing water upward like the spray from a geyser. The water dashed up on shore to a height of only 3 feet except at the place of juncture, where it swept over the top of a sandspit 5 feet above sea level.

Progressively southward around the shores of Kauai, the average height of the high-water marks gradually decreases, and along much of the southern shore it is 6 to 12 feet above sea level. However, in a zone 3 or 4 miles wide it ranges from 15 to 18 feet. This zone is almost directly across the island from the direction of wave origin, and probably represents the area in which the waves refracted around opposite sides of the island met and reinforced each other.

DAMAGE BY THE TSUNAMI

Damage by the tsunami can be divided into structural damage, damage by erosion and deposition, and damage by flooding. The total property damage has been estimated by the office of the Governor, Territory of Hawaii, at about $25,000,000. Space permits only a brief review of the types of damage. The numbers of dwellings destroyed and damaged by the tsunami on the major islands are listed in Table 2 on page 36.

Structural damage includes damage to buildings, roads, railroads, bridges, piers, breakwaters, fishpond walls, and ships. Frame buildings at low altitudes along Hawaiian shores suffered extensive damage. Some were knocked over, by the force of the waves, by cutting away of the sand on which they stood, or by destruction of the foundations. Others were bodily washed away from their foundations. Some had walls pushed in by the force of the water, and in a few residences the water went on through the house and took out the opposite wall. As with earthquakes, there was a tendency to reduce the few two-story buildings to a single story, by destruction of the lower story. It is noteworthy that houses which were well built and tied together internally could be moved for considerable distances without suffering severe damage. Even more striking was the fact that houses elevated on stilts a foot to several feet above the ground survived the waves much more effectively than did those built directly on the ground. Apparently the water was able to pass under such houses without greatly disturbing them, unless it was deep enough actually to float

the house off the stilts. The few reinforced concrete structures in devastated areas suffered little or no damage except that caused by flooding.

The railroads along the northern coast of Oahu and in Hilo were wrecked, partly through destruction of the roadbed, but largely because the tracks were shifted off the roadbed, either inland or shoreward. Locally rails were torn loose, but more generally the track was moved en masse, a motion probably aided by the buoyancy of the ties. Coastal highways also were partly destroyed, largely by undercutting as the water returned seaward, but partly by the direct force of the waves. Several highway and railway bridges were destroyed. Most appear to have been partly or entirely lifted from their foundations by the rising of the water under them. The head of the pier at Waianae, Oahu, was damaged in the same manner. At the Wailuku River, in Hilo, an entire span of the steel railroad bridge was torn loose and carried 750 feet upstream, passing under but not damaging a highway bridge. At Kolekole Stream, 11 miles farther north, an entire leg of the high steel railroad trestle was removed and carried upstream about 500 feet.

Part of the end and much of the shed of Pier 1 in Hilo was wrecked by the force of the wave. Most of the damage on Pier 2, however, resulted when heavy pontoons, which had been moored near by, were washed across the pier. The wharves at Kahului on Maui were flooded, but sustained little structural damage.

The upper part of the breakwater at Hilo was about 61 per cent destroyed (Plate 1). Blocks of rock weighing more than 8 tons were lifted off the breakwater and dropped both inside and outside it. Destruction was limited, however, to the part above water or that only slightly submerged. The average depth of water over the destroyed sections after the wave was only about 3 feet. The breakwater at Kahului, Maui, also suffered minor damage. At both Hilo and Kahului the breakwaters appear to have reduced materially the height and violence of the waves in the enclosed portions of the harbors.

Many small boats were washed ashore and damaged. Railroad cars were overturned on Oahu, Maui, and Hawaii. Many automobiles were wrecked. The loose stone walls of fishponds along the southern coast of Molokai were partly thrown down. The mill of the Hakalau Sugar Company, situated only about 10 feet above sea level at the mouth of Hakalau Gulch on the island of Hawaii, suffered severe damage.

Erosion by the tsunami resulted in the partial removal of some sand beaches, in some places causing a retreat of the shore line for several tens of feet, cutting of small scarps, and forming of large beach cusps at the heads of beaches; locally, erosion caused stripping away of a small amount of soil. The erosion was largely concentrated high on the beach, several feet above sea level. Some of the sand from the beaches was carried inland and redeposited. At Haena, Kauai, the highway was buried under 4 feet of sand, and thinner layers of sand covered roads on Oahu.

Flooding caused much water damage to house furnishings and personal property.

LOSS OF LIFE AND PERSONAL INJURY

The following table summarizes, by islands, the number of persons killed, injured, or missing as a result of the tsunami. The figures were supplied by the American Red Cross. Most of the deaths were by drowning. By far the heaviest toll was at Hilo, with 83 known dead and 13 missing. Those listed as missing have been missing for more than 2 months, and must be presumed dead, bringing the total number of probable dead to 159. Great as it was, this loss of life was moderate compared to that in some other tsunamis, such as that of 1896 in the Sanriku

district in Japan, which took more than 27,000 lives (Byerly, 1942: 72).

TABLE 2

LIST OF CASUALTIES DURING THE TSUNAMI OF APRIL 1, 1946

ISLAND	KNOWN DEAD	MISSING	INJURED*	HOMES DEMOLISHED†	HOMES DAMAGED†
Hawaii	87	34	153	283	313
Maui	9	5	2	65	144
Oahu	9	0	0	67	335
Molokai	0	0	0	13	14
Kauai	10	5	8	60	130
Total	115	44	163	488	936
	159				

* Injury sufficiently serious to require hospitalization.
† Homes only; other buildings not included. Data from Lowers and Cooke, Ltd.

MITIGATION OF DISASTERS RESULTING FROM FUTURE TSUNAMIS

There is no Hawaiian shore which is exempt from tsunamis. The most likely sources of devastating tsunamis are the North Pacific and South America. The areas heavily hit by the 1946 tsunami are probably those most likely to be hit hard again by tsunamis from the North Pacific. Violent tsunamis from Central or South America might, however, cause much more damage than did the 1946 tsunami along eastern and southern coasts. There is also possibility of serious damage on western shores by a tsunami from Japan, particularly if the tsunami occurred during a heavy southwesterly storm. Tsunamis of local origin might do heavy damage on any shore.

It is obviously impractical to consider the removal of all dwellings from Hawaiian shores because of the danger from tsunamis. It might, however, be advisable to prevent or restrict building in certain areas of greatest danger, particularly in centers of heavy population, such as the waterfront at Hilo. Construction of suitable sea walls might also be advisable in places. Sea walls cannot, however, be built high and strong enough to hold the water back completely, and an open zone should be left back of the wall in which the water pouring over the wall can use up its energy in turbulence. Any construction permitted in such areas should be of a wave-resistant type, such as reinforced concrete. These wave-resistant buildings would have the added virtue of serving as a line of defense for frailer structures behind them. Frame structures in rural areas should be built up off the ground, and far enough back from the edge of the beach to reduce the danger of undercutting. They should also be properly reinforced and tied together.

It appears inevitable that future tsunamis will cause loss of property on Hawaiian shores, but loss of life from all except tsunamis of local origin could be largely or entirely avoided. A system of stations could be established around the shores of the Pacific and on mid-Pacific islands, which would observe either visually or instrumentally the arrival of large long waves of the period characterizing tsunamis. The arrival of these waves should be reported immediately to a central station, whose duty it would be to correlate the reports and issue warnings to places in the path of the waves. It should be possible in this way to give the people of the Hawaiian Islands enough warning of the approach of a tsunami to permit them to reach places of safety. The effectiveness of the warning, however, would depend on education of the public on the necessity for leaving areas of danger, and on the efficiency of the local organization in spreading the warning and evacuating the threatened areas. Eventually it should also be possible to state, at the same time, which areas are likely to suffer the most damage. Before that can be done, however, we need more knowledge of the behavior of tsunamis on Hawaiian shores, particularly tsunamis from sources in the eastern and western Pacific, and a more complete picture of the submarine topography around the Hawaiian Islands.

SUMMARY

The tsunami which reached the shores of the Hawaiian Islands on April 1, 1946, was the most destructive in the history of the islands. Generated by a sudden shifting of the sea bottom on the northern slope of the Aleutian trough, the waves traveled southward to Hawaii with an average speed of 490 miles an hour, an average wave length of about 122 miles, and a height over the deep ocean of about 2 feet. Effects on Hawaiian shores varied greatly. Locally the water dashed more than 50 feet above sea level and swept as much as half a mile inland. Elsewhere the rise in water level was very small, and waves were gentle. Property damage was heavy but loss of life was moderate.

The heights and intensities of the waves at different points were influenced by position on the island toward or away from the source of the waves, offshore submarine topography, presence or absence of coral reefs, shore-line configuration, mutual reinforcement or interference by waves traveling different paths, and the presence or absence of storm waves. Loss of property during future tsunamis can be reduced by proper construction, by erection of sea walls, and by restricting or prohibiting construction in certain especially dangerous areas. Loss of life can be nearly or entirely eliminated by the establishment of a suitable system for warning of the approach of waves.

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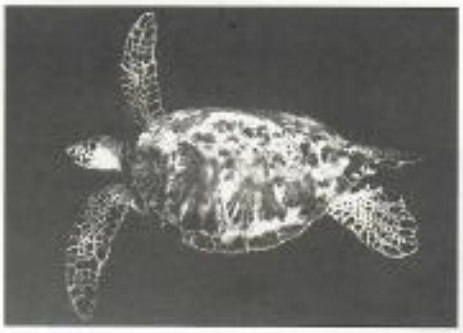
Turtle Tumors

by Niki Lauren



Left: Healthy green sea turtle. Photo by David Schrichte.

Below: Turtle suffering from GTFP. Photo by George Balazs.

The idyllic scene of Hawaiian green sea turtles effortlessly gliding through the sea as the sun reflects off their glistening, smooth skin is becoming rarer and rarer. Turtles with tumors are appearing everywhere, some heavily infested.

In the last few years, green sea turtles around Hawai'i and Florida have developed tumors, called fibropapilloma, in epidemic proportions. The cause is yet unknown, but it is the unanimous belief among scientists that this disease represents a significant threat to the green turtle's survival and will continue to affect turtle populations, both local and worldwide, according to the report, "Research Plan for Marine Turtle Papilloma—Results of a 1990 Workshop," edited by George H. Balazs and Samuel G. Pooley. Much of the report was based on papers submitted by workshop participants.

Green turtle fibropapilloma (GTFP) can develop on the skin (neck, flippers, or tail), eyes, mouth, and internal organs of turtles. Tumors range from a few millimeters to 30 cm in diameter. If lesions are near the mouth or eyes, turtles may have trouble eating, breathing, or seeing. Some turtles are blinded. GTFP can also affect swimming ability.

GTFP appears to increase turtles' susceptibility to parasitism by marine leeches. Observations in Hawai'i suggest that GTFP can cause emaciation, increased predation by tiger sharks and humans, reduced ability to migrate and breed, and increased entanglement in fishing gear. GTFP, then, is not simply a cosmetic problem but one which interferes with the species' survival. So far GTFP has been documented almost exclusively in green sea turtles, although there have been a few sightings of afflicted olive ridleys in the eastern Pacific and loggerheads in Florida.

Green sea turtles, *Chelonia mydas*, are listed as a threatened species in Hawai'i and are protected under the U.S. Endangered Species Act. Historically their populations have suffered serious decline due to over harvesting, habitat destruction, and incidental capture and mortality due to fisheries. The Hawaiian green sea turtle population is geographically isolated, and the number of reproductive females has been reduced to only 100-500 annually, according to George Balazs. Up to 12% of the nesting females tagged yearly at the breeding colony of the French Frigate Shoals have lesions, he continued. At Kane'ohe Bay the live capture by hand of 121 turtles since 1989 has shown GTFP rates ranging from 50-90%, according to the report.

Although GTFP has been reported in sea turtles since 1938 (Lucke 1938; Smith and Coates 1938), the earliest documented incidence of the disease in Hawai'i dates to 1958. The cause of the disease is still unknown. Participants (including scientists from across the country) at the 1990 workshop in Hawai'i on GTFP hypothesized the following causes: viruses, parasites, pollutants, environmental factors such as water temperature changes, food chain contaminants, transmissible tumors (nonviral) through sexual or other direct contacts, wound complications, weakened immune systems, genetics, or a combination of these factors.

According to the report, the most hopeful direction seems to point to identifying either a virus or a parasite in relation to the disease. Meanwhile, there are a number of immediate solutions which do not require the cause of the disease to be known first. Some of these include tumor removal (e.g. by surgery, cryogeny, or experimental dye infusion which is laser activated to produce tissue necrosis), removal of diseased turtles from the population, drugs to reduce collagen levels in the reptiles (since the larger tumors consist mainly of collagen), immunization of turtles with tumor extract (similar to early attempts at immunizing humans against smallpox when the isolated virus was still unidentifiable), and improving the turtle's habitat.

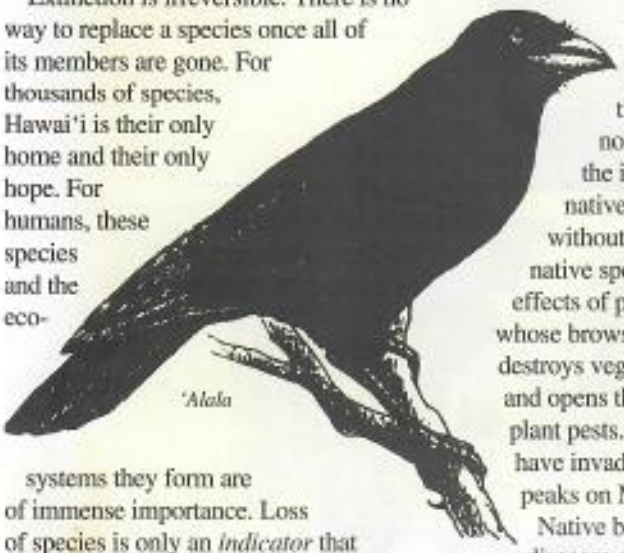
Unfortunately, there are many constraints to finding the cause for GTFP. Inadequate funding and lack of time commitment due to other priorities of researchers are some problems. Also needed are a coordinated research plan to deal with this highly mobile population, research materials (green turtles and their tissues), data on the life cycle of green turtles, a controlled facility for experimental studies, and a public awareness of GTFP.

There are important reasons, however, for finding the cause of GTFP. First, there is the welfare and survival of this rare and threatened species. Second, diseased turtles, their stranded carcasses, or factors causing the disease may be possible threats to humans. And finally, there is the question of aesthetics and negative impacts to marine recreation and tourism.

Crisis: A Call to Action

(continued from page one)

Extinction is irreversible. There is no way to replace a species once all of its members are gone. For thousands of species, Hawai'i is their only home and their only hope. For humans, these species and the eco-



'Alala

systems they form are of immense importance. Loss of species is only an *indicator* that something very serious is happening to our islands and our world environment. When species disappear, ecosystems deteriorate and human life suffers. With the loss of each individual species, the ecosystem deteriorates incrementally. We seldom know at which point this deterioration will mean the collapse of the entire ecosystem. We do know, however, that our day-to-day survival depends on the maintenance of a healthy, natural environment.

We rely on forest watershed areas for almost all of our fresh water. The forest intercepts rainfall, allowing water to slowly percolate into groundwater aquifers and streams. The constant recharge of our potable water supplies homes, businesses, and agriculture—services of the forest to Hawai'i's economy. Native forests protect fragile soils from erosion and, in turn, prevent siltation of reefs offshore. The health of our ocean fisheries is directly linked to the health of our forests.

We rely on native organisms for approximately 75% of all the modern medicines and pharmaceutical products we use. Valuable medical breakthroughs continue to be made. For example, scientists recently discovered a powerful anti-tumor compound in a soft coral, the *limu make o Hana*, found only in a few spots on Hawaiian reefs. The *limu make o Hana* has such promise that a research corporation was founded in Hawai'i to synthesize the new drug. Common plants and fungi contain thousands of chemical compounds which have the potential to become effective in treating disease. Yet fewer than 10% of Hawai'i's plants have been surveyed for their possible medicinal value.

The main threat to Hawai'i's surviving native species and natural communities is the destructive effect of non-native species introduced to the islands by people. Hawai'i's native species evolved on islands without large mammals. Hence, many native species cannot withstand the effects of pigs, goats, cattle, and deer, whose browsing, rooting, and trampling destroys vegetation, accelerates erosion, and opens the way for other animal and plant pests. Today, these hoofed animals have invaded all but a few mountain peaks on Moloka'i, Maui, and Kaua'i.

Native birds have been hit hard by diseases carried to Hawai'i by non-native birds. Avian malaria and pox are transmitted to the native birds by mosquitoes, another introduced pest which has spread into the forest.

Some plants brought to Hawai'i by humans have exploded in an environment lacking the natural controls that kept them in check in their homeland. For example, banana poka, an attractive passion flower vine, is limited in its native South America by insects that feed on it. But in Hawai'i, banana poka has already smothered over 70,000 acres of native forest on two islands and threatens to destroy even larger areas unless effective controls are found.

Species that pose even greater threats are poised to invade Hawai'i. For example, on Guam the brown tree snake has wiped out 9 of the 11 species of native forest birds since 1975. This snake has stowed away on flights from Guam to Hawai'i. It has been found here by inspectors on six occasions. But how many times has it not been intercepted? If it establishes itself here, the outlook for protecting Hawai'i's native birds will worsen dramatically.

The brown tree snake is a frightening symbol of a disturbing trend: each year Hawai'i is invaded by at least 12 new, non-native species. As many as 35 new, non-native species have been known to invade Hawai'i in a single year. Among these are species destructive to forests, agriculture, and human health. Without strong, effective inspection and enforcement programs, there will be more destructive and costly invasions.

Nukupu'u

The voyaging canoes of the Polynesians brought the first humans to Hawai'i 1,500 years ago. With humans came the need to clear land for food and housing, and the introduction of new plant and animal species. Unfortunately, some of these new species—such as pigs, dogs, and rats—preyed on native birds, plants, and insects. Others competed with native species for habitat. For cultural purposes, the feathers of thousands of forest birds were used to create ceremonial capes.

Damaging introductions accelerated greatly with the arrival of Europeans in the late 1700s. They introduced many more non-native species, including cattle, goats, European boars, and mosquitoes. They felled much of the forests for agriculture, grazing, and fuel for sugar mills. Just as European and Asian diseases decimated the native Hawaiian people, so did increased forest clearing. Introduced pest species continue to take a heavy toll on native Hawaiian plants and wildlife.

Today, land conversion to agriculture, ranching, and residential uses has permanently displaced native vegetation on over half of the Hawaiian landscape. Coastal and lowland areas have been particularly affected. Wildfires often destroy rare dryland native plants. Flammable non-native weeds take over these burned areas, creating a vicious cycle of destruction. Modern fishing techniques threaten marine and seabird life. Increased development, tourism, and a growing population continue to impact Hawai'i's natural resource base.

While Hawai'i's early inhabitants relied heavily on Hawai'i's natural resources for their survival, our survival today depends on saving what is left of our native ecosystems. We need to strike the proper balance between the needs of an island economy and growing population and the preservation of Hawai'i's limited natural resources.

The challenge of saving Hawai'i's remarkable natural heritage has spurred state and federal agencies, private organizations, and individuals to work together.

To protect essential habitat for native species, more than one million acres of land are now included in a network of state, federal, and private natural areas. Together, these areas include examples of nearly 75%

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Summary of Green Turtle Surveys Conducted at French Frigate Shoals April - August 1983

Introduction

Over 90 percent of the reproductive activity of the Hawaiian green turtle (Chelonia mydas) takes place at French Frigate Shoals (Balazs 1980), a coral atoll located in the Northwestern Hawaiian Islands and administered by the U.S. Fish and Wildlife Service as part of the Hawaiian Islands National Wildlife Refuge. Although French Frigate Shoals is utilized by green turtles year-round as a resident foraging area, the annual breeding assemblage is primarily composed of adults which have made long-distance migrations to the breeding atoll from other areas of the Hawaiian Archepelago (Balazs 1976). The influx of turtles occurs mid-April through early June, and most courtship and copulation takes place at this time. Nesting commences mid-May, peaks in June, then drops to lower levels in late July. By the end of August most of the migratory breeding assemblage has departed (Balazs 1980).

Surveys of basking Chelonia were conducted over the period 13 April through 3 August to monitor the relative abundance and reproductive activities of the atoll's breeding assemblage from the onset through most of the 1983 breeding season.

Study Area

The crescent-shaped, 26 km atoll contains 10 small sand islands, two of which have been significantly altered by man. Tern Island, modified to serve as an airstrip in 1942, has been continuously

occupied since that time and is presently maintained as a research station by the U.S. Fish and Wildlife Service. East Island was occupied by Coast Guard personnel from 1944 to 1952, and although efforts have been made to remove man-made rubble from the island, buried debris is still present and potentially hazardous and/or an impediment to nesting turtles.

During the period of this study, the north-northwestern unvegetated area of Trig Island remained separated by water from the higher, vegetated section of the island. For a complete description of French Frigate Shoals see Amerson (1971).

Although turtles bask on all of the islands within the atoll, the resident aggregation most heavily utilizes the northeastern and northern shores of Whale-Skate and Trig Islands, respectively. The incidence of basking on East Island tends to coincide with the breeding season and the arrival of the migratory breeding assemblage (Balazs 1980). Approximately 55 percent of the atoll's nesting females in a given breeding season nest on East Island, 35 percent on Whale-Skate Island, and the remainder on Trig, Tern, Gin and Little Gin Islands (Balazs 1980).

Methods

Turtle surveys were made in conjunction with the Hawaiian monk seal (Monachus schauinslandi) and green turtle research conducted at French Frigate Shoals 12 April through 3 August 1983 by the Marine Mammals and Endangered Species Program of the National Marine Fisheries Service. In addition, monk seal and green turtle censusing was performed every four days on Tern Island and approximately every 36 days on an atoll-wide basis by U.S. Fish and Wildlife personnel.

The sources of all data incorporated herein are presented in Tables I through VI.

Between 13 April and 3 August turtle surveys of Tern, Trig, Whale-Skate and East Islands were conducted on a regular basis. Occasional overnight visits to Whale-Skate and East Islands often made it possible to census turtles on successive days. During the month of June Whale-Skate and East Islands were surveyed almost daily in conjunction with the monitoring of Chelonia nesting activity. Surveys of Round and Mullet Islands, and occasionally surveys of Trig Island, were made from the water through binoculars; Gin, Little Gin, Disappearing and Shark Islands were visited infrequently.

Surveys were usually conducted after 1400 hours, when basking numbers of turtles is the highest (Balazs, pers. comm., and see for example Table IV, 5-6). The perimeter of an island was carefully walked and observations of turtles made through binoculars. When possible to ascertain, the age class and sex of basking turtles were recorded. Physical abnormalities, nearshore and copulatory activities, and nesting excavations were noted. Care was taken to insure that turtles and monk seals utilizing the beach remained unaware of the presence of an observer.

Age class was determined on the basis of straight carapace length: adult, length greater than 81 cm; subadult, length between 65 and 81 cm; juveniles, length less than 65 cm. Sexual dimorphism is externally apparent only in turtles 65 cm or greater in length (Balazs 1980).

When conditions allowed for minimum disturbance, a basking turtle would be approached and checked for tags. If no tags were present, size 681 Iconel 625 alloy tags were applied at a proximal

location on the trailing edge of a front flipper. Tags already present were read and additional tags applied when possible. Subadult turtles were measured in conjunction with tagging (straight carapace length and width).

As part of the concurrent monitoring of Chelonia nesting activity on Whale-Skate and East Islands during June, identification numbers were spray-painted on the carapaces of nesting females to provide short-term recognition of those turtles from a distance. The paint remained readable approximately ten days and was still in evidence for up to two weeks later.

Results

1. Tags applied. See Table I. Tags were applied to 22 adult (4 male, 18 female) and six subadult (4 female, 2 sex unknown) previously untagged turtles. An additional tag was applied to one previously tagged subadult male.

2. Tags recovered from basking turtles. See Table II. Tag numbers were recovered from twenty adult (11 male, 9 female) and three subadult (1 male, 1 female, 1 sex unknown) basking turtles. Seven adults (5 male, 2 female) and one subadult (sex unknown) were resighted more than once during the study period.

3. Size of subadults. See Tables I and II.

Sex	Tag # (R/L)	Length (cm)	Width (cm)
U	6363 (R)	69.8	51.9
F	6364 (R)	78.2	58.5
M	3038 (R)*	76.8	-
F	6666 (R)	76.4	57.0
F	6665 (L)	80.0	-
U	6669 (L)	70.5	-
U	3136 (R)*	49.2	39.1

*tag recovery

4. Age class of basking turtles. Atoll-wide during this study,

1.1 percent (7/633) of the turtles observed basking during surveys were subadults. No juveniles were observed basking.

Island	percent subadults observed surveys post 1400 hours	
Tern	12.5	(2/16)
Whale-Skate	1.2	(3/251)
East	0.0	(1/318)
Trig	0.3	(1/44)
Other (Gin, L. Gin, Disappearing, Shark)	0.0	(0/4)

Sheekey (1982) reports that from 15 April to 5 June 1981 21 percent (14/68) of the turtles observed basking on Tern Island were subadults.

5. Censuses of basking adults. 81 percent (143/176) of the turtle surveys were conducted post 1400 hours. The results of the surveys conducted post 1400 hours are summarized below.

Island	percent of the total number of surveys conducted post 1400 hours at French Frigate Shoals	
Tern	35.7	(51/143)
Whale-Skate	30.1	(43/143)
East	25.9	(37/143)
Trig	6.3	(9/143)
Other (Gin, L. Gin, Disappearing, Shark)	2.1	(3/143)

A. Tern Island. See Table III, Figures 1 and 3. 51 surveys were conducted 13 April through 31 July. No turtles were observed on 36 surveys (70.6%). One turtle was observed on 14 occasions (27.5%) and only on one occasion (2.0%) were two turtles observed. Basking turtles were more frequently seen during late April.

B. Whale-Skate Island. See Table IV, Figures 2 and 3. 43 surveys were conducted 15 April through 2 August. The overall average number of basking turtles was 5.8 (7.7 for the month of June); highest counts were observed 7 and 18 June (18 turtles). Numbers of

basking turtles fluctuated greatly over the duration of the study period.

C. East Island. See Table V, Figures 2 and 3. 37 surveys were conducted 7 May through 3 August. The overall average number of basking turtles was 8.6 (8.5 for the month of June); highest count was observed 3 June (20 turtles). Numbers of basking turtles were greatest during late May and early June.

D. Trig Island. See Table VI, Figures 1 and 2. Nine surveys were conducted 16 April through 3 August. The overall average number of basking turtles was 4.8; highest count was observed at 1250-1400 hours 5 May (11 turtles).

E. Gin, Little Gin, Disappearing and Shark Islands. Two surveys were conducted on each island during late April and the first half of May. At those times low numbers of turtles were observed. Census data is presented in Table VI.

F. Round, Mullet and Bare Islands. These islands were surveyed periodically from the water 14 April through 25 July. No turtles were ever observed basking on these islands.

6. Nearshore censusing off Whale-Skate Island. See Table IV, Figure 4. In conjunction with surveys of basking turtles on Whale-Skate Island, an attempt was made every survey to count numbers of turtles utilizing nearshore waters to approximately 50 meters offshore, although visibility was sometimes limited and the movements of swimming turtles difficult to track. Numbers of turtles in the water were greatest during May and early June, then gradually declined as the breeding season progressed.

7. Copulations observed.

Island	Dates copulations observed
Tern	None
Whale-Skate	5-2, 3, 5, 6, 7, 23
East	5-7, 26
Trig	5-5
Other (Gin, L. Gin, Disappearing, Shark)	None

8. Onset of Nesting activity.

Island	Date of first activity
Tern	5-16
Whale-Skate	5-18 - 5-21*
East	5-4 - 5-6 *
Trig	4-28 - 5-4 *
Other (Gin, L. Gin, Disappearing, Shark)	Unknown

*first nesting activity occurred sometime between these dates

9. Sex ratios. Atoll-wide in surveys post 1400 hours, approximately 71 percent of the adult turtles observed were sexed.

Island	percent turtles sex known surveys post 1400 hours	
Tern	78.6	(11/14)
Whale-Skate	71.8	(178/248)
East	69.7	(221/317)
Trig	76.7	(33/43)
All islands (including Gin, L. Gin, Disappearing, Shark)	70.9	(443/625)

The overall sex ratios presented below must be seen in light of the following considerations:

A. The daily exchange rate of individuals is unknown;

B. Males and females may not bask with the same frequency;

C. During this study period females became more visible as the breeding season progressed due to carapace marking with paint;

D. Sex ratios may change during the course of the breeding season -- males of the migratory breeding assemblage may arrive at the atoll prior to the arrival of breeding females and may depart prior

prior to the departure of breeding females (Balazs 1980).

Island	percent male	percent female	percent sex unknown
Tern	57 (8/14)	21 (3/14)	21 (3/14)
Whale-Skate	44 (109/248)	28 (69/248)	28 (70/248)
East	17 (54/317)	53 (167/317)	30 (96/317)
Trig	42 (18/43)	35 (15/43)	23 (10/43)
sex ratios observed during the month of June:			
Whale-Skate	38 (47/123)	35 (43/123)	27 (33/123)
East	14 (24/177)	48 (85/177)	38 (68/177)

Balazs (1980) reports a sex ratio of 34 percent male (range 23-50%) and 66 percent female (range 50-81%) based upon counts of basking turtles ashore at one time during June on East Island over a number of years. From 15 April to 5 June 1981 Sheekey (1982) observed a sex ratio on Tern Island of 48 percent male (15/31), 52 percent female (16/31).

Conclusion

The dates on which reproductive activities marking the onset of the 1983 breeding season were observed are in accord with the observations of Balazs (1980) and Sheekey (1982).

Numbers of basking turtles and the level of nesting activity on Tern Island were lower than observed by Sheekey (1982) in 1981 during the same time period. Compared with previous years, the 1983 breeding season probably represents a year of low reproductive activity (Balazs, pers. comm.).

Acknowledgments

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Abbreviations

WS Whale-Skate Island

L GIN Little Gin Island

FB Observations made from boat offshore island

B Basking on shore

N Nesting

DN David Nelson
GB George Balazs
GF Gale Fairezel
GP Gail Peiterson
JH John Henderson

TABLE I

1983 French Frigate Shoals

GREEN TURTLES TAGGED

Date	Location	Status	Sex	Age Class	Tag R	Tag L	straight carapace meas. (cm) length	width	
4-28	TRIG	B	U	SA	6363	6362	69.8	51.9	
5-3	WS	B	F	SA	6364		78.2	58.5	
5-7	WS	B	M	SA	(3038)*	6365	78.6		
6-3	WS	N	F	A	6359				
6-3	WS	N	F	A	6367	6654	86.5	67.2	L tag appli 6-7
6-4	WS	N	F	A		6368	98.8	72.7	
6-4	WS	N	F	A		6370			
6-4	WS	N	F	A	6372	6371	88.2	67.0	
6-4	WS	N	F	A	6374	6373	97.3	74.0	
6-6	WS	N	F	A	6671/6672	6375	88.1	70.6	R tags applied 8-2
6-6	WS	N	F	A	6667	6651	90.9	71.6	R tag applied 7-6
6-7	WS	B	M	A		6652			
6-7	WS	B	M	A		6653			
6-8	WS	B	F	SA	6666	6655	76.4	57.0	R tag applied 7-3
6-10	WS	N	F	A		6656			
6-12	WS	B	M	A		6658			
6-12	WS	N	F	A		6657	89.2	72.8	
6-13	WS	N	F	A		6659	90.0	70.2	
6-15	WS	N	F	A	6661	6660	92.4		
6-17	WS	B	M	A		6662			
6-19	WS	N	F	A		6663	94.7	75.0	
6-26	TRIG	B	F	SA		6665	80.0		
7-9	EAST	N	F	A	7204	(7203)	93.7	73.8	
7-17	WS	B	U	SA		6669	70.5		
7-20	TERN	B	F	SA	6670				
7-26	EAST	N	F	A	7205	7206	94.0		
7-26	EAST	N	F	A	7207	7208			
8-3	EAST	N	F	A	6674	6673	86.7	71.5	
8-3	EAST	N	F	A		(6675)			
(new 9778)									

REC. 6/12/86 EAST-N

REC. 6/24/86 EAST-N

TABLE II 1983 French Frigate Shoals

GREEN TURTLE TAG RECOVERIES
BASKING TURTLES

Date	Location	Sex	Age class	Tag R	Tag L	st carapace meas (cm) length	width		Observer
4-19	WS	F	A		2825				JH
4-24	TERN	M	A	6361		also recovered		on 5-8	SHARK JH
								6-16	TERN GP
5-3	WS	M	A		5171	also recovered		on 5-12	WS
								6-18	WS
5-4	EAST	U	SA	3136	3135	49.2	39.2		
	also recovered on 5-31 EAST					49.2	39.0		
5-7	WS	M	SA	3038	(6365)*	76.8			
5-13	L GIN	M	A	3024	stub L foreflipper				
6-7	WS	M/F	A	5417		also recovered		6-17 WS	
6-12	WS	M	A	5236	5237	also recovered		6-15 WS	
6-15	WS	M	A		6658	tagged 6-12-83			
						also recovered		7-6 WS,	7-17 WS
6-18	WS	F	A	5986	679				
6-19	WS	M	A	2400					
6-20	WS	F	A		3755				
7-2	WS	M	A		960	#49-size tag			
7-3	WS	F	SA	(6666)*	6655	76.4	57.0	tagged	6-7-83
7-6	WS	F	A	(6667)*	6651	tagged 6-6-83;		nested	'83 season
						also recovered		7-21 WS	
7-7	TRIG	M	A	3066					RW
7-15	EAST	F	A		3846	nested '83 season			
7-15	EAST	F	A		7164	tagged '83; nested '83			season
						also recovered		8-3 EAST	
7-22	TRIG	M	A		5400				
7-25	EAST	F	A	3628		nested '83 season			
7-25	EAST	F	A		3228				
7-28	TRIG	F	A		5397				
7-28	TRIG	M	A		3277				

*( ) tag applied

TABLE III

1983 French Frigate Shoals

TERN ISLAND
GREEN TURTLE BASKING CENSUSES

Date	Time		Male		Female		Sex Unknown	Total	Observer
4-13	1415	1653	0		0		0	0	GF
4-17	1415	1630	0		0		0	0	GF
4-18	1400	1535	-		-		1	1	JH
4-20	1415	1546	1		0		0	1	JH
4-21	1430	1550	0		0		0	0	GF
4-22	1420		0		1		0	1	
4-24	1506	1658	1		0		0	1	JH
4-25	1430	1615	1		0		0	1	
4-27	1550	1645	0		0		0	0	
4-29	1430	1510	1		0		0	1	
4-30	1400	1620	0		0		0	0	
5-1	1545		0		0		0	0	
5-3	1430	1545	1	SA	0		0	1	GF
5-7	1415		0		0		0	0	GF
5-8	1400		0		0		0	0	
5-11	1430	1600	0		0		0	0	GF
5-13	1430		0		0		0	0	GF
5-15	1430	1530	0		0		0	0	
5-16	1530		-		-		1	1	JH
5-17	1515		0		0		0	0	
5-19	1407	1545	1		0		0	1	
5-21	1437	1530	0		0		0	0	
5-23	1430	1545	0		0		0	0	GF
5-24	1425	1435	0		0		0	0	
5-25	1430		-		-		1	1	
5-27	1400	1530	0		0		0	0	GF
5-29	1335		0		0		0	0 *	
5-30	1455		0		0		0	0	
5-31	1430		0		0		0	0	GF
6-3	1445	1515	0		0		0	0	
6-4	1430	1530	0		0		0	0	GF
6-8	1430	1600	0		0		0	0	GF
6-9	1330	1500	0		0		0	0	GF
6-12	1430	1515	0		0		0	0	GF
6-13	1800		0		0		0	0	
6-16	1430	1530	2		0		0	2	GF
6-20	1430	1600	0		0		0	0	GF
6-24	1400	1515	0		0		0	0	GF
6-28	1500	1615	0		0		0	0	GF
7-2	1400	1500	0		0		0	0	GF
7-5	1455		0		1		0	1	
7-6	1430	1530	0		1	SA	0	1	GF
7-10	1415	1515	0		0		0	0	GF
7-14	1415	1515	0		0		0	0	GF

*census conducted pre-1400 hrs.

TERN ISLAND
GREEN TURTLE BASKING CENSUSES

Date	Time		Male		Female		Sex Unknown	Total	Observer
7-18	1430	1530	1		0		0	1	GF
7-20	1500		0		1		0	1	
7-22	1430	1530	0		0		0	0	GF
7-23	1630		0		0		0	0	
7-26	1430	1530	0		0		0	0	GF
7-29	1600		0		0		0	0	
7-30	1600		0		0		0	0	
7-31	1700		0		0		0	0	

TABLE IV

1983 French Frigate Shoals

WHALE-SKATE ISLAND
GREEN TURTLE BASKING CENSUSES

Date	Time		sex of basking turtles: Male	Female	Unknown	Number Basking	Number in Water	Total	Observer
4-15	1400	1506	-	-	4	4	1	5	JH
4-19	1348	1448	-	1	6	7	6	13	JH
4-26	1515	1600	4	2	5	11	7	18	
5-3	1430		2	-	1 SA	3	21	24	
5-4	1525	1600	5	0	0	5	4	9	
5-5	1545	1630	8	0	0	8	5	13	
5-6	0935	1035	1	1	0	2	1	3 *	
	1215	1255	5	-	1	6	5	11 *	
	1535	1635	9	1	3	13	4	17	
5-7	1630	1730	4	0	0	4	7	11	
5-10	1715	1803	3	2	0	5	8	13	
5-11	1600	1627	3	-	3	6	9	15	
5-12	1330	1428	3	-	1	4	12	16	
5-13	1130	1230	1	-	1	2	-	2 *	GF
5-14	1455	1612	2	1	1	4	12	16	
5-15	1344	1425	0	0	0	0	10	10	
5-18	1521	1600	0	0	0	0	3	3	
5-22	1420	1530	5	1	4	10	8	18	
5-23	1650	1750	4	4	3	11	7	18	
5-24	0750	0830	1	0	0	1	3	4 *	
	1120	1150	4	2	3	9	3	12 *	
5-28	1000	1200	-	2	1	3	-	3 *	
	1355	1455	-	-	3	3	1	4	
5-31	1725	1840	3	1	2	6	9	15	
6-1	1400	1505	2	1	0	3	8	11	
6-4	1510	1610	-	-	1	1	8	9	
6-5	1500	1630	3	-	1	4	11	15	
6-6	0835	1021	-	1	1	2	0	2 *	
	1513	1632	2	3	4	9	4	13	
6-7	1510	1700	7	5	6	18	2	20	
6-9	1510	1707	5	1	2	8	8	16	
6-10	1410	1515	-	1	2	3	4	7	
6-11	1503	1632	3	1	2	6	7	13	
6-13	1503	1610	3	1	4	8	7	15	
6-15	1510	1710	2	1	0	3	6	9	
6-16	1507	1700	3	2	0	5	6	11	
6-17	1500	1640	4	3	2	9	6	15	
6-18	1635		7	7	4	18	2	20	
6-19	1130		3	8	0	11	-	11 *	
	1513	1710	4	5	2	11	0	11	
6-20	1508	1750	2	10	0	12	1	13	
6-25	1500	1630	-	2	3	5	3	8	
7-2	1400		-	-	2	2	6	8	
	1458	1559	1	-	1	2	5	7	RW

*census conducted pre-1400 hrs.

WHALE-SKATE ISLAND
GREEN TURTLE BASKING CENSUSES

Date	Time		sex of basking turtles			Number Basking	Number in Water	Total	Observer
			Male	Female	sex Unknown				
7-3	1142	1303	-	1	3	4	2	6 *	
7-6	1300		1	-	1	2	3	5 *	
	1635	1725	3	4	0	7	1	8	
7-7	1240	1338	-	-	4	4	-	4 *	JH
	1625		-	1	1	2	0	2	
7-17	1515	1530	-	-	1A/1SA	2	7	9	
	1700		1	3	2SA	6	-	6	
7-18	1320		2	-	1SA	3	-	3 *	
7-21	1210		-	-	3	3	-	3 *	
	1610		1	1	0	2	5	7	
7-22	1100		0	0	0	0	-	0 *	
7-25	1100	1200	-	1	1A/2SA	4	-	4 *	GF
7-27	1700		1	2	0	3	1	4	
7-28	1308	1415	0	0	0	0	2	2	
8-1	1600		0	1	0	1	-	1	
8-2	1338	1425	1SA	1	0	2	1	3	
	1630		0	1	0	1	-	1	

*census conducted pre-1400 hrs.

TABLE V

1983 French Frigate Shoals

EAST ISLAND
GREEN TURTLE BASKING CENSUSES

Date	Time		Male		Female		Sex Unknown	Total	Observer
4-19	1005	1130	2		1		1	4 *	JH
4-26	1040	1400	1		1		0	2 *	
5-4	0935	1030	2		-		7	9 *	
5-7	1015	1110	0		3		0	3 *	
	1430	1500	3		5		2	10	
5-9	1530	1625	3		4		4	11	
5-10	1430	1455	4		6		1	11	
5-13	1435	1520	-		4		2	6	
5-14	1319		0		0		0	0 *	JH
5-18	1454	1515	1		4		2	7	JH
5-20	1402	1425	2		5		0	7	
5-23	1100	1200	2		3		4	9 *	
	1440	1530	7		6		2	15	
5-26	1115	1230	2		2		3	7 *	
	1540	1610	5		5		3	13	
	1600	1703	-		-		14	14	DN
5-27	1000		0		0		0	0 *	
	1220	1330	3		1		1	5 *	
5-31	1010		1		1		2	4 *	
	1355	1455	2		4		4	10	
	1500	1555	-		-		13	13	DN
6-2	1052	1220	-		-		4	4 *	
6-3	1200		-		-		3	3 *	GB
	1258	1430	1		1		6	8	GP
6-4	1930		7		4		2	13	GB
	1745	1945	-		-		20	20	GP
6-5	0730	0900	2		0		0	2 *	GP
	1427	1630	-		1		11	12	GP
6-6	1800		3		7		0	10	GB
6-7	1600		3		4		5	12	GB
6-8	1630	1723	-		-		11	11	GP
6-9	0847	1050	-		3		4	7 *	GP
	1730		2		2		7	11	GB
6-10	1730		1		8		1	10	GB
6-11	1400		1		2		5	8	GB
	1800		2		4		3	9	GB
6-12	0940	1150	0		1		0	1 *	GP
	1745	1945	-		-		4	4	GP
6-13	1016	1215	0		1		0	1 *	GP
	1501	1550	-		-		3	3	GP
	1700		1		7		0	8	GB
6-14	1830		0		4		0	4	GB
6-15	1606	1850	-		2		6	8	GP
6-16	1630		-		-		2	2	GB

*census conducted pre-1400 hrs.

TABLE V, CONT. 1983 French Frigate Shoals

EAST ISLAND
GREEN TURTLE BASKING CENSUSES

Date	Time		Male		Female		Sex Unknown	Total	Observer
	1800		-		1		1	2	GP
6-17	1330		1		7		0	8 *	GB
	1720		-		5		3	8	GP
6-18	0907	0954	0		0		0	0 *	DN
	1700		1		7		0	8	GB
6-19	1500		2		7		0	9	GB
6-20	1535		0		4		0	4	GB
	1800		1		4		0	5	GB
6-21	0645	0800	0		0		0	0 *	DN
6-29	1335		-		6		1	7 *	
	1630	1745	-		9		1	10	
6-30	1610		0		8		0	8	
7-1	1800		0		5		0	5	
7-8	1400		2		5		2	9	
7-9	1450	1530	1		9		1	11	
7-15	1200		-		4		2	6 *	
	1615		-		5		1 SA	6	
7-16	1615		-		10		1	11	
7-25	1530		0		2		0	2	
7-26	1610		0		2		0	2	
7-27	1230		0		0		0	0 *	
8-3	1500		0		0		0	0	
	1700		0		1		0	1	

*census conducted pre-1400 hrs.

TABLE VI 1983 French Frigate Shoals

TRIG, GIN, LITTLE GIN, DISAPPEARING AND SHARK ISLANDS
GREEN TURTLE BASKING CENSUSES

Date	Time		Male		Female		Sex Unknown	Total	Observer
TRIG ISLAND									
4-16	1610	1640	1		1		3	5	JH
4-28	1145	1315	1		2		1A/1SA	5 *	
5-5	1250	1400	7		3		1	11 *	
5-13	1300	1330	3		2		0	5 *	GF
5-15	1220	1300	2		0		0	2 *	
FB	1550		5		4		0	9	
5-18FB	1640		3		2		2	7	
5-22FB	1000		-		-		6	6 *	
5-24FB	1200		1		1		3	5 *	
5-27	1500		3		3		1	7	
6-1 FB	1540		2		2		3	7	
6-6	1325	1348	-		-		5	5 *	DN
6-10	1400	1415	0		0		0	0	GF
6-18	1040	1059	-		-		1	1 *	GP
6-26	1227	1257	0		1		0	1 *	GP
7-3	1342		-		-		3	3 *	
7-7	1425		1		1		1	3	
7-18	1428		2		1		1SA	4	
7-21	1030		1		0		0	1 *	
7-22	1338		1		0		0	1 *	
7-28	1530		1		1		0	2	
8-1	1100		0		0		0	0 *	
8-3	1330		2		0		0	2 *	
GIN ISLAND									
4-23	1600		0		0		0	0	JH
5-13	1100		1		0		0	1 *	JH
LITTLE GIN ISLAND									
4-23	1600		-		-		3	3	JH
5-13	1100		2		-		1	3 *	JH
DISAPPEARING ISLAND									
4-23	1232	1454	0		0		0	0	JH
5-13	1114	1250	0		0		0	0 *	JH
SHARK ISLAND									
5-8	1200		1		0		0	1 *	JH
5-13	0948	1000	0		0		0	0 *	JH

*census conducted pre-1400 hrs.

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Summary of green turtle (Chelonia mydas) fieldwork conducted at French Frigate Shoals 8 through 30 June 1984

Note: This report does not include data from the work conducted concurrently at FFS by George Balazs.

Basking Counts

Date	Island	Time	Number Basking
6-8	Whale-Skate	1900	30
6-9	Whale-Skate	1415	24
6-10	Whale-Skate	1730	56
6-11	Whale-Skate	1445	46
6-13	Whale-Skate	1830	45
6-14	Whale-Skate	1800	37
6-15	Whale-Skate	1700	31 (27 female, 4 male)
6-18	Trig	1453	9
6-18	East	1730	32
6-19	East	1615	43
6-20	East	1430	49
6-21	East	1730	37
6-22	East	1730	28
6-24	East	1915	23
6-25	East	1700	24
6-26	East	1715	28
6-26	Little Gin	1318	0
6-26	Gin	1430	0
6-27	East	1700	33

For comparison, in 1983 basking counts taken at the same time of day 7 through 16 June (7 surveys) on Whale-Skate averaged 7 turtles per survey (range 3-18); on East over the period 16 through 20 June (5 surveys) the average number of basking turtles per survey was 6 (range 2-9).

Tags Applied - Basking Turtles

Forty-one adult (16 male, 25 female) and one juvenile (sex unknown) basking turtles were tagged.

Date	Sex	Tag Left	Tag Right	Island
6-9	F	7968	---	Whale-Skate
6-9	M	7969	---	Whale-Skate
6-10	F	7980	---	Whale-Skate
6-10	M	7982	---	Whale-Skate
6-11	F	7984	---	Whale-Skate

Tags Applied.- Nesting Females, cont.

Date 1984	Island	Tag Left	Tag Right	straight (s) or curved (c) carapace measurement (cm)
6-8	Whale-Skate	7951	7952	
6-8	Whale-Skate	7953	--	
6-8	Whale-Skate	7954	--	
6-8	Whale-Skate	7955	7956	
6-8	Whale-Skate	7957	--	
6-8	Whale-Skate	7958	--	
6-8	Whale-Skate	7959	--	
6-8	Whale-Skate	7960	--	
6-9	Whale-Skate	7966	----------	92.0 (c)
6-9	Whale-Skate	7967	--	
6-9	Whale-Skate	7965	----------	97.0 (c)
6-9	Whale-Skate	7963	--	
6-9	Whale-Skate	7961	--	
6-9	Whale-Skate	7964	--	
6-9	Whale-Skate	7972	--	
6-9	Whale-Skate	7973	--	
6-9	Whale-Skate	8104	--	
6-10	Whale-Skate	7974	----------	101.0 (c)
6-10	Whale-Skate	7975	----------	95.0 (c)
6-10	Whale-Skate	7976	--	
6-10	Whale-Skate	7983	--	
6-10	Whale-Skate	7977	----------	95.5 (c)
6-10	Whale-Skate	8101	8110	101.0 (c)
6-10	Whale-Skate	7979	--	105.5
6-10	Whale-Skate	7981	--	
6-11	Whale-Skate	7996	7997	
6-11	Whale-Skate	7989	8000 ----------	98.0 (c)
6-11	Whale-Skate		8103	
6-11	Whale-Skate	8127	-- ----------	98.0 (c)
6-11	Whale-Skate	8105	--	
6-11	Whale-Skate	8107	8106	
6-11	Whale-Skate	7998	--	
6-13	Whale-Skate	--	8108	
6-13	Whale-Skate	8134	--	
6-13	Whale-Skate	8126	--	
6-13	Whale-Skate	8113	----------	99.5 (c)
6-13	Whale-Skate	8109	--	
6-14	Whale-Skate	--	8123	
6-14	Whale-Skate	8124	--	
6-14	Whale-Skate	8125	--	
6-14	Whale-Skate	8128	8129	
6-15	Whale-Skate	8135	8136 ----------	90.5 (c)
6-15	Whale-Skate	8137	--	
6-15	Whale-Skate	8138	8139	
6-15	Whale-Skate	8140	--	
6-15	Whale-Skate	8142	--	
6-17	Tern	8144	--	
6-18	East	8151	--	
6-18	East	8153	--	
6-18	East	8156	8155	

Long-Term Tag Recoveries - Basking Turtles

Date 1984	Island	Sex	Tag Left	Tag Right	Date tagged-Location and Status
6-9	Whale-Skate	M		2750	6/17/78 Whale-Skate, FFS - Basking
6-10	Whale-Skate	M	5988		6/29/80 Trig. FFS - Basking
6-10	Whale-Skate	M		2625	6/12/78 Whale-Skate, FFS - Basking
6-10	Whale-Skate	M	3765	3234	6/26/79 Whale-Skate, FFS - Basking
6-10	Whale-Skate	M	3018		5/2/79 Whale-Skate, FFS - Basking
6-11	Whale-Skate	M	3044		5/4/79 Whale-Skate, FFS - Basking
6-11	Whale-Skate	F		2722	6/15/78 Whale-Skate, FFS - Basking
6-11	Whale-Skate	F		5150	5/30/81 Whale-Skate, FFS - Basking
6-11	Whale-Skate	F		6171	6/17/82 Whale-Skate, FFS - Basking
6-15	Whale-Skate	M	2704		6/15/78 Whale-Skate, FFS - Basking
6-20	East	M	6017		6/7/82 East, FFS - Basking
6-24	East	F	5440	5439	6/18/81 East, FFS - Nesting

Number of Adult Females Nesting

Date 1984	Total number ashore to nest	Number of new females first seen ashore to nest in 1984	Repeat nesters seen ashore from prev. nts.	Long-term tag recoveries
WHALE-SKATE				
6-8	12	12	0	1
6-9	19	13	6	2
6-10	13	8	5	0
6-11	23	10	13	2
6-13	15	8	7	1
6-14	15	8	7	2
6-15	17	10	7	0
		69		
EAST				
6-18	20	7	13	1
6-19	28	9	19	4
6-20	39	3	36	1
6-21	41	2	39	0
6-22	26	2	24	1
6-24	20	6	14	3
6-25	22	5	17	1
6-26	13	1	12	0
6-27	11	0	11	0

For comparison, in 1983 the average number of females ashore nesting on Whale-Skate 8 through 15 June (8 nights) was one (range 0-3) per evening.

Tags Applied - Nesting Females

Tags were applied to 46 adult females ashore nesting on Whale-Skate, to 21 females nesting on East, and to one female nesting on Tern.

Tags Applied, Basking Turtles, cont.

Date	Sex	Tag Left	Tag Right	Island	
6-11	M	7985	---	Whale-Skate	
6-11	F	7986	---	Whale-Skate	
6-11	F	7987	---	Whale-Skate	
6-11	M	7988	---	Whale-Skate	
6-11	F	7989	---	Whale-Skate	
6-11	F	7990	---	Whale-Skate	
6-11	F	7991	---	Whale-Skate	
6-11	M	7992	---	Whale-Skate	
6-11	F	7993	---	Whale-Skate	
6-11	F	7994	---	Whale-Skate	
6-13	F	8111	---	Whale-Skate	
6-13	M	8114	---	Whale-Skate	
6-14	F	8115	---	Whale-Skate	
6-14	M	8116	---	Whale-Skate	
6-14	F	8117	---	Whale-Skate	
6-14	F	8118	---	Whale-Skate	
6-14	F	8119	---	Whale-Skate	
6-14	F	8120	---	Whale-Skate	
6-14	M	8121	---	Whale-Skate	
6-14	F	---	8122	Whale-Skate	
6-15	F	8130	---	Whale-Skate	
6-15	F	8131	---	Whale-Skate	
6-15	F	8132	---	Whale-Skate	
6-15	M	8133	---	Whale-Skate	
6-15	F	8141	---	Whale-Skate	
6-16	F	8143	---	Whale-Skate	
6-18	F	8145	---	Trig	
6-18	M	8146	---	Trig	
6-18	F	8147	---	Trig	
6-18	M	8148	---	Trig	
6-18	F	8149	---	Trig	
6-20	M	8166	---	East	
6-21	M	8172	---	East	
6-21	M	8173	---	East	
6-22	M	8178	---	East	
6-28	?	8196	8197	Trig	straight carapace length: 62.2 cm.
6-30	M	8198	---	Tern	(This turtle was entangled in a net, which was tangled with a puerolator line. Turtle was cut free.)

Long-Term Tag Recoveries[1] -- Basking Turtles

Tag numbers were recovered from 12 (8 male, 4 female) adult basking turtles. Information on original tagging dates from Balazs (1983) and the revised edition of that publication (in press).

[1]does not include tags applied summer of 1984.

Tags Applied - Nesting Females, cont.

Date 1984	Island	Tag Left	Tag Right	straight (s) or curved (c) carapace measurement (cm)
6-19	East	--	8157	89.5 (s)
6-19	East	8158	--	88.2 (s)
6-19	East	8160	8161	88.2 (s)
6-19	East	8162	--	
6-19	East	8163	8171	
6-20	East	8167	8168	84.8 (s)
6-20	East	8169	--	
6-21	East	8174	8175	
6-21	East	8176	8177	
6-22	East	8179	--	
6-24	East	8182, 8180	8181	88.5 (s)
6-24	East	8183	8184	
6-24	East	8185	--	
6-25	East	--	8186	
6-25	East	--	8187	
6-25	East	8188	8189	91.3 (s)
6-25	East	8190	--	94.0 (s)
6-26	East	8191	8192	97.5 (s)

Long-Term Tag Recoveries[1] - Nesting Females

Tag numbers were recovered from 8 females nesting on Whale-Skate, and from 11 females nesting on East. Information on original tagging dates from Balazs (1983) and the revised edition of that publication (in press).

Date 1984	Island	Tag Left	Tag Right	carapace msmt (cm) st. or curved	Date tagged-Location and Status
6-8	Whale-Skate		5350		6/8/81 Whale-Skate, FFS - Basking
6-9	Whale-Skate	2818	7962*		6/20/78 Whale-Skate, FFS - Basking
6-9	Whale-Skate	5463	5464		8/18/81 Makapuu, Oahu (Kahala Hilton) released from captivity
6-11	Whale-Skate		5149		5/30/81 Whale-Skate, FFS - Basking
6-11	Whale-Skate		6171	101.5 (c)	6/17/82 Whale-Skate, FFS - Basking
6-13	Whale-Skate	3752	3752		6/9/80 Whale-Skate, FFS - Basking
6-14	Whale-Skate	5156	3187	104.5 (c)	5/3/79 East, FFS - Basking
6-14	Whale-Skate		5154	96.5 (c)	5/30/81 Whale-Skate, FFS - Basking
6-18	East	5099			6/16/81 East, FFS - Nesting
6-19	East		3601	95.5 (s)	6/29/80 East, FFS - Nesting
6-19	East	5189			5/31/81 East, FFS - Nesting
6-19	East	8164*	5428		6/14/81 East, FFS - Basking
6-19	East	8165*	5008	97.2 (s)	5/7/77 Punaluu, Hawaii - Offshore net capture and release
6-20	East		5145	95.2 (s)	6/25/77 East, FFS - Nesting
6-22	East	3595	6094	92.8 (s)	6/28/80 East, FFS - Nesting
6-24	East		5306	96.8 (s)	6/17/81 East, FFS - Nesting
6-24	East	5440			6/18/81 East, FFS - Nesting
6-24	East	2999	3002		4/27/79 Necker Island - Basking
6-25	East	3127	3128	95.2 (s)	6/17/79 East, FFS - Nesting

*Tag applied

[1]does not include tags applied summer of 1984.

Hatchlings

Green turtle hatchlings were observed on East Islands the evenings of 6-19, 20, 21, and 27. Since the mean incubation period is 64.5 days (range 54-88 days) (Balazs 1980), the egg clutches in the nests which erupted 6/19-21 must have been layed around mid-April. This represents an early commencement of nesting, which usually begins mid-May (Balazs 1980 and pers. comm.).

Summary

The number of turtles in the breeding assemblage at French Frigate Shoals this year was markedly greater than the number present in 1983. The breeding season also appears to have commenced earlier than in previous years.

References cited

Balazs, G.H.
1980. Synopsis of biological data on the green turtle in the Hawaiian Islands. NOAA Tech. Memo. NMFS, NOAA-TM-NMFS-SWFC-7, 141 p.

1983. Recovery records of adult green turtles observed or originally tagged at French Frigate Shoals, Northwestern Hawaiian Islands. NOAA Tech. Memo. NMFS, NOAA-TM-NMFS-SWFC-36, 42 p.

National
WILDLIFE.

Volume 23, Number 5 **August-September 1985**

Your Houseplants May Keep You Healthy

Bill Wolverton, a space scientist, is working on something that will help keep you healthy in your own home.

For years, most houses leaked enough air that indoor poisons were quickly dissipated. But these days, houses are sealed tighter, which means that indoor pollutants can accumulate in them. Some of those pollutants can make you sick.

Wolverton's story goes back to when scientists first identified more than 100 chemicals in the air inside Sky Lab. The chemicals, some of them irritating to people, were leaking from plastic objects, upholstery and other furnishings inside the spacecraft.

NASA officials knew that Wolverton had once saved them millions of dollars when he discovered that water hyacinths could purify polluted water. They approached him again, asking: "How do we get rid of these toxics?"

Wolverton began experimenting with houseplants, looking for one that would filter out air pollutants. He found that the spider plant is a real star. Indeed, it processes carbon monoxide, formaldehyde and other volatile chemicals at a surprising rate. One reason: it produces baby spider plants that feed out of the air. (See "Plants That Eat Pollution," page 10.)

John Strohm
EDITOR

ABOUT OUR COVERS

Front: In Washington's Olympic Mountains, Art Wolfe photographed a black-tailed buck in the morning sun. Wolfe used a Canon F-1 camera, a 300mm Canon lens and Kodachrome film. For more, turn to page 44.

Back: Frans Lanting found a green sea turtle swimming in a lagoon at French Frigate Shoals in the Northwestern Hawaiian Islands. He photographed it with a Nikon FE camera, a 24mm Nikkor lens and Kodachrome film.

30

by Michael C. Lipske, DEFENDERS Staff

By law federal officials must protect beasts, but

Sea Turtles Suffer As Bureaucrats Bicker

NO SEA TURTLES nest on the muddy banks of the Potomac. Yet in Washington, far from the sandy ocean beaches, the fate of this ancient race is being determined.

For three years, officials of two federal agencies have drafted reports, attended meetings, composed memos, solicited opinions, and bickered (mostly bickered) about how to protect three species of sea turtles. Long after several states have passed laws to guard the turtles, and scientists have declared the reptiles endangered, the bureaucrats continue to move with all the slow deliberation of, well, of turtles.

Three species of sea turtles, hawksbill, Atlantic ridley, and leatherback, have been on the U.S. Endangered Species list since 1970. But three others receive no official federal protection at all: the loggerhead (classified as vulnerable in the Red Data Book of the International Union for the Conservation of Nature and Natural Resources), the green, and the Pacific ridley (both considered endangered by the IUCN).

Commerce in any of the three species or their products has been banned, as of May 23, 1977, by the Convention on International Trade in Endangered Species of Wild Fauna and Flora. Delegates to the Convention—including representatives from the United States—voted last November to raise almost all species of sea turtles from Appendix II of the Treaty (which lists species that can be traded so long as the trade is monitored) to the more stringent Appendix I.

Each of the three species merits protection. The Pacific ridley's nesting congregations have been reduced by continued massive poaching off the Mexican coast, and by smuggling of hides. Only a few green sea turtles lumber ashore in Florida at the Cape Canaveral National Seashore/Merritt Island National Wildlife Refuge. Green turtles also breed at French Frigate Shoals, 480 miles northwest of Honolulu, in the Hawaiian Islands National Wildlife Refuge.

Hopes for saving the loggerhead in the Atlantic center on the coast of the Southeastern United States. Colonies along the South Carolina and Florida coasts are the largest in the world. Yet, the loggerheads face a wide range of threats. Commercial development snaps up nesting habitat. Highway lights disorient hatchlings at night, drawing them to death on the asphalt instead of life in the sea. Nighttime activity on beaches discourages turtles from coming on shore to lay eggs. Dune buggies compress nests, preventing baby

S.C. Wildlife & Marine Resources

The Perils of Caretta: Her duty done, a mother loggerhead *(Caretta caretta)* hauls slowly back to the sea, crossing a tire track in the sand, witness to man's heavy intrusion on ancient nesting beaches. Daylight reveals the "turtle crawl" from the night before (at left). One broad track leads to the turtle's nest, the other returns to the sea. Like living ping-pong balls, loggerhead eggs (below) are removed from a nest in South Carolina's Cape Romain National Wildlife Refuge. They will hatch safe from raccoons, which claim 95 percent of the eggs on some beaches. Hatchling (right) scrambles toward the sea. Baby turtles aim for the relative brightness of the ocean surface. At night, highway lights draw hundreds to destruction.

E.P. Haddon, FWS

Green turtle, by John C. Yrizarry

turtles from reaching the surface. Offshore, shrimp trawlers snare and drown the adults.

Add to these man-made problems the destruction caused by raccoons, opossums, feral hogs, and sand crabs (at some rookeries as much as 95 percent of a season's egg production has been consumed by predators) and the loggerheads' future looks bleak.

Federal officials are, of course, aware of the status of sea turtles. Environmentalists have warned them repeatedly that, without quick action, there may not be any sea turtles left to protect.

Two of the three species nearly achieved protected status a few years back. The Interior Department proposed the green and loggerhead for listing as endangered species (the only classification existing at the time) under the 1969 version of the Endangered Species Act. However, that came on the last day the 1969 act was in effect. The following day the Endangered Species Act of 1973 became law. In one stroke, jurisdiction over endangered and threatened wildlife was split between the Departments of Commerce and Interior, and the turtle listing went overboard.

A few months later the turtles got a second chance. F. Wayne King, a director of both the New York Zoological Society and the Caribbean Conservation Corporation, petitioned the Secretary of the Interior, in April, 1974, to list the green sea turtle as endangered, and the loggerhead and Pacific ridley as threatened.

King also petitioned Interior, in August 1974, to list the green sea turtle under the Endangered Species Act's similarity-of-appearance provision. The "look-alike law," this section of the act allows a species to be listed if it closely resembles a genuine endangered species. King claimed the look-alike listing for the green was necessary in order to protect the hawksbill.

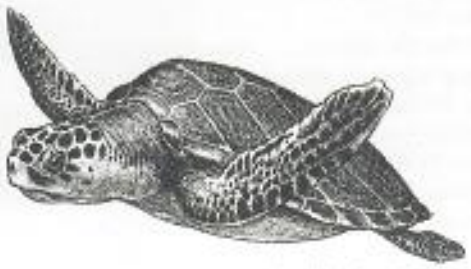
The same month a green turtle farming operation, Mariculture Ltd. (now Cayman Turtle Farm Ltd., of Grand Cayman Island) also petitioned the Secretary of Interior. But Mariculture asked that the green sea turtle be listed only as a threatened species, and that special exceptions for turtles bred and raised in captivity be provided in any ensuing regulations.

Ideally, the Secretaries of Interior and Commerce, and their attendant staffs, would have met shortly after, drawn up regulations, listed the turtles, declared critical habitat where necessary. Today the green, loggerhead, and Pacific ridley would bask under federal protection.

That was not to be. On May 20, 1975, Interior's Fish and Wildlife Service (FWS) and Commerce's National Marine Fisheries Service (NMFS) did publish a joint proposal to list all three turtles as threatened. The following day, the press office at Interior did publish a news release declaring "Sea Turtles To Be Added To Threatened List." But the turtles and their fate have been mired ever since in the federal bureaucracy.

No one from either agency will say just what the problem is. One ironic assessment came from outside government, from an attorney for the shrimp fishing industry, who said, "There seems to be this loggerhead between the two agencies."

As of last September, draft regulations to protect the sea turtles had been written, and approved by Keith Schreiner, associate director of FWS. Oddly, they gave over primary authority for the turtles to NMFS, not the sort of act one expects from Washington's usually turf-conscious bureaucrats.



Loggerhead, by John C. Yrizarry

Last fall, Schreiner's boss at Interior, Curtis Bohlen, acting Assistant Secretary for Fish and Wildlife and Parks, vetoed the draft proposal. Bohlen explained that although it may have seemed easier to have a single agency take charge of the turtles, he overturned the regulations because Interior had a mandate to remain involved with all threatened and endangered species.

David Wallace, Associate Administrator for Marine Resources at the National Oceanic and Atmospheric Administration, of which NMFS is part, is Bohlen's counterpart in turtle negotiations. Wallace says the snafu in listing, which he calls "intolerable," exists because the 1973 Endangered Species Act does not clearly distinguish which agency is responsible for the turtles. Hence, a compromise must be agreed upon. When DEFENDERS last spoke with Wallace, on May 23, he said he had high hopes of reaching that compromise soon.

In April, we had asked Curtis Bohlen, of Interior, to estimate when the three species of sea turtles might finally achieve protection. "I damned well hope we do it in April," said Bohlen.

In late May, after a memo of understanding between the two agencies had been deemed unacceptable by Bohlen, he was less optimistic. Bohlen said he rejected the memo because Interior "would have given up all say on the turtles except when they're firmly on land." Whether or not to list the turtles is not the issue, he says. The dispute is over who will protect turtles where. Commerce, said Bohlen, wants "total say over the turtles in the water."

"It may sound just like a turf problem, but it's more than the turtles. We clearly have a responsibility in the estuaries," he said. If Commerce's authority is extended "to the fast land" an unacceptable precedent will have been created, and Interior's protection of other estuarine creatures will be hampered. Bohlen also said he could not now predict whether the sea turtles would be listed in the summer of 1977.

FWS and NMFS officials refuse to say what the regulations they are working on call for in the way of turtle protection or, for that matter, what the vetoed Schreiner regulations called for. Fine points cannot be made public.

However, it is expected that the FWS will administer import and export of turtles and turtle products, and guard rookery beaches in national parks, seashores, and wildlife refuges. NMFS will be responsible for turtles at sea, including the issue of "incidental take" by shrimp trawlers. To its credit, Commerce is now trying to establish how many turtles do drown in the shrimpers' nets, and at the NMFS lab in Pascagoula, Mississippi, Commerce engineers are working to develop a turtle-proof trawl they hope to have ready for industry use by the end of 1979.

ALTHOUGH IT'S IMPOSSIBLE to judge how Commerce and Interior intend to protect the turtles, one aspect of the regulations has come under scrutiny. A provision in the vetoed Schreiner regulations, expected to carry over into any new Commerce–Interior agreement, provides a glimpse into government thinking. A two-year grace period is provided in which turtle farmers could continue exporting their products to the United

Photos by Rhett Talbert

Victims of the shrimpers' nets, young loggerheads (above) wash up on South Carolina beaches. Sharks mutilated the carcass on left. While green, loggerhead, and Pacific ridley sea turtles (opposite page and below) await meaningful federal protection, wildlife officials in Washington bicker over regulations.

States. Turtle farming, at this stage, usually means taking eggs from the wild and hatching the babies. The proposed exception allows mariculturists two years to establish self-sustaining, closed-cycle farms that deal in a turtle population bred entirely in captivity.

According to F. Wayne King (who submitted the original petition to list the turtles way back in 1974) the exception arose out of the petition from Mariculture Ltd. Although virtually bankrupt in 1975, the firm had in captivity 75,000 to 100,000 green sea turtles, according to an environmental impact statement prepared by the Commerce Department. (The year before, Interior had estimated the wild green sea turtle population in the Caribbean at less than 10,000. Some 50 million greens once swam the Caribbean.)

In 1975, representatives of Mariculture were predicting self-sufficiency by 1979. This spring, Carleton Jones, a lawyer with the Washington firm that represents Cayman Turtle Farm Ltd. (successor to Mariculture), provided an updated prediction.

Apparently, the green turtles are not following the Cayman Turtle Farm timetable. Convincing them to breed in captivity has been difficult, said Jones, but the Cayman venture is now "partially self-sufficient" (Jones was not certain just how partially). By 1981, he said, Cayman Turtle Farm hopes it will no longer require eggs from the wild: "It would be a true farm, just like a cattle ranch, or a mink farm."

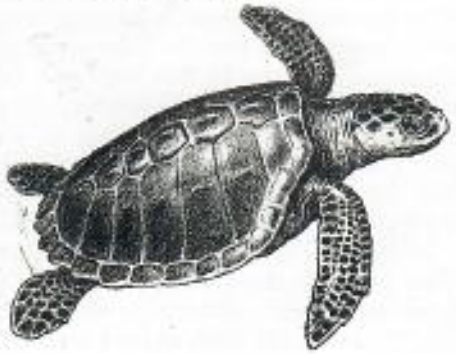
Interior's Curtis Bohlen was skeptical. "We share their objective. We just have considerable doubts that they can achieve it," he said. Nevertheless, the two-year grace period (with possible extensions) will likely remain a feature of any new protective regulations for turtles, said Bohlen.

Turtle farming actually drains wild populations. According to a statement prepared by the Environmental Defense Fund (EDF) in April 1976, Cayman Turtle Farm is expected to take up to 100,000 wild eggs over the next few years from Surinam, while pressure from trawlers increases off that nation's shores.

William Butler, EDF's Washington counsel, raised another question about the sea turtle regulations—the Commerce Department's record on the tuna-porpoise issue. Though in charge of enforcing the Marine Mammal Protection Act, Commerce made little effort to enforce the act against tuna fishermen until environmentalists sued.

Now, with sea turtles, Commerce faces a similar issue—how to keep shrimp fishermen from accidentally netting sea turtles. Though the agency is developing new trawl designs, would it be willing to declare sections of the coast off limits to shrimpers, as some environmentalists say it must if the turtles are to survive? "Commerce has been unduly sympathetic to the tuna industry. It's likely they'll be sympathetic to the shrimp industry. It's like asking the fox to guard the chickens," said Butler.

Pacific Ridley, by John C. Yrizarry



Statements from Commerce are not reassuring. Jack Gehringer, Deputy Director of NMFS, said he prefers the sea turtles be listed as threatened rather than endangered, because the latter classification would prohibit any incidental capture by shrimp trawlers: "This could create a serious problem for the fishing industry."

Not all the criticism of Commerce's handling of sea turtles has come from outside government. The agency's draft environmental impact statement was reviewed (a standard procedure) by the Environmental Protection Agency. In March 1976, EPA's Rebecca Hanmer, acting Director of the Office of Federal Activities, wrote to NMFS Director Robert Schoning. Hanmer pointed out that while the impact statement concluded that none of the three turtle species were in immediate danger of extinction, she felt the green sea turtle did warrant endangered status. The impact statement itself, she pointed out, "describes the green sea turtle population with such expressions as 'eliminated,' 'destroyed,' 'serious drop,' 'declined drastically,' 'heavily exploited,' and 'decreasing rapidly,' to cite a few."

EDF's William Butler and other environmentalists are losing patience with the government's slow and not-so-sure approach to sea turtle protection. "While this putzing around in Washington continues, the species are pushed ever closer to biological extinction. It's just preposterous that because bureaucrats can't get together the turtles go down the tube," said Butler.

IN BIRD LAND.

Part of the Journal of a Visit to Laysan Island.

By Prof. A. E. Lyons. From the Malle Wreath.

July 16th. Here we are at Laysan Island we have brought the schooner inside the reef under the lea of the island, and are lying in quiet water within two hundred yards of the shore. The only indication of land this morning at day break was the flocks of sea birds which we could see in every direction, although we were in reality only twenty miles from the island. The land lies so low that it can be seen from the deck of a vessel only a few miles.

We were sure that our schooner was watched for impatiently by the two men who were left in February to hold possession of the island. As we approached we could see that the men were still there, but they only stood near their little cabin watching us, without offering to come off and meet us, whence we concluded that their boat was lost or disabled. A rough looking pair indeed, we found them when we landed—a veritable Robinson Crusoe and his man Friday, only rather more decently clad. They were quite beside themselves, with excitement at the sight of new faces, and the opportunity to hear from the great world, from which they have so long been cut off.

We, on our part, were eager to stretch our limbs a little after six days of close confinement. There was nothing indeed, particularly inviting in the land itself. A beach of white shell sand, a steep bank, also of sand, with little vegetation,—beyond a strip of nearly level land scantily covered with coarse bunch grass and low shrubberry,—that was all we could see as we approached the shore. Not quite all, for there rests over the land perpetually a cloud of sea fowl, and these you can see at a glance hold undisputed possession of the island.

Along the beach stand in erect expectant attitude groups or lines of young gonies, full grown, but waiting for their wings to gain strength before they venture flight. Some are fanning the air with their wings, apparently purely for exercise. Most of the adult birds, we learn from Capt. Cook—the Robinson Crusoe of the island—left for parts unknown about two months ago. The young ones who were strong enough went with them. The feeble and less mature ones remained behind, in most cases evidently deserted by their parents, and multitudes of them have perished of starvation. We found the carcasses scattered everywhere, but it is remarkable that there is scarcely any odor of putrefaction about them.

A few of the mother birds have remained faithful to their maternal charge, and every now and then one comes in from a fishing excursion. They seem to come empty handed, but whatever treasures they have brought for their pets are safely stored in their portmanteaus. Curious things too they bring home for the young ones. The ground in the vicinity of their nests is quite thickly strewn with fragments of pumice stone which must have been picked up floating in the ocean, and brought home probably to serve the same purpose as the cuttle bone we put into canary bird cages. Bits of charcoal seem also to be regarded as suitable for tokens of affection, and other objects found floating in the sea, such as walnuts, bits of resin or amber, etc.

When the old bird returns from a foraging expedition, she greets her offspring in a manner that reminds one of the old Hawaiian custom of rubbing noses. The touching of beaks, however, has for the birds an esoteric significance as presently appears. After the first salutations are over, the young bird begins to coax for something to eat. It will open its beak suggestively, sometimes uttering at the same time its piping plaintive "peep," which says as plainly as can be, "please." The mother will only shake her head as much as to say "no, my child," just for the pleasure, it would seem, of seeing the young one beg. In fact I suppose it is because it takes some time for her to unlock her portmanteau. At last she seems to relent and allows the young bird to insert its beak between her open mandibles, and presently there is a transfer of property to the evident gratification of the infant bird. The infant it must be understood, is at this season nearly as large as its parent, and has exchanged its long clothes of dark gray down for a more snug and serviceable white suit like that of the adult.

In the center of the island near the lagoon, there are bare spaces where the gonies make their nests, and where even now hundreds of young birds remain prisoners (although the surrounding shrubbery which makes their prison wall is seldom more than two feet high) until they shall have gained the use of their wings. They pay little attention to you, unless you come quite close to them. Then they will snap their beaks sharply four or five times in rapid succession in a threatening sort of way, but seldom think of stepping aside to let you pass, still less of striking at you with their strong sharp beaks. Now and then, one of the old birds will decide that you are an intruder that should be shown the door, and will make a run for you in her ungainly fashion, and unless you carry a stick to ward off the attack you are likely to learn more than you care to know about the bird's beak.

The island is quite small, barely two miles long by a mile and a quarter wide, of the familiar ring form, with a small closed lagoon. In its highest part the land may be as much as 35 or possibly 40 feet above high tide mark. Although the island is surrounded with reefs, there is very little rock to be seen above the water level, except on the south-east coast when there is a rampart of sandstone rising ten feet or more perpendicularly from the water. The rock is all a shell sandstone containing a very little coral, and even on the reefs little living coral is to be seen. The soil of the island consists of a peculiar kind of white sand, made up partly of fragments of sea shells, but largely of bits of egg shells and the bones of sea birds.

While the Captain and the crew were bringing the schooner to her present moorings, inside the reef, I went with my Kodak to explore the island a little. I followed the beach a short distance, looking for sea shells, but found very few perfect specimens, and those of species not remarkable for their beauty or rarity.

Numerous turtles lay basking in the sun on the sand just above the the water line. There was a huge sea lion also lying comfortably on its back with folded arms, fast asleep. I caught with my Kodak its expression of amazement as it lifted its head on my approach. Its contortions of body as it endeavored in an agony of haste to regain the sea have left in memory a vivid photograph which brings fresh amusement whenever I recall it.

Along the shore, there were standing a number of white "boobies," apparently absorbed in contemplation. I did not pay any especial attention to them until I saw a frigate bird swoop down on one of them as if he meant to carry him off. The booby, startled from his reverie, made loud remonstrance after the manner of his kind. The frigate bird sailed off, but only to renew the assault, provoking another ear-splitting outcry. This was repeated three or four times. It seemed as though the frigate bird was doing it simply to amuse himself with the senseless squawking of the booby; but presently the real object of the attack came apparent, for the booby at last decided that he must take refuge from his tormentor in flight, but before he could do that, he must relieve himself of the load of fish which he had just brought home. That was all the frigate bird wanted; of course, he appropriated at once to his own use the disgorged fish.

The quantity of fish that a booby will bring home is something incredible. Some of the fish disgorged must have weighed a pound and a half; and were certainly as long as the bird's body. Sometimes there will be half a dozen or more fish, whose united weight would not fall short of two pounds.

The sand near the beach being deep and loose, I took to the higher ground. Here I found the land in possession of a dense population of terns or "wide awakes," beautiful, slender-bodied birds, scarcely as large as a pigeon, plumage glossy black and white. On the clear sand, one spot seemed to be as good as another for a nest. Nearly every bird that started up from the ground as I passed

through their territory disclosed a single egg, nearly as large as a pullet's egg, mottled brown in color, over which it had been brooding. There was no semblance of a nest, and how the parent bird was ever to recognize her individual property, I could not make out. When you looked closely, you would see lurking under the tufts of grass or the foliage of the low shrubbery the young chicks, who have learned that their safety depends on such concealment. There are always numbers of frigate birds, professional robbers and cut-throats, sailing over head, watching for a stray chick, and woe to the one that is left even for a moment without shelter.

The birds you have startled from their nests follow you some little distance out of curiosity, so that before you have advanced half a dozen rods you find yourself under a canopy that shelters you to an appreciable extent from the scorching effect of the sun's rays. The birds fly low, often so that you might reach them by stretching out the hand, and the murmur of the myriad wings is like the roaring of a gale about you, while your ears are deafened with the multitudinous cries of the alarmed birds. The whole crest of the sand ridge on both sides of the island is occupied by these birds—not exclusively, for the taller shrubbery is everywhere pre-empted by frigate birds and boobies, and there are also small land birds that live principally at this season of the year on the eggs of these sea fowl.

Under the low shrubbery also the tropic birds have their nests. Beautiful white birds they are, with dark eyes and straight tapering red beaks and with one or two slender red feathers, a foot or more long, in the tail. At present they are absorbed in the occupation of incubating their eggs, few of which have as yet hatched. They do not offer to move when you approach their nests, but they hold their beaks ready for service if you venture too near. However, you may safely seize their ornamental tail feather and pluck it out, eliciting only a harsh squawk of remonstrance from the bird, who will sometimes take this insult as a hint that it is time to leave.

Descending from the ridge into the lagoon basin, I found myself in a region of pitfalls. Without warning you find the sand give way under your foot, and you have an unpleasant sensation as of stepping on a live kitten. You have broken into the tunnel of a "mutton bird," and unless you have injured it too seriously, you will see the poor creature presently extricating itself from the sand in a demoralized condition. It is a bird of dark slate color, approaching black, rather larger than a pigeon, which it resembles in its smooth plumage and the graceful curves of its head and body.

The egg—all these sea birds seem to be content with a single egg—is pure white, rather larger than a hen's egg, more elongated and rounded equally at both ends. They are considered very good eating; when boiled, the white never becomes very solid, a peculiarity that is said to belong to the eggs of the sea-fowl generally. When burrowing, the mutton birds make lively play with their feet; the sand will fly behind them almost in a continuous stream.

I do not believe any other creature is capable of giving vent to such lugubrious groans as these same mutton birds. Coming from the ground under your feet, these sepulchral sounds are peculiarly blood-curdling, particulraly after nightfall.

Near the lagoon, I came upon a small flock of snowy terns which followed me for some time hovering in the air just over my head, and within arm's length. They seem to find some fascination about one's eye, for they will hover just in front of you, peering up inquiringly under your hat. They are not much larger than a mynah bird, but with much larger wings, and slender little bodies—the plumage of a lustrous, satiny white, eyes large, full and jet black. These birds select for a nest the most unlikely place imaginable. They place their single spotted egg, the size of a pigeon's egg, on some narrow ledge of bare rock, or—more preposterous still—on a log where it requires to be held in place to prevent it from rolling off. I am told that, while the bird sits on its egg it is fed, like a young bird, by its mate.

On the east side of the lagoon, I came upon a rookery of frigate birds, or "man-of-war hawks," as they are often called. Every little shrub—there were few more than three feet high—held from one to a dozen nests, rude structures, mere platforms built of twigs and coarse grass. The adult birds, as they sit perched on the bushes, remind one strongly of hawks or even of the nobler bird from which they have taken their specific name of "Aquila." The plumage is iridescent black; the beak, unlike the eagle's, long and hooked only at the point. When you approach, unless they are asleep, or over-gorged with food, or else devoted to the care of an egg or of an unefldged birdling, they will spread their great wings and flap lazily away, the resemblance to an eagle suddenly gone. Once on the wing, however, the bird needs resemble nothing but itself, for its movement in flight are the embodiment of self poise and mastery. In spite of its angular outline, the kite like form of the bird is not without grace. I have often watched single birds floating almost motionless high in the air, or darting with lightning-like speed after the fish, which they have compelled other birds to drop, but I never saw before as now hundreds of the birds in the air at once.

My attention was, however, more particularly directed to the baby birds left behind on the nests. It is hard to believe that these snow white balls of swan's down can ever grow into the semblance of one of those sombre, angular adult birds. They resemble the parent now only in the beak, which, massive and black as it is, is in striking contrast with the rest of the creature's make up. Some of them are as large as a spring chicken. Comical creatures enough they are. When undisturbed, they will be sitting bolt upright on the nest. On your approach, they will first crouch and crane their necks toward you, opening wide their great beaks as if they meant to swallow you whole. Then if you come closer, they will show fight, striking at you viciously with their sharp beaks. They are, for all the world, like a lot of little children dressed in their night gowns, aroused by some unusual disturbance when they should be fast asleep in bed.

The young boobies look almost exactly like the frigate birds, but they have a straight, pointed beak, and red instead of black eyes, and when you disturb them, they squawk just as their parents do. This impresses you very much as it would to hear from a young child, apparelled like a prince, the language of Billingsgate.

This must answer for the present for bird stories. I have not even mentioned the game birds, curlew, snipe, plover and duck, or the little land birds, of which there are several species, or the very interesting red eyed wingless birds, but time and space would fail, were I to try to exhaust the subject. A rough calculation puts the bird population of the island at about 800,000; it may reach 1,000,000. They have not yet learned to fear man excessively, and are in fact no more shy than barn door fowl, so that it is very easy to study their habits.

The flora of the island I find interesting, although somewhat disappointing. I gathered only twenty-one species of flowering plants, nearly all of them Hawaiian or cosmopolitan plants. The seeds of most if not all of them have floated to the island in sea-water. Among them should be mentioned the loulu palm, the maia pilo (caper) the Koali (convolvulus) and a stunted species of sandal-wood.

To-morrow we shall undertake a systematic examination of the deposits of phosphate of lime which give a commercial importance to this little island. They represent the bones of millions of fish that have, age after age, supplied food to birds innumerable.

[Subsequent entries in the log book are taken up with details of the survey and exploration of the island, of the continuation of the trip to Liaiansky, and of the tedious return voyage of twenty-four days.] get next issue

Outward polish and grace only make a person's inward deformities seem the blacker when they are discovered.

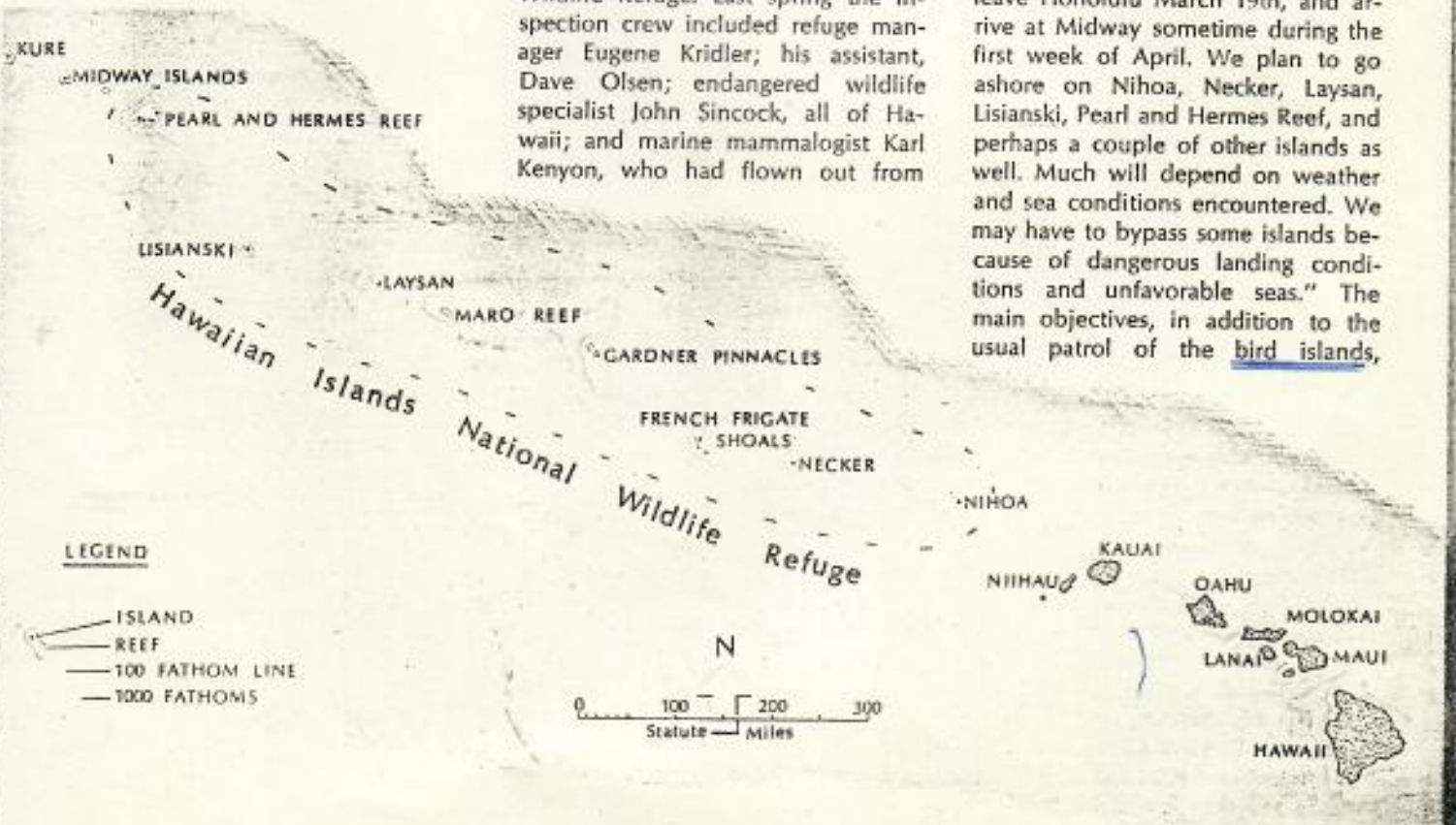
The Hawaiian Islands of Birds

story and photography
by GEORGE LAYCOCK

ON A CLEAR WARM MORNING in March the U.S. Coast Guard cutter *Buttonwood*, with Commander Henry Haugen at the helm, eased out of the harbor at Honolulu and began her sluggish journey northwestward across the rolling Pacific toward Midway, 1,100 miles distant. In addition to her able crew of 45 officers and enlisted men, there was aboard a five-man crew referred to by the seamen as "the bird people."

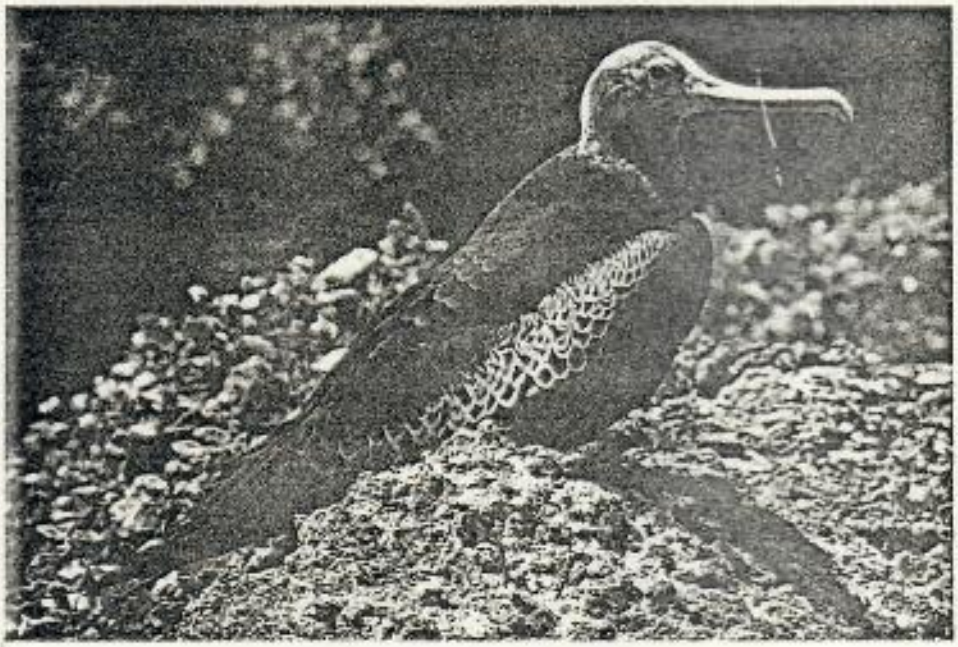
The "bird people" were biologists of the U.S. Bureau of Sport Fisheries and Wildlife—off on their annual inspection tour of the remote and unpopulated little islands that make up the Hawaiian Islands National Wildlife Refuge. Last spring the inspection crew included refuge manager Eugene Kridler; his assistant, Dave Olsen; endangered wildlife specialist John Sincock, all of Hawaii; and marine mammalogist Karl Kenyon, who had flown out from Seattle. When Gene Kridler decided there would be room for an *Audubon* reporter to join the crew, I signed on eagerly as the fifth "bird man."

With a fine sense of understatement, Gene had written before I left Ohio, "You may find it to be somewhat of an adventure. We expect to leave Honolulu March 19th, and arrive at Midway sometime during the first week of April. We plan to go ashore on Nihoa, Necker, Laysan, Lisianski, Pearl and Hermes Reef, and perhaps a couple of other islands as well. Much will depend on weather and sea conditions encountered. We may have to bypass some islands because of dangerous landing conditions and unfavorable seas." The main objectives, in addition to the usual patrol of the bird islands,



NIHOA - 146 ACRES, 910' conquest - 170 acres
NECKER - 41 ACRES 278' - 500 nests per acre
conquest - 45 acres

GARDNER PINNACLES - 600 long, 170'
LISIANSKI - 382 ACRES 50'
LEHUA - 291 acres (canon)



The breeding male of the great frigatebird shines in the Pacific sun, its gular pouch a crimson balloon which attracts females flying overhead. The young man-o'-war perched on a Nihoa Island rock survived six weeks of incubation by both parents plus careful guarding as a chick to prevent it from being eaten by another adult. Here, and nowhere else on Earth, is found the bright yellow Nihoa finch.

would be to census seabirds, continue studies of rare and endangered species, and tag monk seals and green turtles. Almost as an afterthought, Gene added, "I hope you are agile."

The Hawaiian archipelago is strung out in a line 1,600 miles long, reaching from the Big Island of Hawaii on the southeast end of the chain to the little-known outpost of Kure on the west. From such evidence as they can find, scientists have attempted to piece together the geologic history of the Hawaiian Islands—believed to have been born of a fault in the ocean floor. When stress weakened the crust, molten lava pushed up out of the heart of the Earth. Over the ages hundreds of eruptions added layer after layer to the underwater structures, each of them rising higher toward the ocean's surface until eventually a barren volcanic island emerged from the sea.

This action continues today on the Big Island, whose highest summit, Mauna Kea, stands 13,796 feet above the Pacific and 32,000 feet above its floor, making it the highest mountain—from its base—on Earth. The older islands, the Leewards, have eroded from wind and water until some have sunken again beneath the surface. The rising sea following the Ice Age is believed to have covered them still more. Some islands, though, have been built up by growing coral organisms extracting minerals from the ocean waters and adding limestone to the volcanic shelves.

The main islands of Hawaii are people islands. But beyond this world of tourism lie the Leeward Islands, with all but Midway and Kure within the National Wildlife Refuge System. These refuge islands are known to few and restricted to scientists visiting them under special permit. The remote and fascinating Leewards are Hawaii's bird islands, the nesting grounds for hundreds of thousands of albatrosses, boobies, terns, petrels, and shearwaters. With each approaching nesting season the seabirds converge upon these bits of land from thousands of square miles of open ocean. And as they raise their young, they live in incredible concentrations, making these little is-

were the cliffs of which Dr. Alfred M. Bailey had written when telling of the 1912 trip to Laysan. Enroute, the party hoped to go ashore on Necker. "A great ground swell was running when we attempted to land," Dr. Bailey wrote, "and we were unable to get a boat against the steep rocks, but George Willet succeeded in getting ashore by swimming. He rode a white-crested wave against the cliff and was left dangling as the waters surged away." I looked again at the pounding surf and could see George Willet riding his wave, and decided the rubber raft was a better way. As he had on previous occasions, Gene Kridler led his party around the cliffs to the landing site.

The landing area was a twenty-foot-long lava ledge eighteen feet above the sea. The boat must be carefully guided to this narrow perpendicular wall, and its bow must be held against it long enough for a man to leap onto the rocks. The two youthful Coastguardsmen moved the raft in close and the boat rose on the crest of a wave. Gene, experienced in such landings, leaped for the rocks and scrambled up the wall to get out of the way before the next wave came booming in. The receding water fell away beneath the boat and dropped us far below, almost to the base of the wall. A rush of water cascaded down over us from the rocks above. The next swell carried us back up and Dave, with fine timing, jumped for the rocks. In this manner the whole party went ashore, each man riding his own wave to its crest. Then the packs of scales, bird bands, cameras, food, water, and other equipment were thrown ashore and passed along the line of men, up the rocks and out of reach of the sea.

During the previous September, Gene and his crew had erected a heavy refuge sign supported on sturdy wooden posts cemented in the rocks 45 feet above the ocean. The sign had vanished. Great waves during winter storms had smashed it, broken the marine steel guy wires, and straightened out the steel eyebolts anchored in the rocks. All that remained were two spots of gray concrete in the black lava.

Above us, black and red cliffs rose in jagged walls, along which narrow ledges provided a route to the top. Screaming seabirds were everywhere. The same species nest here as on Nihoa, except there were none of the little finches and millerbirds. We worked single file along the series of ledges and switchbacks, higher and higher toward the top of the cliff. In the distance, the *Buttonwood* moved off on some practice exercise for the day.

Necker Island has an amazing concentration of seabirds—more than 20,000 active nests, 500 per acre. Our nest counts showed: sooty tern, 16,500; gray-backed tern, 1,300; white-capped noddy, 500; fairy tern, 500; blue-gray noddy, 750; common noddy, 25; brown noddy, 20; wedge-tailed shearwater, 2,000; Laysan albatross, 510; black-footed albatross, 175; and blue-faced (or masked) booby, 230.

My assignment was the blue-faced booby. I was to count the number of nests on the island, then make individual studies of at least 100 to determine how many contained one, two, or three eggs. What I soon learned about a nesting blue-faced booby is that the big bird possesses a strongly developed sense of territory and has no intention of going along gracefully with the egg count idea. No matter how close you walk to the incubating bird it gives no ground, and the bill of the booby—long, sharp, and strong—is freely used against even human invaders. I solved the problem of seeing eggs hidden beneath these birds by holding up the sole of one of my heavy boots within pecking distance. The irate booby struck with such vigor that the effort half lifted it from the nest, and in that brief time I could peer beneath the bird and count the eggs. My notes read: *1 egg, 6; 2 eggs, 59; 3 eggs, 15; 1 egg & 1 young, 16; no eggs, 12; total nests checked, 108.*

On top of the barren and rocky little mountain are upright stone shafts of ancient Hawaiian temples, said to bear a striking resemblance to temples in parts of Tahiti. We also found the rotting platforms left by U.S. Air Force personnel who had camped on Necker in 1963 and departed without cleaning up the trash. In addition to their tent platforms, they had left a pile of rusting food cans and other assorted junk. We spent part of our limited time cleaning up behind them.

An Hawaiian monk seal pup nuzzles its mother on the shore of Lisianski.

Attached to Necker by a narrow shelf of rock is a small rockbound cape, and late in the morning we worked our way across this neck to look down upon a secluded harbor where 20 Hawaiian monk seals were asleep on the rocks. The seals awakened as we approached and stared incredulously at the first humans they had seen in months. Some went back to sleep while others

bumped across the rocks into the sea.

During the afternoon we noticed shifting winds and rising waves. Hopefully, the Coast Guard would come early. But the boats came into sight sharply at five o'clock. The whaleboat held off in the rough seas, while the rubber raft came to take us off the island. Karl Kenyon awaited the rising raft as the waves came far higher than they had during the morning's landing. One carried the raft to the level of the shelf and Karl leaped quickly into the boat.

Now each wave was coming in higher than those before it, and we often had to grab our bags of equipment and scramble up the cliffs to escape. Rushing water broke across the shelf and pi'ed up around us in warm white foam. I congratulated myself on having sealed my metal camera case with masking tape. My turn had come. I stood on the edge of the cliff gauging the rise and fall until, finally, a breaker came that promised to lift the raft to the exact level of the ledge. I leaped as the wave crested and landed flat in the middle of the raft, with a seaman steadying me as we slid down the wave to its trough. Dave came in behind me.

Behind us, Gene and John, old hands at this business, were still waiting on the rocks. We rode the raft up and back down several times. Each surging wave moved it close against the rocks. The danger was that the bow would hang up on the edge as the sea rolled back out beneath it, standing it on its stern or flipping it over backwards. The swells rolled in steadily higher.

The raft rose again on the wildest wave yet. A wall of water rushed across the ledge before Gene and John could climb to safety, enveloping the biologists and knocking them flat on the rocks. As the sea surged back it pulled with a demoniac force, hanging on with foamy fingers reaching into hidden crevices.

This time, as the boat dropped back on the receding wave, I saw Gene and John hanging on to each other and on to the rocks in a frantic struggle to keep the Pacific from pulling them off into its depths. I expected them to slide over the edge of the cliff with the rushing water, but they somehow kept their grip on the rocks. The waves were now more than twenty feet high.

The Coastguardsmen decided to transfer us to the whaleboat. We watched as they moved in again. Skillfully they held the raft in close to the rocks and John leaped for it as the raft rode the wave downward twenty feet or more. "I jumped into space like a skydiver," he said later, "and I didn't catch up with the boat until it was at the bottom of the surge." He landed heavily but safely in the raft. Then on the next wave, Gene dove, and as John explains it, "came down spread-eagled on top of the Coastguardsman in the bow." We had lost only a few bags of equipment. All five of us were free of Necker's treacherous shores.

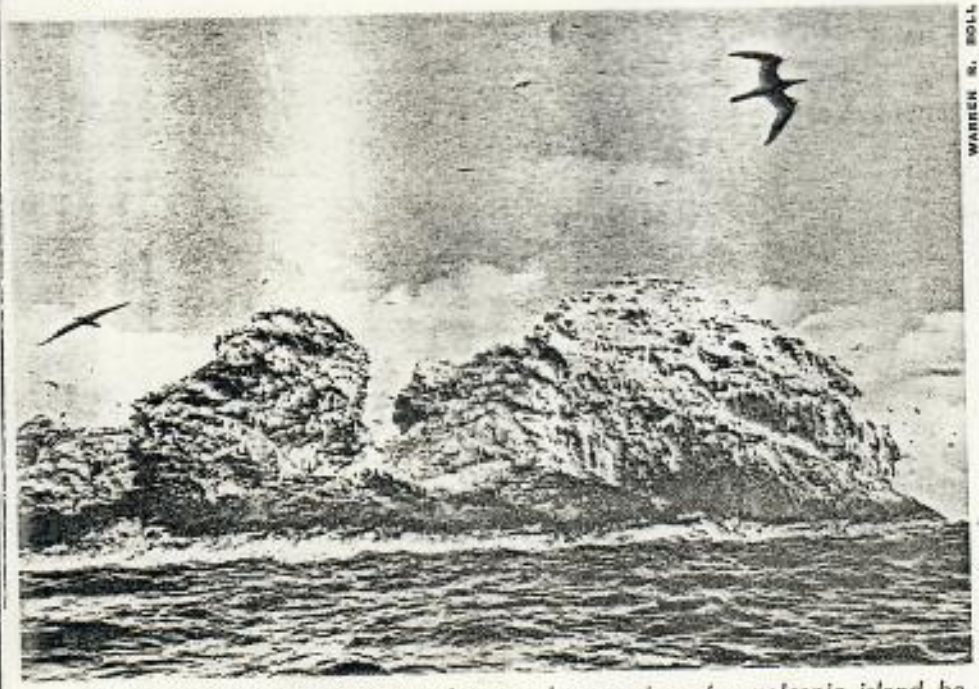
Karl Kenyon had made dozens of such landings, both in the Hawaiians and the Aleutians. "This is the roughest I've ever seen it," he said.

Back aboard the cutter, we dried our clothes and checked our equipment as the *Buttonwood* turned west toward French Frigate Shoal, an overnight run of 85 miles. There are eleven islands within the barrier reef of this atoll, and the largest of them, Tern Island, is the base for a Coast Guard loran station. A crew of twenty men serves on this lonely outpost for tours of one year. This is the only human habitation on any of the refuge islands.

Tern Island is used less by wildlife than it once was. But the nearby islets are home to sea turtles, seals, and more colonies of seabirds. The pristine waters of the lagoon are the heart of a delicate marine ecosystem still undamaged by human activity. But the shoals and reefs and shallow banks in the area have attracted the attention of commercial fishing interests eager to move in on this wonderful laboratory of marine life.

Rough seas forced us to bypass Gardner Pinnacles and head directly for Laysan, two-thirds of the way along the Leeward chain. Here we would find the biggest nesting concentrations anywhere of both the Laysan albatross and black-footed albatross, as well as the thousands of sooty terns which descend on the island each year to raise their young.

Turbulence has marked the history of Laysan, but surely no more fateful day confronted it in historic times than the one in which the Royal Kingdom of Hawaii granted a private company rights to mine guano. The foreman of the operation imported and released six pairs of rabbits to



WARREN K. BOLL

Guano-covered Gardner Pinnacles are the remains of a volcanic island believed to have been 140 square miles in size. Wind and sea have carved it to an outcrop 170 feet high, 600 feet long. Landing here is usually impossible.

ing, and a clacking of bills as the excitement mounts. One or both may point their bills straight up at the sky and call. Then one will lower its bill and stick it beneath an extended wing. Serious students of the albatross have noted that Laysan albatrosses, at this moment, extend only one wing, while the black-footed albatrosses extend both wings. The series of displays may go on for several minutes.

Occasionally a neighboring albatross will waddle up to the dancing couple as if about to cut in, or actually join halfheartedly in the steps. Once I saw four black-footed albatrosses forming their own square-dance set. Why do they carry out the elaborate courtship procedure and why do they continue it so late in the breeding season? "It may," Karl said seriously, "be the way the sexes recognize each other. And some have suggested he added, "that they dance for fun. After all, the days are long out here and there isn't much else to do."

Happily, the albatrosses seem to face no immediate troubles. It is believed there may be 1,500,000 Laysan and 300,000 black-footed albatrosses in the world.

Where an island exists, the seabirds take advantage of practically every square foot of land. Each island produces enough birds to spread across hundreds of square miles of open ocean. Together, the islands within this refuge are home to the breeding populations of all the world's Laysan and black-footed albatrosses, Bonin petrels, Laysan ducks, Laysan finches, Nihoa millerbirds, and Nihoa finches. For hundreds of thousands of years these islands had played this vital role. But outside the refuge, islands which the birds once occupied have been changed by man reducing the total numbers of seabirds that can survive, and rendering those bird islands that remain more important than ever.

Hundreds of miles of open ocean separate these wilderness islands from the main inhabited islands, and each is isolated within the island chain. Today, when we are studying the face of America for areas deserving true wilderness designation, the Leeward Islands of Hawaii merit careful consideration. These wild islands, wilderness in fact, deserve to be wilderness by official designation as well. And not the dots of land alone, but the shallow ocean shelves around them and the basins within the atolls. These shallow waters belong to the islands ecologically, and where the wilderness embraces them it would protect populations of seals, turtles, and fishes, plus corals and other organisms that have survived together over the ages.

We had been told by Commander Henry Haugen that the time of arrival at Midway was to be "10 hundred hours," and precisely at 10 a.m. on the appointed morning, the *Buttonwood* eased up against the dock. Few islands anywhere have had more controversial conflicts between the native wildlife and invading man than Midway. A succession of past military commanders struggled to eliminate its nesting populations of albatrosses and petrels, sometimes because it was believed the birds presented a hazard to aircraft, and sometimes because the commander did not, as one of them phrased it, "Choose to live in a goddamned barnyard." In recent years commanding officers have brought a more sympathetic view to Midway.

The maze of high towers draped with guy wires and antennas that once killed the flying albatrosses are gone now. The gooneybirds dance in the barrack's yards and nest in the shade of the officer's houses. "People living here," I was assured by one base officer, "have developed a protective feeling toward the gooneys. If dogs or kids chase the birds, adults reprimand the dogs and kids. And you get used to the noise the birds make at night."

Perhaps the biggest threat of all to the birds of Midway is the possibility that the U.S. Navy base there will enlarge its facilities. The result would be to whittle down still more of the world's population of these magnificent soaring birds of the open seas.

Dave Olson, assistant refuge manager, grabs the flippers of a young monk seal for tagging. The older the seal pup, the harder the biologist's task becomes.

From Midway, twice-weekly charter planes fly between that outpost and Honolulu. We lifted above the sand dunes where flocks of Laysan albatrosses rest near the runways. Our plane roared across the island and the graceful seabirds turned and soared in a manner that put our lumbering craft to shame.

We soon passed over Pearl and Hermes Reef, where we had broken camp the day before. Far below I could see Southeast Island on which our tents had stood. We were too far up to see the birds. But I knew they were down there, the albatrosses, shearwaters, petrels, terns, tropicbirds, boobies, curlews, and others whose ancestors have raised their young on these islands for unknown thousands of years. They were free of human pressure, at least for the moment. And hopefully for a long time to come. ■

1968 Audubon Jul/Aug V70 N4 - The Lure of the Islands - Bird Finding by O.S. Pettingill Jr.
P6-29

4 Groups of Birds - 1) Native landbirds 2) resident and mig freshwater birds and shorebirds 3) seabirds 4) introduced - exotics

"Most sea-birds nest in colonies on the small islands and shoals of the so-called northwestern chain that extends all the way from Nihoa northwest to Midway and Kure."

1966 Nov/Dec V68 N5 - Olulaau O Kauai by Robert Wenkam
P430-435

Map of Major Islands - but does not show Lehua or Kaula

Bird catchers called kia manu

1791 - Kauai Capt. John Kendrick
1793 - Capt George Vancouver - cattle and Goats

olona fiber grows deep inside wet forests, became prized by sailors for harpoon lines.

1962 Nov/Dec V64 N6 Bird Finding by (with) Sewall Pettingill
P 342-344

"In Hawaii, Jan-Feb are the best months

Chart of majors, No Lehua or Kaula included.

1960 Nov/Dec V62 N6 Bird's-Eye View Roger Peterson
P258-261

Rediscovery on Kauai

One of Society's goals - "Help establish and protect wildlife Refuges, wilderness areas, nature preserves, wild and scenic rivers"

"Defend the integrity of the national wildlife refuges, national parks, and national forests, all work for appropriate additions to these systems. Promote their sound management."

DAVID B. MARSHALL, U.S. FISH AND WILDLIFE SERVICE

Laysan Island—a speck of coral, sand, and lagoon in the North Pacific scarcely 40 feet above the sea, its incredible birdlife once so besieged that three unique species were lost to the world, a ghost island rescued by intrepid scientists so that the Laysan albatross still dances in the sun

FROM THE GENTLY ROCKING DECK of the U.S. Coast Guard cutter *Buttonwood* we could see, lying off to the east, the historic bird island of Laysan. Unlike some of the other rocky islets and atolls we had visited within the boundary of the Hawaiian Islands National Wildlife Refuge, Laysan scarcely rose above the surface of the ocean. From this distance, in the early morning sunlight, it was only a thin yellow line between the sea and the deep-blue sky. But that unimpressive stretch of coral has long been known as one of the world's most productive seabird nurseries. Thus, small groups of people have been coming to this remote part of the mid-Pacific for decades.

Earliest of the ornithologists to visit Laysan were Henry Palmer and George C. Munro, who spent eleven days there in 1891; Walter Rothschild then wrote a three-volume report on their pioneering expedition, although he personally never visited any of the Hawaiian islands. Sailing aboard the U.S. Fish Commission steamer *Albatross*, Walter K. Fisher, C. C. Nutting, and John O. Snyder landed on Laysan on May 16, 1902, and stayed for a week; Fisher wrote a sound and detailed report on the island's birdlife.

Our five-man scientific party was led by Eugene Krider of the Bureau of Sport Fisheries and Wildlife. Gene is manager of the refuge that includes most of the Leeward Islands in the Hawaiian archipelago, and he was accompanied by his assistant, Dave Olsen, and biologists Karl Kenyon and John Sincock. As field editor for *Audubon*, I had signed on as the fifth member.

Of all the intrusions on Laysan Island, none brought greater change than the arrival of Max Schlemmer, 79 years ahead of our landing. In 1890 the Kingdom of

Haunted Sands of Laysan

by GEORGE LAYCOCK

GEORGE LAYCOCK

Hawaii granted mining rights on Laysan to a guano company which dispatched Schlemmer from the main islands to manage the operation. As he sailed from Honolulu with his family and worldly belongings, Schlemmer must have had only the vaguest idea of how life would be on an island less than two miles long.

He saw Laysan as it had been through centuries—low sand dunes rising no more than forty feet above the high-tide mark, and blanketed with the dark greens of thick-growing *Scaevola*, a flowering shrub peculiar to these islands that in some places was shoulder-high. In the heart of the island lay a mile-long lagoon, a shallow basin of water saltier than the surrounding ocean. And on the north side of this pond was a tiny pool, the only source of freshwater on the island except for rain.

A long gentle slope extended down to the lagoon's edge, and here the main cover was *Eragrostis*, a coarse-bladed bunch grass growing in clumps two to three feet high.

Everywhere over this scene were seabirds, some of which are present on Laysan each month of the year. Schlemmer, looking across his new domain, saw clouds of sooty terns mixed with soaring albatrosses and tropic-birds, fairy terns, boobies, and as evening came, thousands of petrels and shearwaters. This extravaganza must have amazed Schlemmer, and as he tried to sleep that first night on Laysan, the calling of the terns mingled with the deep-throated moaning of the shearwaters certainly gave him long wakeful hours to ponder the wisdom of coming to this lonely place to live and work.

Laysan was indeed a frontier where men were cut off from the rest of the world the moment their ship steamed out of sight. There was no radio, no regular postal service, no medical help, and no way of obtaining emergency supplies. The guano workers on the island would truly learn the meaning of isolation. Yet Schlemmer lived there fifteen years, and his son Eric, born in 1904, was perhaps the only person ever to have claimed Laysan Island as his birthplace.

Schlemmer's ship had brought lumber, with which he built a modest frame house on the ridge above the landing, plus several small outbuildings used in the mining operation. The rest of the wood went into crossties for a short stretch of track reaching across the sands. Along these rails, carts carried guano from the deposit to the beach, where it awaited shipment to Honolulu.

But Schlemmer also saw other possibilities in his island. He brought a few coconut seedlings to plant beside his house. He imported a few guinea pigs and turned them loose. He brought a supply of tobacco seed and planted a patch.

Then Schlemmer decided Laysan needed some animals to supply meat. There was all that greenery growing there and not doing anyone a bit of good—and it would take a world of rabbits to eat that much.

Word went back to Honolulu on a visiting ship that Max Schlemmer wanted some Belgian hares, the big domestic rabbits that produce a lot of fine white meat and good-sized skins as well. So one fateful day in 1902, along with a supply of flour, salt, bacon, cloth, and hand tools, there arrived on Laysan's beach the first rabbits ever to reach that Pacific island. The number of rabbits brought ashore in that first shipment has been lost to history, but it was small, for Schlemmer imported rabbits

three times that year and the next, and they totaled only eight or nine. But eight or nine rabbits, as events—and rabbits—were soon to prove, can go a long way.

By 1906, with the guano business rapidly sliding downhill, Schlemmer had packed up his family and belongings and had shipped out for Honolulu. He left behind some weathered buildings standing in the shade of two scrawny coconut trees, a few feral guinea pigs, plus a vigorous and fast-expanding colony of multicolored Belgian hares, hopping through the *Scaevola* bushes and nibbling contentedly at the native vegetation.

The rabbits shared the island with the seabirds whose descendants still come to Laysan to nest. But there were also a few birds that lived on Laysan the year around, some of them known nowhere else in the world. These endemic species included the teal-sized dark-brown Laysan ducks which fattened on brine flies swarming around the edges of the lagoon. There were Laysan finches, yellowish, sparrow-sized birds that nested in the *Eragrostis* clumps. There were red-tinted honeycreepers, and skulking millerbirds, about the size of house wrens. And running through the grass were strange little rails that had evolved only one place on Earth.

The Laysan rails scurried around the abandoned buildings like tiny domestic chickens. Their wings were short and the birds were incapable of flight. They survived because the vegetation provided escape cover from larger birds and because there were no predatory mammals or reptiles to pursue them.

The Schlemmers had been gone from Laysan only a few years when President Theodore Roosevelt, early in 1909, signed an executive order declaring the Leeward Islands to be the Hawaiian Islands Reservation, one of the earliest of America's national wildlife refuges. The same year a band of Japanese plume-hunters ran their boat up on the shore of Laysan Island and took up residency in the old Schlemmer home.

THESE NEW INTRUDERS arranged their tools, stacked their shipping crates in one of the sheds, and set to their grisly task with unequaled efficiency. Their major victims were the thousands of albatrosses that historically returned to Laysan in incredible numbers to nest, but the plumers also took feathers of several other species. They found it exceedingly simple to walk among the unafraid seabirds and knock them on the heads with sticks. To gather the wing feathers, they usually cut off the entire wing, sometimes killing the bird, sometimes not. Soon dead and crippled seabirds littered the coral sand.

Word of the depredations on the new federal refuge leaked out and the revenue cutter *Thetis* was dispatched from Honolulu to apprehend the poachers. Government agents swooped in on the beach and the bird-killers, having no place to run, were soon captives. The whole band, feathers and all, were taken back to Honolulu on the *Thetis*. Behind them was a desolate scene, the weather-beaten buildings once again empty—surrounded with trash now, and the decaying bodies of thousands of birds, around which swarmed multiplying flies. Meanwhile the rabbits, more abundant than ever, spent their days in petrel burrows or in holes they themselves dug, emerging in the evenings to continue cutting away at the disappearing vegetation, bringing Laysan steadily closer to its day of biological reckoning.

Among those saddened by the turn of affairs on Laysan was ornithologist C. C. Nutting, professor of zoology at the University of Iowa, who had visited the island in 1902. Two years later, on a visit to Iowa City, he showed lantern slides of the amazing courtship dance of the albatrosses. In the audience was a nine-year-old lad named Alfred M. Bailey. "I went home that night and dreamed about albatrosses," he told me recently, "and ever since I've been interested in them."

In 1911 Dr. Nutting influenced the U.S. Biological Survey to send a party to the Leeward Islands to make a museum collection of the native birds there. Professor Nutting handed the assignment to lead this party to an assistant professor, Homer R. Dill, who was shortly enroute to Hawaii in the company of a few assistants.

Dill and his group sailed out of Honolulu April 17, 1911, on the *Thetis*. Several days later, when they came within about fifty miles of Laysan, they began seeing increasing numbers of albatrosses, petrels, and terns around their ship. They stayed on Laysan until June 5th, taking their turn at living in the old Schlemmer place. As they came ashore, desolation greeted them. "Our first impression of Laysan," Dill later wrote, "was that the poachers had stripped the place of birdlife. An area of over 300 acres on each side of the buildings was apparently abandoned. Only the shearwaters moaning in their burrows, the little wingless rail skulking from one grass tussock to another, and the saucy finch remained . . . Here on every side are bones bleaching in the sun, showing where the poachers have piled the bodies of the birds as they stripped them of wings and feathers. In the old open guano shed were seen the remains of hundreds and possibly thousands of wings which were placed there but never cured for shipping, as the marauders were interrupted in their work."

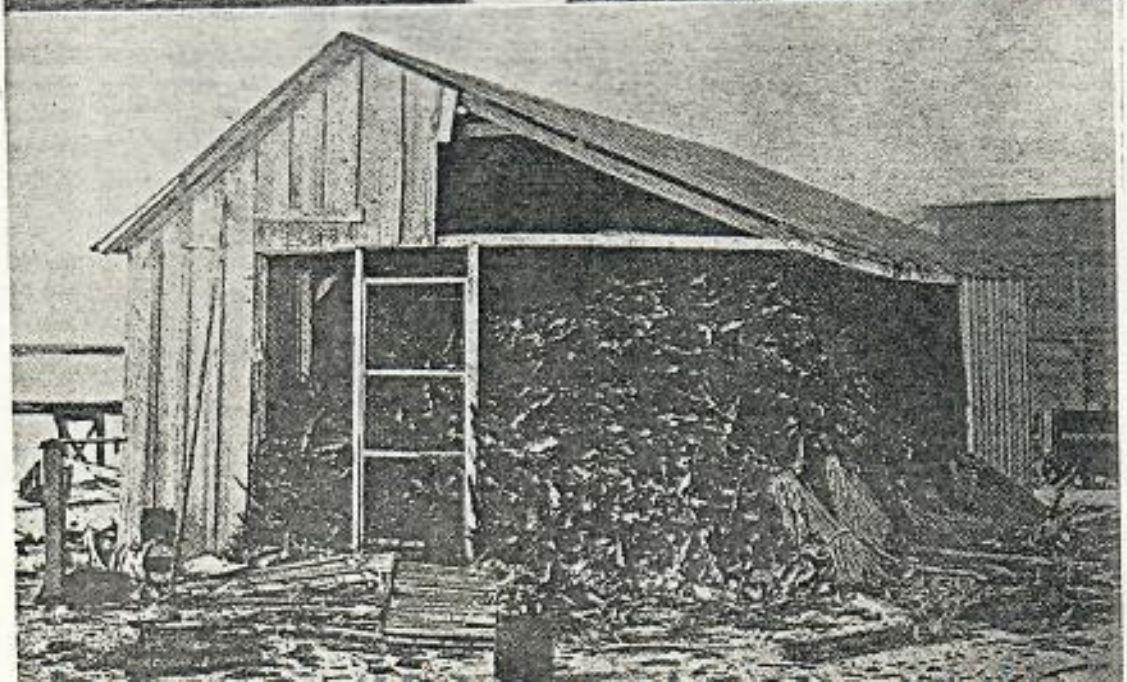
The clubs, nets, and other tools of the bird-killers still littered the ground. "Hundreds of boxes to be used in shipping the bird skins were packed in an old building. It was evident that they intended to carry on their slaughter as long as the birds lasted."

But what astounded the professor from Iowa most were the rabbits. He was surrounded by rabbits. They had taken over Laysan Island. The vegetation was gone from large areas and the sand was free to move before the winds. It may well be that the visit of Professor Dill in 1911 coincided very closely with the maximum population of rabbits, and that the invading mammals were at that moment reaching the point where further breeding would so heavily cut into their food supplies that the rabbits would threaten their own future. "They were very fond," wrote Professor Dill, "of the green juncus that grows near the lagoon, and, while they are eating, their bodies are concealed among the thick growth and only their ears show." In the evenings the island seemed to be a garden of ears.

When Homer Dill returned to Iowa he carried the carefully skinned and packed remains of the rails, finches, and other birds collected to form the planned museum exhibit. But he also carried a warning. Unless

An incredible, uncountable Laysan albatross colony is photographed sometime before 1900; the scientific world was just then learning about the vast populations of seabirds on this islet.

The same photographer from Honolulu, J.J. Williams, also made this pre-1900 picture—like the others, from the historic files of Alfred M. Bailey. Thousands of eggs from the nests of Laysan albatrosses were being gathered for trade in Hawaii. But while this egging would wipe out one year's nesting, it was a rare occurrence and hardly as destructive as the rabbits and plume-hunters that came to Laysan Island later.



Japanese poachers came to slaughter Laysan's seabirds in 1909—the year these Leeward Islands were declared a bird reservation. Their depredations had annihilated the birdlife before federal agents arrived and found the old buildings of the guano mine filled with the wings of thousands of albatrosses.

an official party could be dispatched to Laysan soon to attack the rabbit hordes, the future was indeed bleak for that amazing bird island.

To this was added the opinion of Professor William A. Bryan of the College of Hawaii, who had joined the party for the first week of its Laysan expedition. "If active steps are not taken by the government to check or exterminate the rabbits on Laysan, it is only a matter of a very short time indeed when they will reduce this green island to a barren heap of white sand."

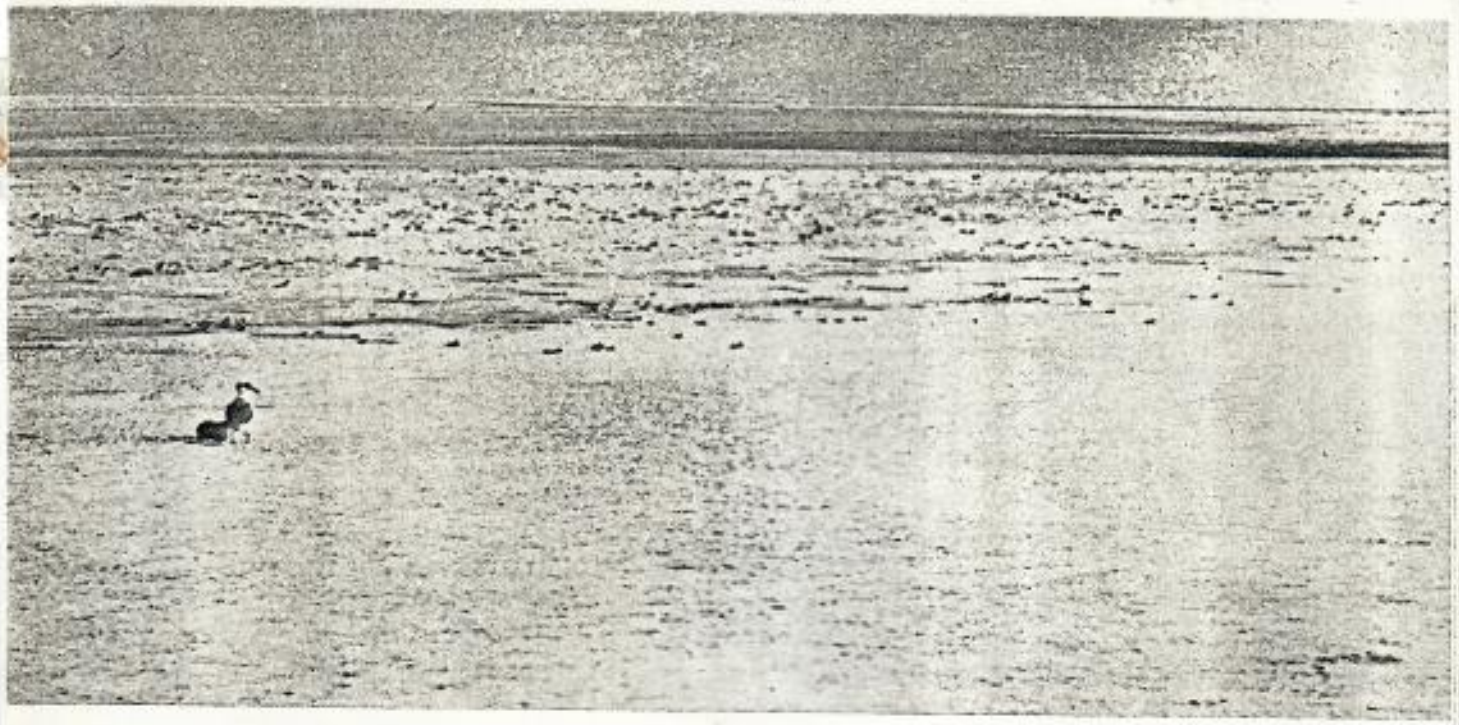
Because of these warnings, the U.S. Biological Survey organized still another expedition. This one would have a gruesome mission. In charge was a former governor of Guam, Commodore G. R. Saulsbury. The ornithologist aboard was George Willett. The youngest member of the team was Alfred Bailey who, years before, had dreamed of albatrosses. By 1912 the 18-year-old Bailey was a sophomore at the University of Iowa. Recently I visited with Dr. Bailey in his office in Denver, where he is the director of the noted Denver Museum of Natural History. "It would be nice," Dr. Bailey told me, "to be able to say that I was chosen because of my skills as a young naturalist, but I was the expedition cook." But he was also an expert taxidermist, as well as an experienced and self-reliant outdoorsman—an experienced hunter and a crack shot with a rifle. The expedition shipped out aboard the *Thetis* for Laysan, and three days before Christmas they stepped onto the beach. They had become the new tenants of the disintegrating buildings erected by Max Schlemmer.

Before them lay a staggering assignment. They had brought only two .22 rifles, one of which was Bailey's personal gun. "We also took along two or three ferrets, Dr. Bailey told me, "thinking these might help chase the rabbits out. We took only males. But when we went ashore and saw how many birds were in burrows, we put the ferrets back on board the *Thetis*." They had brought 6,000 rounds of ammunition, but there were probably more than that number of rabbits on Laysan at the time.

The rabbits at first were so tame that some could be caught by hand. Bailey kept score of the numbers killed. On their best day the rabbit population was reduced by 254. Toward the end of their tour on the island the rabbits became increasingly wary, and the men knew they were going to fail in their mission. Ammunition was running low, and time was running out. Thumbing his aging journals written more than half a century ago, Dr. Bailey said, "We killed 5,020 rabbits while we were there, and four guinea pigs. It wasn't a pleasant job. But it was one that had to be done. At the last we had a rule that anyone who made a poor shot on a rabbit had to run it down instead of using another shell." Complete elimination of the rabbits during this visit proved impossible. Starvation would eventually confront the ones remaining.

Dr. Bailey's journals also tell the sad tale of Laysan's birds at the time of his visit. The Laysan duck had become the world's rarest waterfowl—only seven remained. The Laysan rails still scurried from one shadow to the next, while beautiful honeycreepers still sang and millerbirds still skulked. All of these endemic species—unlike the traveling seabirds—found their food only on Laysan. The vegetation that supported the insects on which some of them fed, and which provided nesting and escape cover, was vanishing. With the rabbit population still substantial, the future for these resident birds was dim. So in the last days of their tour on Laysan, Willet told Bailey to capture as many of the flightless rails as possible. He penned them in one of the sheds, and on the day of departure 50 Laysan rails went aboard ship for release on Midway, where they flourished for many years.

During those lonely weeks on Laysan, Alfred Bailey made an excellent set of pictures of his favorite birds, the albatrosses. The party also collected birds for museum exhibits, but steadfastly resisted the temptation to take the Laysan ducks. Although only seven of their kind were



left, there was still hope that they would somehow survive the rabbit tragedy that men had visited upon this coral island.

Following my visit with Dr. Bailey, I had one more call to make in my efforts to unravel the patchy history of Laysan Island. In Washington I talked with Dr. Alexander Wetmore of the Smithsonian Institution. Of all those who visited Laysan with the early scientific groups, only Dr. Bailey and Dr. Wetmore are still alive. Ten years passed between the time Dr. Bailey's group left the island and the arrival of Dr. Wetmore.

At the age of 37, Dr. Wetmore, already one of the world's most widely traveled and knowledgeable ornithologists, organized a party to cruise for four months through the Leeward Islands under sponsorship of the Biological Survey and the famed Bishop Museum in Honolulu, and to concentrate especially on the best-known bird island of the chain, Laysan. In Honolulu, Dr. Wetmore sought out a tall, gangly young man who had once lived on Laysan, Eric Schlemmer, and signed him on as a member of the twelve-man party. Schlemmer had not been "home" since his family left the island many years before. The group left the Honolulu harbor on April 4, 1923, on a World War I mine sweeper, the *U.S.S. Tanager*. Aboard were excellent photographers, scientists with varied interests, plus general helpers, including young Schlemmer.

Also in the baggage was equipment for one more attack on the rabbits—if necessary. In addition to rifles and several thousand rounds of ammunition, Dr. Wetmore had purchased a ton of fine leafy alfalfa hay in San Francisco, and had it compressed into compact bales. "I put it aboard with my baggage," Dr. Wetmore recalls with a smile. Included was a supply of poison.

"I don't know whether we should report all the gory details," Dr. Wetmore commented. He was leafing through the yellowing pages of his old journals, verifying facts as he talked. "But getting rid of the rabbits was

In 1912, a young Alfred M. Bailey, armed with a .22 rifle to attack the island's rabbit hordes, stands amidst a vastly depleted population of Laysan albatrosses—a scene sharply contrasted with the previous photograph taken before the rampage of the Japanese plume-hunters. Worse, the snapshot taken by Alexander Wetmore when he reached Laysan in 1923 shows the island virtually denuded of vegetation by the remaining rabbits. Today, there is little evidence of the guano mining operation which began the tragic chain of events; even the rails carrying carts of guano to the docks have disappeared with time.

WARREN R. ROLL

WALTER K. FISHER

WALTER K. FISHER

DONALD DICKEY

The three species that vanished: The Laysan millerbird (top) and Laysan rail (center) were seen at their nests on this besieged island in 1902; the last Laysan honeycreeper (bottom) was portrayed on movie film in 1923.

absolutely essential to the wildlife of the island. We didn't use more than a bale of the alfalfa. We mixed it with poison, and to protect the birds that might have picked it up otherwise, placed it deep in the rabbit burrows."

During his first half-hour on the island, Dr. Wetmore could do little but stand in awe at the swirling clouds of seabirds. Then, when he began inspecting the island, he was struck at once with the desolation. Only remnant stands of vegetation remained. Petrels and shearwaters, once safe in their burrows, were now trapped with each windstorm. The old buildings were still there, more weatherbeaten than ever. Two coconut trees still stood beside the old Schlemmer house. In the limited shelter of a coral outcropping, Dr. Wetmore found three of the little Laysan honeycreepers, all that remained of a once vigorous population. The millerbirds were gone. And as for the Laysan rail, only the mummified remains of the last of the species were found.

The elimination of Laysan's remaining rabbits began immediately. There were perhaps no more than 500 rabbits left—skinny, starving individuals that came out in the evenings, vainly seeking greenery to satisfy their hunger. By the end of the fourth day the expedition had killed more than 250 rabbits. Already, the scientists could see the difference. Scattered plants, relieved of the incessant gnawing, had begun showing signs of renewed life. With his camp established and his party at work, Dr. Wetmore left Laysan aboard the *Tanager*, bound for a brief survey of the islands to the west.

"I returned the afternoon of April 29th. There had been stormy weather throughout most of the western trip." For three days before his return, gale-force winds had swept across the barren sands of Laysan. "But on the date of my return," he added, "everything was calm again, except for the usual trade wind." But the storm brought tragedy.

What about the three honeycreepers? Dr. Wetmore promptly searched for them around the coral rocks—without success. They were never seen again. This was a rare and sad event, for a naturalist had witnessed the extinction of a species. A few days earlier, Donald Dickey had photographed the last living Laysan honeycreeper.

There was still a glimmer of hope for the Laysan rail. If Dr. Bailey's team had not moved a seed stock of the flightless rails to Midway Islands, this species, too, would have been extinct. Now, Dr. Wetmore had brought eight rails back from Midway to their ancestral island. He released them on Laysan and watched as they scurried about, seeking places to hide. Exposed to view as they were on the now barren dunes, the rails were picked up one by one by frigatebirds. After a few days, no rail was ever seen again on Laysan. The species did prosper on Midway, however, until World War II. But increased military activity on the atoll introduced large numbers of rats. The rails on Midway soon vanished. The rabbits

These were two of the last seven Laysan ducks in 1912; there may be 200 on the island today. Perhaps no other species has survived such a low number. A familiar flying goose marks this refuge of the black-footed albatross.

of Laysan had wrought the extinction of three species.

Dr. Wetmore's expedition saw fewer and fewer rabbits as each day passed on Laysan. There were times when they did not find a single rabbit for three or four days. "I went out at dawn," Dr. Wetmore told me, "to check for them. The wind would die down at night, and rise again in the morning. If you got out early before the winds came up to cover the tracks, you could see where the rabbits might still be living." Finally he could find neither rabbits nor tracks. If the *Tanager* party left any rabbits behind, they too soon perished, victims of the biological disaster their ancestors had visited.

As they were preparing to leave Laysan, Dr. Wetmore noticed one of the ship's sailors playing on the beach with some kind of animal, and he walked over quickly to investigate. "What the sailor had brought ashore," Dr. Wetmore recalls with a smile after all these years, "was a pet rabbit that he kept on the *Tanager*. I told him to take that rabbit, get back on the ship, and never come ashore on Laysan Island again."

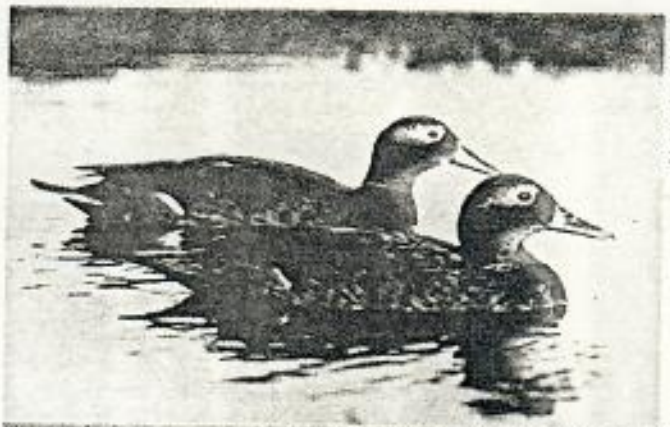
During his visit to the Leeward Islands, Dr. Wetmore also landed on Lisianski, 150 miles farther west. Rabbits had once been released here also, but they had devoured their food sources and starved to death. He then visited Southeast Island in Pearl and Hermes Reef, which I saw in the spring of 1969 with refuge manager Gene Kridler and his team. And there Dr. Wetmore found—and exterminated—still more rabbits, which were wilder than those on Laysan.

As had others before me, I stood one evening on the low ridge where Max Schlemmer had built his frame house, and silently marveled at the multitudes of birds. Hundreds of thousands of wings filled the sky, and the voices of the seabirds created a thunderous din.

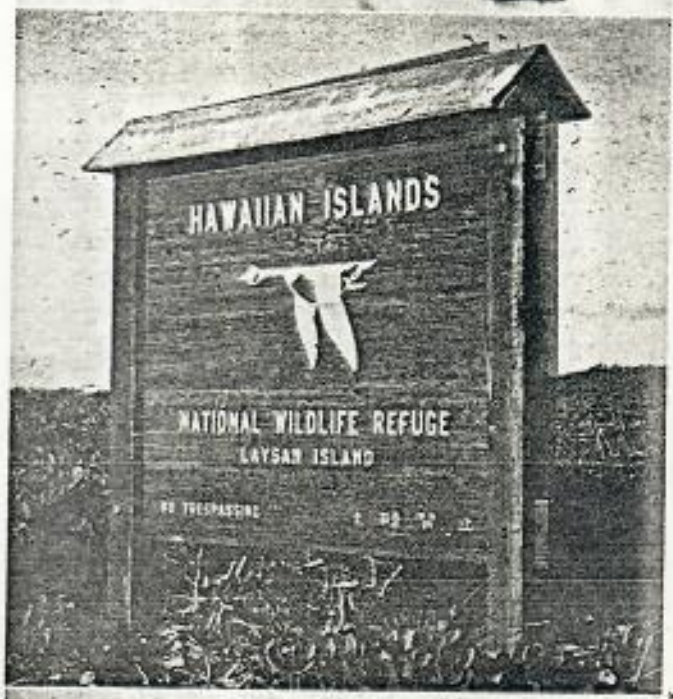
Laysan's vegetation has recovered over the years. The old buildings are gone at last. The coconut trees are gone, too. The only evidence of the guano industry are a few remnants of weather-beaten cross-ties lined out across the sand, where carts once carried their guano burden through nesting colonies of albatrosses.

A more recently planted grove of coconut trees grows at the eastern end of the shallow lagoon. In the low vegetation between the coconut trees and the lagoon, hundreds of Laysan albatrosses with their gleaming white breasts and clean black backs raise their young. And nearby, the little Laysan ducks, now numbering perhaps two hundred, slip out of the dense cover of the *Scaevola* in the late evening sun.

Where the trail leads up from the beach, through thick-growing native vegetation, there stands a large sign to warn that Laysan Island is part of the Hawaiian Islands National Wildlife Refuge, and that unauthorized visitors are forbidden to come ashore. One reason is the ever-present fear that some new foreign animal, whether rat, cat, or mongoose, might find its way to this wondrous island which we have reserved for the birds. ■



ALFRED M. BAILEY



GEORGE LAYCOCK

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U.S. DEPARTMENT OF COMMERCE
National Oceanic and Atmospheric Administration
NATIONAL MARINE FISHERIES SERVICE
Southwest Region
Western Pacific Program Office
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July 2, 1981 F/SWR1:JJN

TO: The File

FROM: John J. Naughton, Fishery Biologist, WPPO

SUBJECT: Green sea turtle entanglement, Kailua Bay, Oahu

On June 19, 1981 at 1610 the NMFS, WPPO, received a call from a Ms. Jean Mooney (835-B North Kalaheo Avenue, Kailua, Oahu, phone No. 261-2447) concerning two turtles they found entangled in a section of line in Kailua Bay. I was on leave that day and since my home is not far from the above address, the office called me and I investigated the report.

I arrived on the scene at approximately 1640 and found a group of young people with two green sea turtles (Chelonia mydas). The larger of the two (25" carapace length) was dead and the smaller (23-1/2" carapace length) was alive but apparently very weak. It was placed in the shade and covered with wet towels and was released approximately an hour later offshore in Kailua Bay. Later inspection indicated the dead turtle probably drowned less than 4 hours before it was found. Both turtles were immature with no obvious physical defects or markings, including tags.

The people on site stated that while water skiing in the bay they sighted a turtle at the surface, a rather common occurrence. However, as they passed, the turtle did not dive and upon closer examination was seen struggling to remain at the surface with another turtle below it. One of the men entered the water and found that the two turtles were entangled in a piece of line which was fixed to the bottom.

The line was attached to a 15-pound "Japan" anchor which was in a little less than 2 fathoms of water. They removed the anchor from the bottom and hoisted the anchor, line and two turtles into their boat and immediately brought everything ashore. The living turtle had several bites of line wrapped around the left fore flipper while the dead animal had three bites tightly wound around its neck. Neither turtle was tied with the line as we first suspected, but apparently became entangled accidentally. The position of the entangled turtles was approximately 200 meters off the mouth of Kaelepulu Canal, immediately northwest of Popoia Island in Kailua Bay (21° 24.3'N, 157° 43.8'W).

The line which the two turtles were entangled in is 6 fathoms long, 1/4-inch diameter braided nylon with a cotton core, and is presently at the Western Pacific Program Office. It had not been in the water long as there was very little marine growth on it or the anchor. There was no float on the

line and it apparently was partially tangled in coral growth on the bottom or the turtles would have easily been able to swim to the surface for air as the water depth was less than 2 fathoms.

cc: F/SWR3
F/SWC2, Richard Shomura
F/MM
SEAN, Washington, D. C.

7-14-83
Hand delivered by
Frances Oishi
(DAR).

WPPO	
DEG	✓
JJN	✓
ETN	✓
PAM	✓
HEW	✓
WCS	✓
SLA	✓
MCS	✓
GKH	

John —

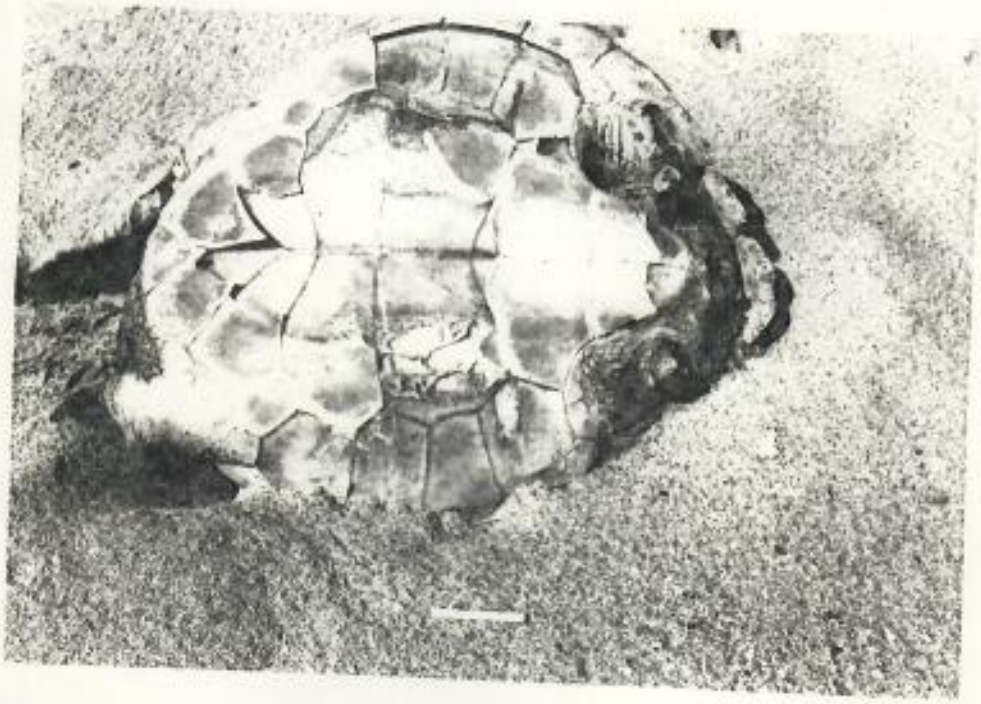
Here are the photos of the "Malaekahana" turtle we said we'd send. The enlargements clearly show the blue-green netting and white, synthetic twine which was adhered to decomposing skin of turtle's throat. Of the smaller prints, one shows the ventral surface of the turtle (as it was found by me on June 23; the "scale bar" in the foreground is 84 mm long); the other shows the stumps of the rear flippers. The smaller prints were exposed first, prior to disturbance. Before the shot in the medium enlargement, I dug out the right fore-flipper to look for a tag -- none, and no signs, in either fore-flipper. Noticing the netting and twine, I then poured water over the neck to wash off some of the sand before shooting the last shot (largest print). Further excavation then disclosed that the lines could not be more clearly separated from decomposing tissue of neck without major effort, and I envisioned that you folks might wish to conduct your own investigation. Incidentally, the anterior 2/3 of the neck vertebrae and the cranium were nearly clean, and the mandible was missing. Note the ocypodid burrow just beyond the position of the buried skull.

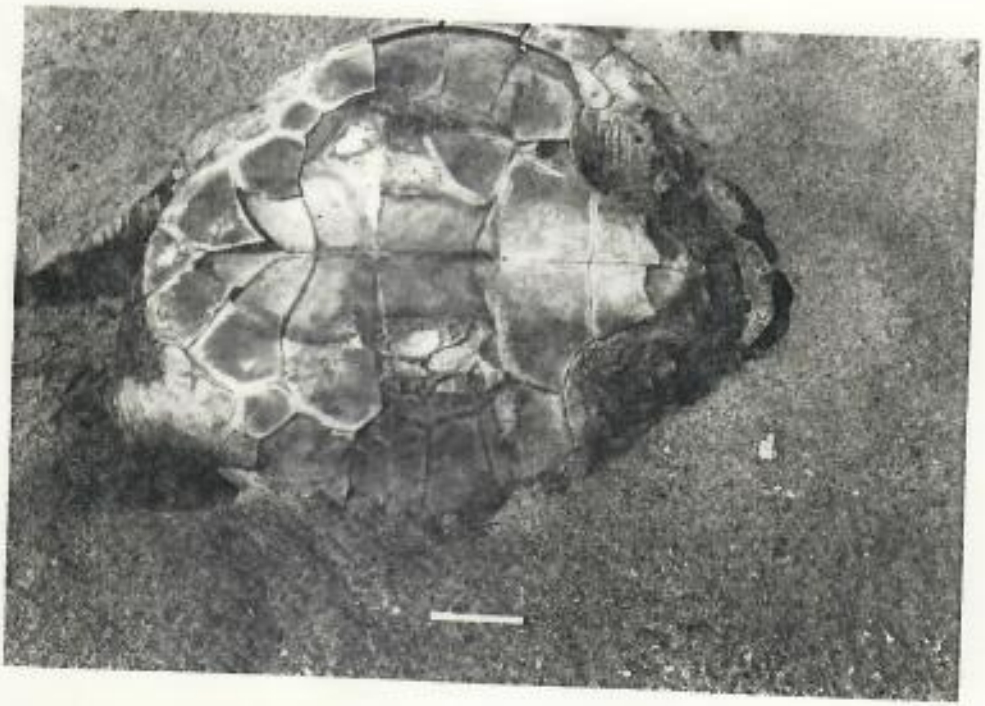
Briefly, as reported to you verbally at the June 24 Waianae outfall meeting, I learned the following on June 23 from a local fisherman (carrying a thrownet):

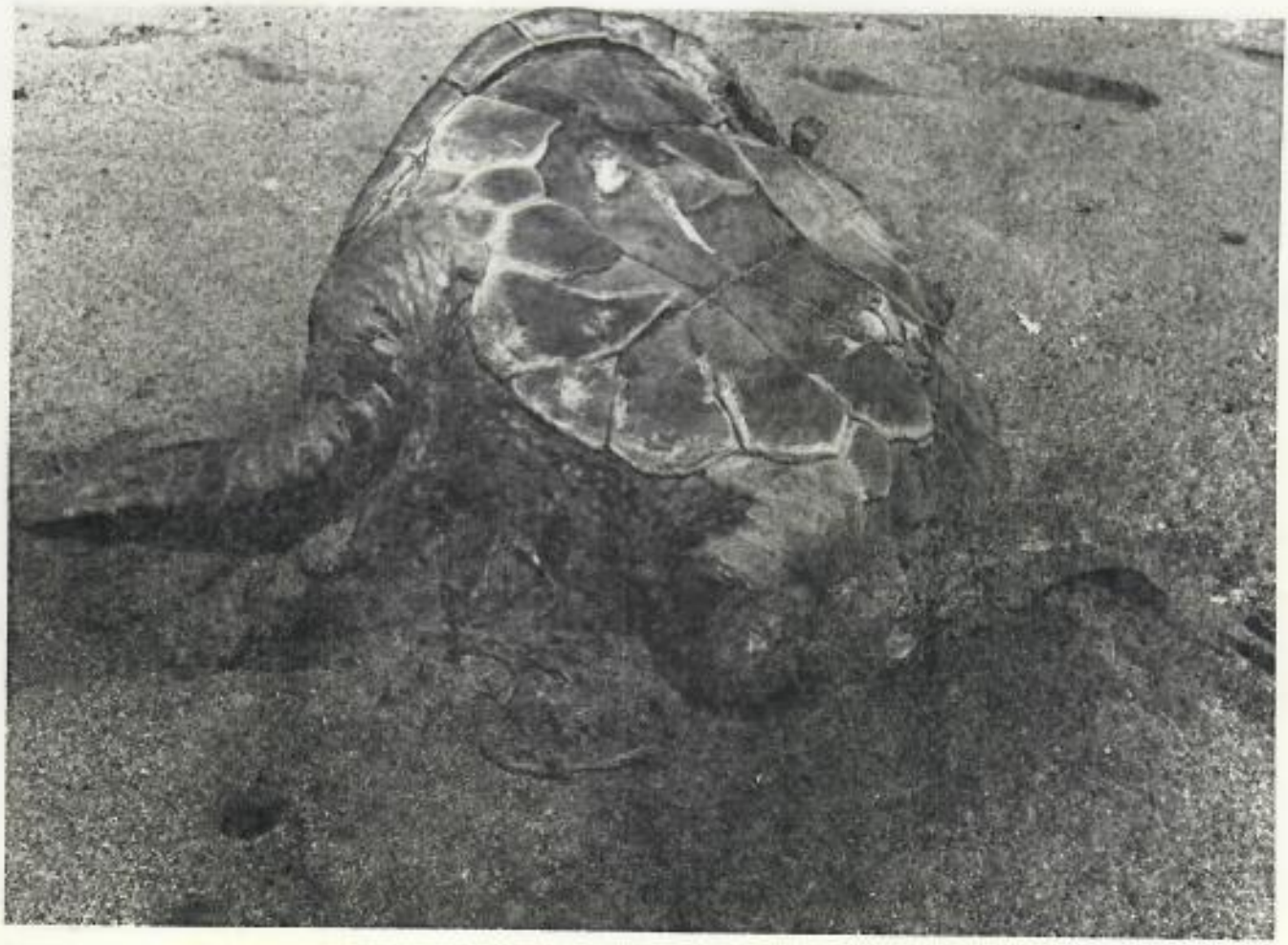
- he was present when the turtle washed across the reef, near the "Kuilima" end of the county golf course at Kahuku, on June 19;
- at that time the turtle was dead and the back flippers were already missing;
- the fisherman called DOCARE (DLNR enforcement) "hotline" to ask if he could keep the shell, and when told "no" he and a friend buried the turtle on the beach.

By June 23, the carapace had split open along the longitudinal axis and internal decomposition appeared/smelled well-advanced. Nevertheless, by June 27 the entire set of remains had vanished; what appeared to be a scapula was found submerged on the reef flat.

- Dave Eckert







The Tale of the Wounded Turtle

By Jan Newhart

Was that a knife in Turtle's shoulder?

I peered through the slightly murky water. Yes, the left flipper was dragging. Turtle was hurt.

On each of my three-times-a-week swims at our Outrigger beach I made it a practice to say hello to Turtle and bring greetings from my children Twain and Tracy on the mainland. Today (mid-March), Turtle didn't respond, just paddled around weakly near a coral reef.

What to do? I certainly didn't want Turtle to end up on someone's dinner table. Turtles have been around for over 75 million years, long before man, but now a person has caused this existence to be threatened.

It took half a dozen telephone calls to various local, state and federal agencies before I reached the right person, George Balaz, a zoologist and turtle expert with the National Marine Fisheries Service. Following his instructions, I watched Turtle for a couple of weeks and reported to him the times and locations of the sightings. George determined when we might mount a rescue effort.

Jan Newhart

George Balaz, National Marine Fisheries Services, brings Turtle in for treatment.

On that day, I was ready in my bathing suit and goggles but George showed up dressed for hiking through the brush! He explained that wrestling a turtle underwater around coral reefs can lead to more than a few abrasions.

I could see his point; the last time I took a guest out to see Turtle, my guest got all cut up.

After a few miscues, I led George to Turtle's lair. George immediately recognized the problem. The 250-pound female Turtle had a large fishing lure imbedded in her shoulder and some of the leader was wrapped about the left flipper.

Directing me to stay back, George dived and then surfaced with his arms wrapped about Turtle. I could certainly see the necessity for George's protective clothing.

When we reached the beach, I had to explain to some angry beachgoers that George was not taking Turtle to the stew pot but to the hospital.

George surgically removed the hook and unwrapped the leader from Turtle's flipper, and Turtle was soon back in the sea.

George said that Turtle is from French Frigate Shoals and will return there to breed upon reaching maturity.

It was a thrill to see Turtle swimming off to freedom and the crowds on the beach told George he was a hero. George told me I was the hero. We weren't thinking of heroism, just a simple act of love for a hurting friend.

As Clint Eastwood says: it "made our day."

For Sale

The Club's 1974 Boston Whaler, 1982 90 HP Johnson outboard motor mounted, and 1982 115 HP Johnson spare outboard motor are for sale to the highest bidder. Also for sale are the Dilly trailer, center console, tachometer, temperature gauge, bilge pump and four 6-gallon fuel tanks. The upset price for the total package is $3,000.

Bids should be submitted to the Club manager. Bids will be opened June 18.

Carolyn Lass is learning to shoot. Sure doesn't feel like a paddle, she says.

Kissel has shaken the sand of Hawaii from his feet to accept an executive position with a Texas oil company. The embryo tycoon was already practicing his Texas style lingo before he left: "Well," he said, "a million here and million there soon adds up to real money."

The Outrigger Canoe Club and member **Joe Quigg** were featured in a March article in the Los Angeles Times. The article quotes the inscription at the Club entrance which reads, "Let this place be a place where man may commune with sun and sand and sea, where good fellowship and aloha prevail and where the sports of old Hawaii shall always have a home."

Quigg is considered one of the world's best designers of racing class paddleboards, according to the article. But in recent years, the article continues, he has achieved notoriety of a different kind for his designs of the Hawaiian canoe, "one of the world's most remarkable vehicles." Joe designed 18 of the first 20 boats to finish last year's Molokai-Oahu race, says the article.

Fred Hemmings is quoted as describing Joe as "a great Hawaiian natural resource" and **Hank Lass** calls him "a master craftsman and a master designer . . ."

Joe is now working on a dream project, the article says, hand carving a canoe from a koa log . . .

John Goss shows off new granddaughter Marilyn Townsend Majors born April 24 in Dallas, Texas. Townsend waited for her grandfather to arrive in Dallas and then before he could get his suitcases from the plane, they were off to the hospital for a fast delivery.

Alice is at the Palace!!! **Alice Guild** assumed the position of managing director of Iolani Palace on April 1. . . . **Sunny Corey** had a nice trip to Hong Kong and Korea in April with her girlfriends, while husband **Jim** stayed home and tended to the "back 40" at their Haiku Plantation home.

New Club Director **John Goss** was pleased with his 16th place finish in the Great Aloha Run in his age division. He ran the course in 1:14.20 . . . Our reciprocal club, the Denver Athletic Club, no longer has sleeping room accommodations. However, they will offer special rates for guests at the Holiday Inn or the Cambridge Club. Contact the DAC for reservations and rates.

The Club has lost one of its colorful members of yesteryear. **Gilbert Brightman,** known as "The Professor," was one of the premier sand doubles players of his time. His nickname came from his studious manner and almost scientific approach to the game. However, as in the tradition of most young members, he was also well adept at handling a surfboard or paddling a canoe.

By 1951, his dominance of the courts reached full stride, having teamed with **Pat O'Connor** to become the youngest pair in Club history to win the Open Doubles Tournament. To his wife and children, and his mother, **Anita Brightman,** we extend both our heartfelt sympathy and our deep appreciation for designating that bequests on his behalf be made to the Outrigger Duke Kahanamoku Foundation.

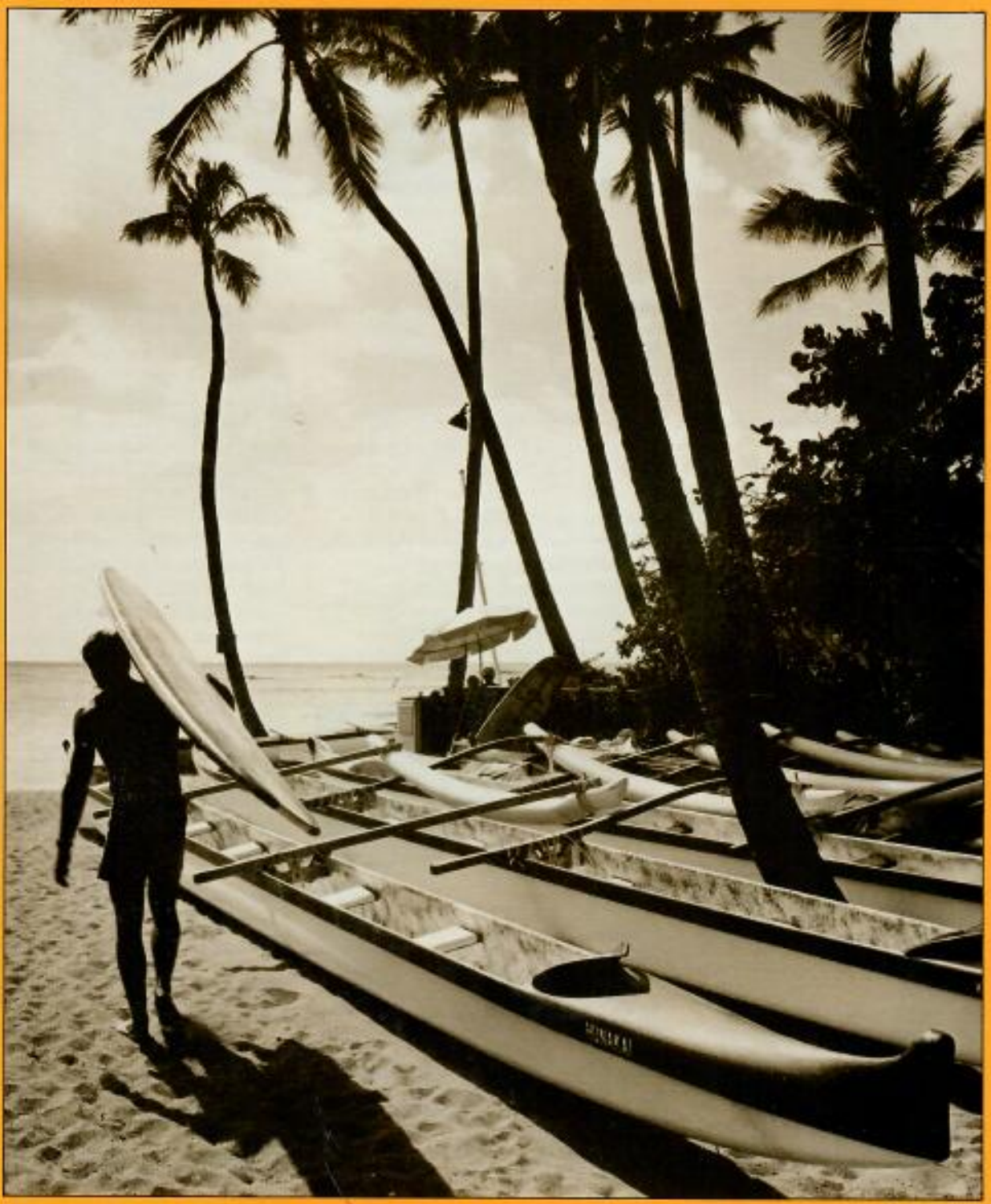
Hank and **Carolyn Lass** postcard that they're having a wonderful time on their three-month trip to Alaska. In late April they were working their way up the coast of California, taking mud baths and massages in Calistoga, glider rides and winery tours in Napa, and skinning and cooking fresh catfish in Lake Berryessa . . .

Contributions to this column are always welcome. Leave items for the Editor at the Front Desk. Please include your name and membership number in case additional information is needed.

Marc Haine and Sandra Stanley were married on February 16.

the Outrigger

June 1986



Published by the Outrigger Canoe Club for Members and Guests at Home and Abroad.

Club Day '86 a Real Winner

Participants in the Run-Bike and Ocean Triathlon gathered at the beginning of their event.

Photos by Di Guild

Peter Balding tags Tim Guard in the Ocean Triathlon.

Club Day 1986 was one of the best in the Club's history as nearly 100 members turned out to run, swim, bike, paddle, spike, kayak, watch the Kentucky Derby, eat, drink, dance and be merry.

May 3rd started with 22 members appearing at 7 a.m. for the first annual Run-Bike event. The names of all competitors were put in a hat and teams were drawn. It was up to the pair to decide who would run around Kapiolani Park and who would bike to the Arco station in Kahala and back.

Thirty-one minutes and forty-three seconds later, after Kimo Austin had run the lap around the park, and Steve Timpson had sprinted on his bike to the finish line at the Kalakaua Avenue fountain in front of the Elks Club, the pair was declared the winner. Andrea Lehman and Dale Hope were second, and Diane Stowell and Kent Davenport finished third.

The action then moved to the beach for the Ocean Triathlon. It consisted of a 700-yard swim out past the windsock and back, a paddleboard race along the same course and finished with a 1,400-yard kayak race (two times out and back).

Again, the teams were drawn from a hat, and had to decide who would do each event. The team of Kisi Haine (swimmer), Karl Heyer IV (paddleboard) and Mary Franco (kayak) won the event in :27:53. Right behind them were Diane Stowell, Roger Cundall and Mike Town in :27:19.

After the Kentucky Derby and some refreshments, the afternoon activity began.

First up was the volleyball game in which eight teams participated. Winning the volleyball game was the team of Kisi Haine, Karl Heyer IV, Janice McPheeters, Michael Scott, Shandy Danford and Grant Senner.

Then it was back to the ocean for the canoe race. Frogman Brant Ackerman added a little excitement to the race when he managed to flip the finalists in the event while they were waiting for the start of the race. After bailing out the canoes, the race got underway and the winners were Peter Balding Jr., Susan Baron, CeeCee Sheehan, Randy Shibuya, Jeanne Jenkins and Roger Cundall.

Dale Hope, coordinating director for athletics, and Paula Carbone, Club Captain, planned a successful Club Day.

Since the second place finishers in the volleyball game and canoe race were the winners of the other event, a swim off was held to determine the champion. Each team member had to swim out to the windsock and then back. The final overall champion was Kisi Haine's team which won the swimoff.

If that wasn't enough, attention was then turned to the sand for the popular flag race, the final event of the day. Sand flew in all directions as competitors vied for the flag in the elimination contest. The winners were Ryan Haneberg in the Boys 10 and under event; Ian Moore in the Boys 10-16; Mike Sheehan in the Men 16-35; John Finney in the Men over 40; and Michele St. John in the women's category.

After the athletic events, the action turned to the Terrace for a Steak Fry, entertainment and dancing.

"I think that all those who participated enjoyed themselves," said Paula Carbone, Club Captain. "I'd particularly like to thank the Board members who participated—Mark Buck, Dale Hope, Kimo Austin and Kent Giles.

"I'd also like to thank all the athletic committee chairpersons who did such a good job in organizing the events—Diane Stowell, Robin Smith, Roger Cundall, Darcy Ames, Tiare Finney, Karl Heyer IV, Peter Balding, George McPheeters, and Mike Buck who emceed."

apparent. If a parasite should entirely exterminate its host, it would itself become exterminated, not having any more of the food specially required for its existence. In a state of nature there is a balance between insects and their parasites by which neither becomes over-abundant. This and the presence of other natural enemies (i. e., birds, etc.) accounts for insects not being pests in undisturbed natural conditions. In the various operations of man, especially in agriculture, natural conditions are disturbed and the "balance of nature" is upset; and many insects have become pests by reason of the unnatural conditions being more favorable to them than to their natural enemies.

The insect pests in Hawaii, except a few which are native, have come here through the channels of commerce, as was stated in the beginning, and are not introduced parasites that have changed their habits and become pests. There is not the least occasion for anticipating that any parasite introduced may later on become a pest. Those who have had any such idea should at once relieve their minds on that point.

WRECKS TO THE NORTH-WEST

By Rev. J. M. Lydgate.

THE islands and reefs to the northwest of Hawaii have been a veritable graveyard of marine disaster. The two sufficient reasons for this have been, first, the low, inconspicuous character of the islands, and, second, the faulty or insufficient location of them on the marine charts.

The menace of an iceberg is the fact that it lies seven-eighths under water, and you strike some submerged, protruding spur of it before you dream of danger. In a much more disastrous way the same thing is true of many of these islands.

In some cases, to be sure, there is a high island, easily visible from afar, but even in these cases there is usually a guarding wall of reef, outlying, which the unfortunate mariner strikes, while he is still far away from any apparent danger.

In other cases there is no such central high island, but only a low-lying strand of coral rock and sand, barely emerging above

these parasites (*Opius humilis*) is already known to have become established in several palces.

In this short paper only the more important of the introduced beneficial insects have been mentioned. There have been many others of less importance, either by reason of their attacking less important insect pests, or that they failed to increase in sufficient numbers to be of significant value. There have been many tried which for climatic or other reasons entirely failed to become established.

The entomologists, encouraged by those which have been successful, are continuing in this method of combatting insect pests, and from one or the other of the institutions here projects for the introduction of more beneficial insects are continually being carried on. At the present time Mr. Muir of the Experiment Station, H. S. P. A., is attempting the introduction of parasites from Japan for the grubs of the *Anomala* beetle, which are very injurious to sugar cane by eating off the roots. Messrs. Fullaway and Bridwell are making further attempts at introducing certain fruit-fly parasites from Africa, discovered by Dr. Silvestri on his first trip, but which failed to survive the voyage to Honolulu.

There seems to be an idea prevalent in the minds of many that the insect parasites introduced by the entomologists always turn into pests later on. We are often asked in regard to a new parasite that has been introduced, "Well, what crop, or fruit, will this parasite attack when it gets the pest exterminated?" This by apparently intelligent persons, too. If there had at any time been an instance of one of the insect parasites introduced by the entomologists having become a pest and injurious to some crop, there might be some grounds for questions of that kind. But none of these parasites have ever become pests, and it is impossible to understand how the notion has become prevalent with so many people.

Parasitic insects do not change habits that way. Once a parasite, always a parasite. Another thing that is not generally understood about insect parasites is the fact that they never exterminate the pest which they parasitize. They only destroy some of them—sometimes only a small percentage, and sometimes nearly to extermination but not quite. The reason for this is

the sea, or a line of sunken reefs on which the ocean breaks in patches, here and there, or, it may be, only in heavy weather.

The mariner, unless he is very wary, especially at night, fetches up on one of these outlying or sunken reefs before he realizes that he is in a position of danger at all.

The Pacific Ocean is a maze of reefs and islands, whose careful and authoritative location is a vast and expensive undertaking, involving many years of exploration and survey. Commerce couldn't wait for such a survey. In default, however, of such survey, it has been the custom of mariners to report such perils to navigation as they might find, and these locations have held until they were superseded by information, more recent or more authoritative.

The most ubiquitous navigators of the Pacific, during the last century, were the American whalers, and very many of these small islands and reefs were reported by them, oftentimes more or less incorrectly. These old whalers were rough and ready navigators, without the skill or the appliances for exact work in navigation. Furthermore, they had oftentimes been a long while at sea, and didn't know very accurately where they were themselves, and weren't in a position to report very accurately any "finds" they might make.

Position at sea is made up of the two elements, latitude and longitude. Latitude is determined directly from the sun, and depends only on the care and skill of the observation. But longitude is a little more complicated. The local time must be ascertained by observation of the sun, and that time compared with Greenwich time, carried by a good watch or chronometer from the beginning of the voyage. Now, this chronometer time may have been carried for months, without opportunity for careful correction, and it may easily happen that this "canned" time is several minutes out. Now, when we remember that one minute of time may mean 15 or 16 miles of distance, we realize how easy it was for these old whalers to be out in their reckoning.

Furthermore, it may not always have been convenient to make an actual observation, at the time of noting such an island or reef, so it was necessary to *deduce* the location by estimating, or guessing, how far they were from the last authoritative observation.

Being nomads of the sea, with no fixed course, and no immediate purpose of arrival, they were content to drift wherever the currents might carry them, and were comparatively indifferent as to where they were, so long as they found whales. This happy-go-lucky frame of mind finds abundant expression in faulty locations.

These whaleship reports, however, imperfect though they were, were, of course, infinitely better than none at all, and accordingly the perils they reported went down on the charts in their appropriate places.

A later navigator, sailing these same seas, and accepting the chart location as authoritative, struck the same reef 15 or 20 miles away, and he in his turn reported it with his latitude and longitude; and perhaps neither of them was correct. Later, perhaps, a survey vessel, properly equipped, made a careful voyage of discovery and confirmed or discredited these locations. So we have to this day, on the best charts of the Pacific, many reefs and islands marked E. D., (existence doubtful) or P. D. (position doubtful).

With this somewhat elaborate introduction, let us now turn to the detailed examination of the various wrecks so far as I have been able to find them.

NIHOA OR BIRD ISLAND.

Discovered by Capt. Douglas of the *Ipheginia* in 1789. This is a high island, 380 ft., very bold in outline, with no outlying reef, and within easy reach of Kauai, so that its exact location was an easy matter. For these reasons, it has not been a menace to navigation and has no wrecks to its credit.

NECKAR ISLAND.

Discovered by La Perouse in 1786. A high island, 280 ft., with no reefs and no wrecks.

FRENCH FRIGATE SHOALS.

Discovered by La Perouse, the French navigator, in 1786, and named by him from his two frigates. The islands consist of a central rock 120 ft. high, surrounded by sixteen small sandy islands, and many reefs and shoals, constituting a most serious menace to navigation, the more so as the central rock presents the illusion of a full-rigged ship, serving as a decoy to the unhappy mariner.

The American whaler *South Seaman* was lost here March 13, 1859. Realizing that their only hope of escape lay in the attempt to reach some inhabited land, they dispatched a boat to Guam, which, though more distant than Honolulu, lay in the track of the "trade winds." Before they had proceeded any distance, however, they fell in with the Hawaiian whaling bark *Kamehameha V*, which picked them up and, proceeding to the shoals, took half the marooned men abuard, conveyed them to Honolulu and then returned for the balance.

April 14, 1867, the *Daniel Wood*, whaler, struck the Bessie Francaise, another of the same group of reefs. It was a beautiful, clear night, with a fine full moon. The captain was below and, hearing a sharp, ringing order to "bout ship," sprang on deck; but it was too late—she was already over one reef and onto another. They cut away the masts, got the boats out and lay by till morning, when they saw at some distance the lone rock and its sandy fringe of beach. They got all possible supplies off the wreck, and stored them on shore, and immediately determined on an expedition to Honolulu. Selecting their best boat, they proceeded to build up and deck her over, and otherwise equip her for the trip. But they were badly handicapped by lack of tools, all they had being a hammer, a saw, and an old chisel. Even nails were denied them, and they must painfully and laboriously extract every nail they used from some portion of the wreck, whence also they must secure evry bit of board they used.

On the completion of the boat, the captain and seven of the crew set out for Honolulu, leaving 27 men behind. This boat's crew were put on short rations of one pint of water and one sea biscuit a day. In due time they reached Niihau, where they were hospitably received and given the best that the island afforded. They remained here 24 hours and then pushed on for Honolulu, which they reached two days later. Fortunately, the *Lackawanna* was there, and she immediately assumed the rescue of the unfortunates, proceeding to French Frigate forthwith, for that purpose.

The *Daniel Wood* left some pigs on the island, which suited themselves to the conditions, and developed aquatic instincts, so that they could swim from island to island in pursuit of fish and

other sea food. They were found here in a thriving condition by the Hawaiian brig *Kamehameha* V in 1872.

The American whaler *Rebecca* was the next victim of these treacherous reefs. Cruising near by she saw at midnight the deceptive full-rigged ship rock, and attempting to come to close quarters, struck the outlying reefs. Fortunately she carried over it into smooth water, so that she was saved from immediate destruction. Farther information as to the fate and fortunes of the crew are lacking.

A sailing schooner (name not recalled) also struck one of these reefs several years ago and came to grief. She was running one night before a fresh breeze with so much headway that she went clear over the reef into the still water beyond where she immediately sunk. The disaster was so sudden that little or nothing was saved except three dories which were on deck and were easily rescued in the confusion. In these little unseaworthy boats, with almost no provisions, they made the trip to these Islands. Fortunately they had smooth weather all the way otherwise a disastrous outcome must have been inevitable. Reaching Niihau, one of the boats fell in with some fishermen clad in such primitive costume that the mariners mistook them for dangerous savages, and, pulling out, sought a distant and secluded section of the island where they remained several days before they were found.

The French bark *Conetable de Richmont*, from Hongkong for Taetal, ran ashore on French Frigate shoals, October 10, 1903, and had to be abandoned, the officers and crew dividing into three boats under charge, respectively, of the captain, chief officer and boatswain, and headed for these islands. The captain's boat reached Niihau on the 18th, and the party was conveyed to Waimea, Kauai, thence to this port. Steamers were sent out in search of the missing boats, but failed to fall in with them. The mate's boat landed at Kailua, Hawaii, on the 22nd—ten days out—while the third boat's crew also reached Niihau, after much hardship through stress of weather and condition of the boat, on the 24th, and was brought hither by the *Mikahala*. The steamer *Kauai* was sent to the scene of disaster and found the ship capsized and entirely submerged save a portion of the bow.

GARDINER ISLAND.

Discovered by Capt. Allen of the American whaler *Maro* in 1820. Shoals and reefs 35 miles in circumference, with no emerging island. Very dangerous, but no wrecks reported.

DOWSETT'S ROCK.

A little to the south of Maro Reef. Discovered by the *Kamehameha V*, which struck one of the reefs and narrowly escaped serious disaster. Named from Dowsett, owner of the *Kamehameha V*.

It was probably on this rock that the *Two Brothers* was lost fifty years before.

Bark *McNear*, en route from this port to Laysan Island, was lost on Dowsett's Reef on the night of May 14, 1900, striking the reef so hard there was no hope of saving her, as she immediately began to fill. Officers, crew and laborers, thirty-three in all, set out on the 15th in three open boats for Laysan, sixty miles distant, which they fortunately reached in safety after 36 hours.

LAYSAN ISLAND.

Discovered by Stanikovitch, the Russian navigator, in 1827, and named after his vessel. Brook, visiting the island in 1859, found the remains of a wreck there, but I have no information in regard to it.

March 3, 1905, the Hawaiian schooner *C. C. Kennedy* went ashore by stress of weather on this island, the vessel and boats becoming total wrecks, from which but a small portion of stores and no personal effects were saved. The crew were fortunately rescued by the U. S. gunboat *Petrel*, March 23rd, and brought to Honolulu.

LISIANSKY ISLAND.

Discovered by Capt. Lisiansky of the Russian ship *Neva*, which struck the island October 15, 1805, and narrowly escaped complete disaster.

This has been a very disastrous island, for the two reasons I have emphasized. It is a low island, with a large extent of outlying reef; it had been so variously and incorrectly reported that, as late as 1859, Capt. Paty found the island one degree, or some 50 or 60 miles, out of place on the charts.

In 1844 the *Holder Borden*, Capt. Pell, was wrecked on this

"unknown island," which was then named Pell's Island. The *Borden* was an American whaler of 442 tons. They immediately set about building a small schooner, which they called the *Hope*, in which to make the voyage to Honolulu. Handicapped as they were for want of tools, this work took four months; but so well built was she, that they sold her afterwards in Honolulu for $1400. In this schooner twenty-five of the crew made the trip to Honolulu, taking 23 days for the voyage, and the brig *Delaware* rescued the remaining eleven men a few weeks later. The *Borden* was pretty well loaded with oil, most of which was stored on the island, and was rescued by the *Delaware*, though a considerable portion of it leaked out and was lost.

The American whaler *Konohasset* was wrecked on the same island May 24, 1846. With surprising alacrity they set to work, and completed a sloop in eighteen days, in which the captain, the mate and five of the crew made the trip to Honolulu in forty-two days. The balance of the crew were rescued August 4 of the same year.

Probably about the middle of May, 1872, the German brig *Wanderer* was lost on this same island. The *Kamehameha V*, arriving there July 24, 1872, found the wreck, waterlogged and deserted. The log was finally found, from which it appeared that she was bound from San Francisco to Tartary. The last entry in the log was May 9, presumably just before she struck. There were indications that a boat had been outfitted for sea; at any rate, no one was left.

This island has a somewhat confused identity, variously answering to Lisiansky, Lassion, Pell's and several other names.

PEARL AND HERMES REEFS.

Discovered by two British whalers, the *Pearl* and the *Hermes*, lost the same night, ten miles apart, April 26, 1822. Fortunately, the disaster was followed by several days of quiet weather, so that they were able to save most of their stores, otherwise they would soon have perished, as the reefs gave promise of very little in the way of subsistence. Mr. James Robinson of the *Hermes*—later of the well-known firm of James Robinson & Co., Honolulu—immediately set about the building of a schooner from the material of the wrecks. During the

building of this relief schooner, an English whaler made the reefs, and took away all but twelve of the crews, who elected to stay by Robinson and take their chances with him. The Robinson party were ten weeks in reaching Honolulu, and were reduced to the last stages of starvation.

Pearl and Hermes consist of twelve low islands surrounded by a tangle of reefs 50 miles in circumference.

MIDWAY, OR BROOKS ISLAND.

Discovered by Brooks in the *Gambia*, July 5, 1859, and called by him Middle-Brooks Islands. He took possession of them in the name of the United States, and left a Kamchatkan in charge of them. He kept the knowledge of them to himself, and afterwards disposed of his information to the Pacific Mail Co., who for years contemplated making it a midway depot for coal and supplies, Honolulu being at that time, it was thought, too much under foreign influence.

November 16, 1886, the little fishing schooner *General Siegel*, lying at anchor in the lagoon, dragged her anchors in a gale and went to pieces on the reef. The crew of eight men were all ashore at the time. Casting about the island for some means of escape, they found a small boat which had drifted across from the wreck of the *Dunnotter Castle* on Ocean Island; also the remains of an old Japanese sampan left on the island by some fishermen. The captain, the mate, named Jorgenson, and a sailor named Brown, took the small boat and went over to the other island across the lagoon. The captain and Brown never came back, and ultimately the story told by Jorgenson was so improbable and so suspicious that it led to the presumption that he had killed them; whether in cold blood, in an altercation, or in the aberration of insanity, there is probably no means of determining. It was perhaps quite natural, under the circumstances, that the little band of three or four remaining should fear and shun him, and that they should exclude him from their reconstructed sampan, when they set out to find some inhabited island to the leeward. I question whether there is a more daring or adventurous undertaking in all seafaring annals than this of four emaciated men setting out, in a cranky, unseaworthy sampan, with nothing but dry fish and water, and with no nautical instru-

ments and no knowledge of navigation, to find a pin-head island they had heard of 1500 miles away, on the great waste of seas. And they found it!—after a twenty days' voyage.

The "murderer," Jorgenson, remained behind, presumably marooned for life. But strange things happen in these lone seas. Early in the following year the *Wandering Minstrel*, a fishing vessel of 467 tons, arrived on the scene to break his Crusoe solitare. Snugly ensconsed within the lagoon, things went well with the *Wandering Minstrel* until the winter storms set in, when the great combers swept in over the reef, flailing the vessel to and fro, straining and tugging at her anchors, until she finally dragged them, and fell foul of one of the coral patches with which Welles Harbor is beset, and, pounding there continually, she soon went to pieces.

Betaking themselves to the shore, they found a rough shelter hut left by the Welles Harbor contractors, which, however, was scant quarters for 29 people, including the captain's wife and family.

Before long, the mate, one Cameron, recognizing a kindred spirit in Jorgenson, the "murderer," together with a Chinese boy, took one of the boats and, having fitted it up as best they could, set sail for Jaluit, which they reached in due time, but failed, so it is said, to report their late companions in distress. Some months later six of the crew took "French leave," with the best of the remaining boats, and were never again heard from.

The trying conditions of starvation and exposure proved too much for some of the crew, and five of them succumbed entirely, while all were reduced to the verge of collapse. Only after fourteen months of this grim imprisonment did they escape, on the fishing schooner *Norma*, which, quite by chance, touched at the island and took them off, landing them April 6, 1888, at Honolulu.

Schooner *Julia E. Whalen*, with supplies from this port for the Midway Island cable station, went ashore there October 22nd, 1903, in attempting to make the anchorage before daylight. Heavy weather setting in, she soon became a total wreck, without opportunity of saving any portion of her cargo.

British bark *Carrollton*, from Newcastle with coal for this port, was lost on Midway Island, December 28, 1906. Her crew was rescued by the cable ship *Restorer*, which was fortunately taking

on supplies here at the time for the station for delivery en route to Vancouver, to which port they were taken. No details of the mishap were received here.

September 16, 1906, the Pacific Mail S. S. *Mongolia* grounded on the western reef off Midway Island. Part of her cargo was jettisoned and the passengers all landed. Word reaching Honolulu, the *Buford, Iroquois* and *Restorer* were dispatched to her aid, but before their arrival she was worked off the reef on the 21st, and two days later left for this port, convoyed by the *Buford,* arriving on the 28th and continuing on two days later to San Francisco.

OCEAN OR KURE ISLAND.

An early American discovery, confirmed by Stanikowitch in 1827. A small island in the neck of a pear-shaped atoll, some thirty miles in circumference.

The English ship *Gledstanes* was lost on Ocean Island at midnight of June 9, 1837. All hands got off safely, save one man who jumped overboard in a state of intoxication. "Capt. Brown remained on the island over five months, when, with his chief mate and eight seamen, he embarked for these islands, in a schooner which had been constructed from the fragments of the wreck. The other officers and men, who remained on the island several months longer, endured great suffering and were finally brought off in a vessel sent for them by H. B. M. Consul."

Five years later, September 24, 1842, the American whaleship *Parker* struck on the Ocean Island reef, and within an hour was a complete wreck. With great difficulty and many vicissitudes they finally reached shore, almost wholly destitute of water, provisions and clothing. They remained on the island, leading a very miserable existence, until May 2 of the following year, when they were rescued by the *Nassau* and brought by her to Honolulu. Capt. Tom King and Molteno were among the victims of this disaster.

The ambitious attempt to create a coaling station at Midway having failed, the U. S. man-of-war *Saginaw,* Capt. Sicard, was detailed to bring away the contractor and his supplies. Proceeding from San Francisco, by way of Honolulu, to Midway, she embarked the party and their stores, without incident, and set

sail from Midway, October 28, 1870. But before leaving these waters for good, Captain Sicard thought it was his duty to run over to Ocean Island, 50 or 60 miles away, to determine more exactly the location of the same, as it was still somewhat uncertain. He gave orders to proceed under such easy sail, during the night, as would bring them within sight of the island at daylight. Suddenly at 3 o'clock in the morning they fetched up on a reef, which morning showed them to be the outlying reef of Ocean Island. With a good deal of difficulty they saved a large part of their stores, their boats, sails, and a donkey-boiler, which was of great value to them as a condenser for the distillation of fresh water.

It soon became evident that their only likely hope of rescue lay in sending a boat to Honolulu, as the many others before them had done. Taking the best of their boats, they built it up and decked it over, and otherwise fitted it up for the long voyage. On the completion of this work, which took about three weeks, a volunteer crew of five men set sail for these islands. They had a very boisterous voyage, extending over 30 days, and ending disastrously at Kalihi-kai, on Kauai, where the boat was caught in the breakers, turned over and over and four out of the five men killed. The sole survivor, Halford, made his way to Honolulu, and from there the *Kona Packet* was immediately despatched to rescue the unfortunate victims on Ocean Island. Shortly after, more mature consideration prompted the Hawaiian government to dispatch the steamer *Kilauea,* which reached the island slightly in advance of the *Kona Packet,* and brought all hands safely to Honolulu.

July 15, 1886, the *Dunnotter Castle,* a fine large steel ship, coming up from the south with coal, and bound for San Francisco, ran full tilt into the southwest curve of the reef, and plowed her way so deep into the soft coral that she stood up on an even keel, apparently with everything intact. She, too, fitted out a boat for the Hawaiian Islands, which reached Kauai after 52 days, landing at Kalalau with the crew in a very much exhausted condition. The *Waialeale,* then just arrived, was dispatched to Ocean Island to rescue the unfortunates. Before she arrived, however, apparently the *Birnam Wood,* bound from Hongkong to Valparaiso,

had already taken the men off, after they had been on the island 33 days.

On the return of the *Waialeale*, reporting the intact condition of the vessel, a wrecking party was organized with intent to return and get the vessel off. On arrival at Ocean Island, however, there was no vestige of her. She had floated off or gone utterly to pieces, so that there was nothing left to tell the tale.

MID-OCEAN DISASTERS.

August 10, 1899, the ill-fated S. S. *City of Columbia*, bound from Honolulu to Hongkong, was abandoned about seventy miles from Kauai.

May 29, 1902, the British bark *Fannie B. Kerr*, laden with coal, was abandoned on fire about 800 miles northwest of Kauai. In the very early morning, and somewhat precipitately, the crew took to the boats. They were seventeen days in reaching these Islands, one of the boats making Niihau and the other two respectively Waimea and Mana. They suffered a good deal from exposure and privation, being reduced finally to two canned peaches and one sea biscuit apiece daily.

American bark *Ceylon*, from Laysan Island with guano for Honolulu, met heavy weather which caused her to leak so freely that she was abandoned ten days out and sank July 3rd, 1902. The officers and crew, in two boats, were four days in returning to Layson, which they fortunately reached in safety.

VISIT OF NOTED SCIENTIST. Honolulu was favored by accident, recently, in the visit of Felix von Luschan, of the University of Berlin, en route to Europe from the Colonies. During a brief months' stay his time was devoted to furthering his anthropological investigations (on which subject he is the foremost scientist), in the study and measurement of Hawaiian skulls with the view of determining the origin of the race. In connection with opportunities afforded him through the Bishop Museum, some 150 skulls were measured, less than a third of the required number for the study in hand, yet with the aid of those in the Berlin collection a report will be made which has the promise of publication by our local institution.

STORY OF KING OLA

By A. F. Knudsen.

OF ALL the Hawaiian traditions, the history of King Ola is respected, or rather beloved of all the people of Kauai more than any other. He was the great, good king, the great civilizer, the great engineer, the road-builder of history. His birth and preparation for the throne however is the subject of my story; a common enough theme, a common enough plot, with, however, its little Hawaiian variations.

The father of King Ola lived a harassed life. The priesthood was degraded, the high priest a keen, intellectual power-loving man, of no spiritual insight, and the king felt that the Tabu was in danger. But in the second generation were growing up a number of splendid young men. The young priests were noble, law-abiding men—the young chiefs, keen warriors, austere, and able to keep up the ancient tradition that the king was the father of all his kingdom. And so, at the great conclave of the priests and chiefs of the fifth degree of initiation, the successor to the throne was chosen,—only to die, shortly afterward, a sudden and mysterious death. Again they chose from among the young chiefs a splendid youth, to be understudy to the king and know how to rule in the kingly seat, and he was openly assassinated outside the temple gate when marching from one of the holiest ceremonies.

The king saw that things were against him, that the priestly party were using means that his party could not stoop to use, because the man who struck an officer with his insignia broke the Tabu. And here was his successor ruthlessly murdered, and the perpetrator of the deed undiscovered. It was a crafty conspiracy, and required a crafty counter-thrust. In those days, of course, as in the days of Solomon, a king had many wives, and in the king's retinue was a princess of high rank, short of stature but exceedingly beautiful. The king threw her out of the house, banished her to her father's keeping, robbed her of her outer insignia of a princess, and restricted her to the confines of Koula valley, where her father, a chief high in council, now did nothing more than oversee the collectors of sacred feathers plucked from