39 SEASONS WITH THE HONU AT FRENCH FRIGATE SHOALS

George Balazs

BIRD LIFE AMONG LAVA ROCK AND CORAL SAND

The Chronicle of a Scientific Expedition to Little-known Islands of Hawaii

By Alexander Wetmore

Assistant Secretary, Smithsonian Institution

With Illustrations from Photographs by Donald R. Dickey and the Author

WHEN the United States annexed Hawaii, in addition to the eight large, inhabited islands* that form the territory as the tourist sees it, a chain of islets that extend from the main group toward the northwest for more than 1,300 miles was also acquired (see map, page 79). Uninhabited by man, except for a cable station at Midway, these have been little known. In 1909, through the interest of former President Roosevelt, these Leeward Islands of the Hawaiian group were set aside as the Hawaiian Bird Reservation, and placed under control of the Biological Survey of the United States Department of Agriculture.

From time to time parties have visited Laysan, an important bird rookery, to study its wonderful bird life, and perhaps en route have landed for a few hours at one or two other points. On the whole, however, the group, from a scientific standpoint, has been unexplored.

Early in 1923 arrangement was made with the Navy Department for transportation and other assistance, and a cooperative expedition was organized by the Biological Survey and the Bishop Museum, of Honolulu, for a complete scientific exploration of these outlying islands. On April 4 a party of 12 left Honolulu on a thousand-ton Naval mine sweeper, the U. S. S. *Tanager*, for a four months' cruise.

Our party included a botanist, an entomologist, a geologist, a conchologist, an ornithologist, one or more collectors of fishes, miscellaneous marine animals, and plants, students of ruins left by man, a topographer, and one or two general assistants.

All had cameras, and, in addition, Mr. Donald R. Dickey, of Pasadena, Calif., an expert in motion and still photography of birds, accompanied the party to Laysan Island. As the representative of the Biological Survey, the direction of the work of the scientific party fell to me.

RELICS OF A VANISHED POLYNESIAN COLONY FOUND ON NIHOA

Though rough and inhospitable to the voyager (see page 76), the first island in the chain, Nihoa, proved of great interest.

Polynesians once had a colony of several hundred persons here. Level house platforms made of flattened stones rose one above the other in a little valley that, during rains, evidently contained water.

The steep slopes, now clothed with bushes, had been terraced with great labor to permit cultivation of the sweet potato and dry land taro, and a cave or two showed signs of ancient occupancy. In our excursions over the slopes we found a number of stone bowls fashioned from porous volcanic rock.

Legend runs that in early times a fisherman living on Nihoa had a beautiful daughter, desired by a prince of Kauai. When the latter came to claim her, the girl ran up the steep cliff paths, the prince in pursuit. At the ragged border of the *pali* (cliff) she stopped and cried: "If you touch me I shall jump." But the prince, unable to control his ardor, stretched out his hand to seize her.

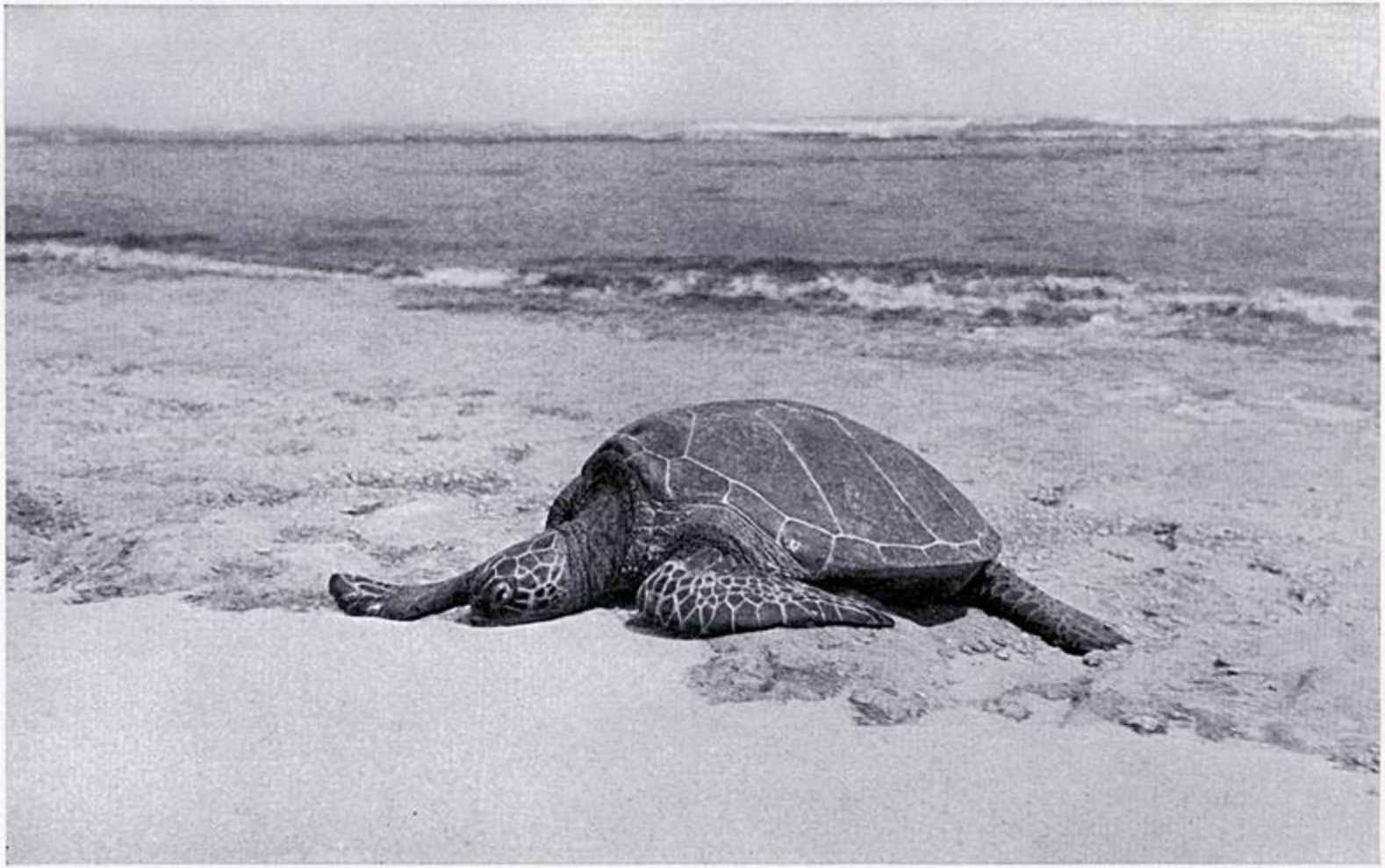
Instantly the girl sprang to her destruction, while the prince was turned to a leaning stone, which still stands on the brink of the precipice, where it may be viewed in corroboration of the story!

Small groves of a slender palm grew in some of the gulches, while a scrubby, woody-stemmed plant allied to our common lamb's-quarters clothed the slopes.

In these were flocks of the saucy Nihoa

* See "The Hawaiian Islands," by Gilbert Grosvenor, LL. D., in the National Geographic Magazine for February, 1924.

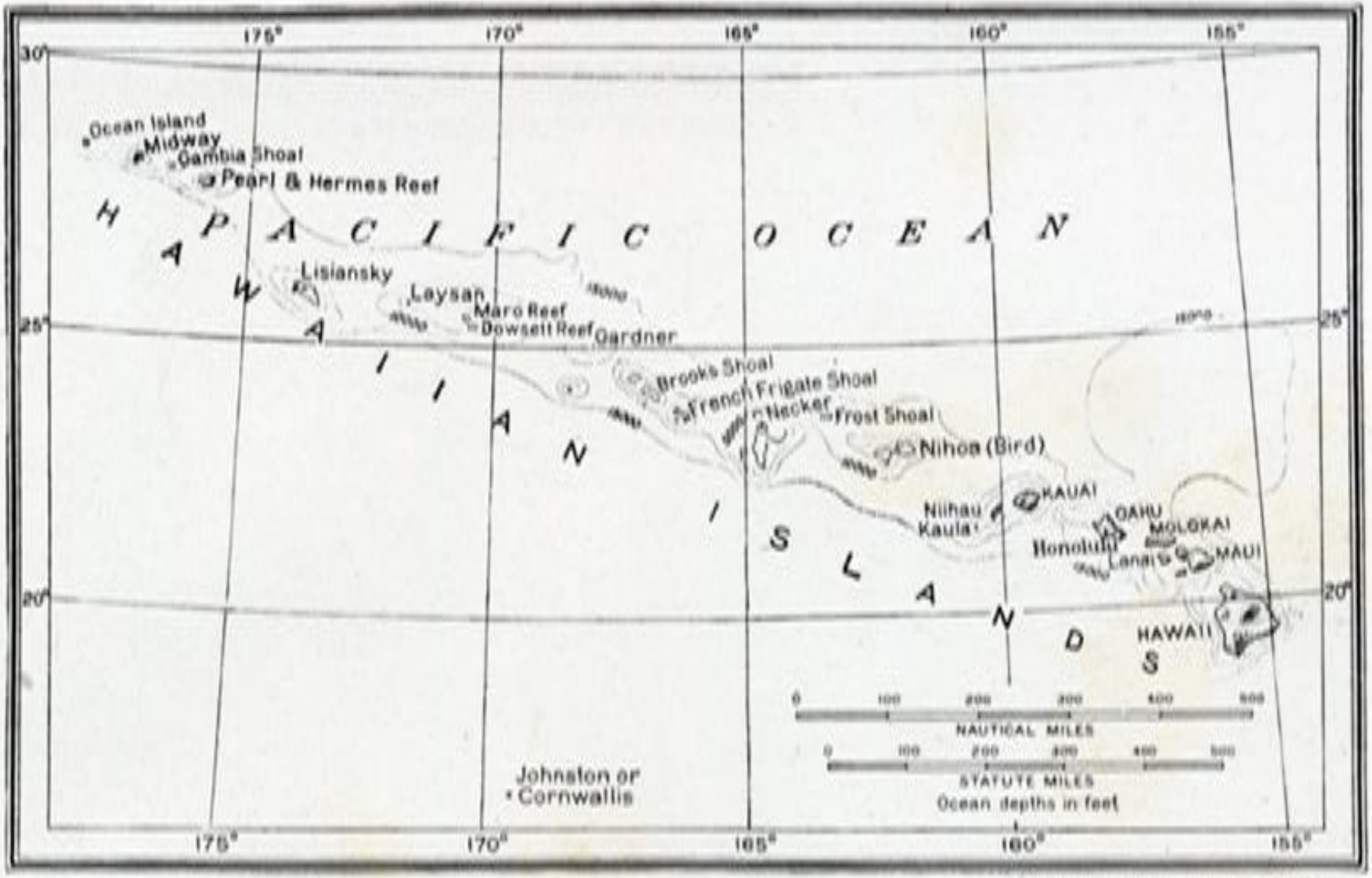
1923



Photograph by Alexander Wetmore

A GREEN TURTLE ASLEEP ON A SANDY BEACH: LISIANSKY ISLAND

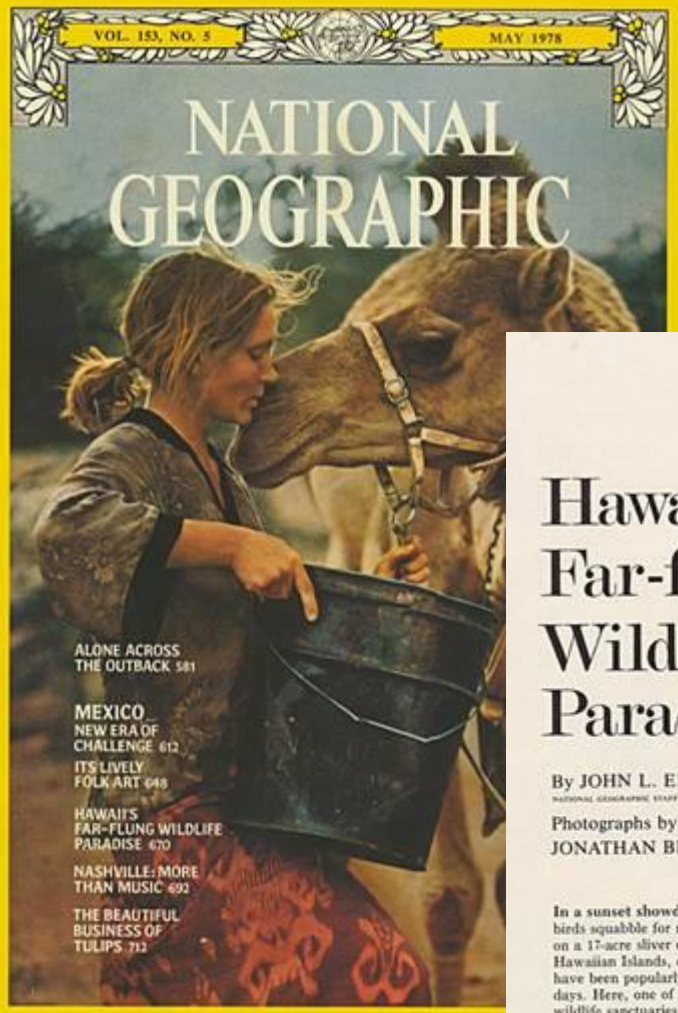
These grotesque creatures browse in submarine fields of algæ until hunger is satisfied, and then crawl heavily out to sprawl in the sand, safe from enemies in the sea. On one occasion, the author, while walking 300 yards along the beach on Lisiansky Island, counted 80 of these creatures from fifteen inches to four feet in length. Others, feeding a few yards offshore, were hidden by ripples on the water and so escaped this casual census. Their only enemies seem to be sharks.



Drawn by A. H. Bumstead

A MAP OF THE HAWAIIAN ISLANDS

1978



Hawaii's Far-flung Wildlife Paradise

By JOHN L. ELIOT

Photographs by JONATHAN BLAIR

In a sunset showdown, greater frigatebirds squabble for roosting room on a 17-acre sliver of the Northwestern Hawaiian Islands, or Leewards, as they have been popularly called since sailing days. Here, one of America's most unusual wildlife sanctuaries grants footholds of life to millions of seabirds as well as to a rare collection of indigenous land birds, seals, and turtles.

THE DIN IS INCREDIBLE, the sight unforgettable. Like an inrushing tide, the birds materialize from the horizon and sweep by the tens of thousands over the beach. Headed for nests with food for their young, they darken the dying sun in a shrieking whirlwind. Their numbers seem endless. Their island home is minuscule. Yet somehow, somewhere, they all find a niche.

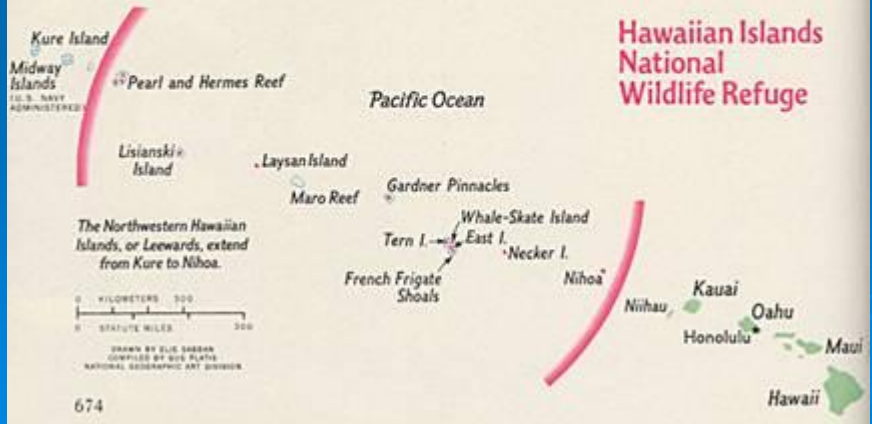
Again and again I watched such scenes unfold in Hawaii's backyard, still known as the Leeward Islands. Politically part of Honolulu, they are flung like grains of sand across a thousand miles of ocean to the northwest of the main islands. Most of the chain is preserved as a rarely glimpsed treasure: the Hawaiian Islands National Wildlife Refuge. These volcanic fragments and coral atolls total less than three square miles—and wildlife competes for every foot.

The refuge, one of the world's important rookeries, is home to millions of seabirds, including petrels, shearwaters, terns, boobies, frigatebirds, and albatrosses. It also harbors, in much smaller numbers, four

Roar of an impostor raises a blizzard of sooty terns, as a DC-3 takes off after a welcome delivery of mail and supplies to 20 Coast Guardsmen on Tern Island.

National Geographic, May 1978

EXQUISITE NECKLACE of French Frigate Shoals features Whale-Skate Island (**right**), one of the atoll's 13 islets. The western Leewards, perhaps 25 million years old, were the first Hawaiian islands to rise from the ocean floor. Most of the chain has been whittled flat by the sea, but a few volcanic chips remain, such as Nihoa (**above**), easternmost of the refuge islands (**map**). Its avian life includes Nihoa millerbirds and finches, the latter close relatives of the Laysan finch (**left**), another refuge native.



UP TO THEIR EARS in albatross eggs, youngsters and a worker display evidence of Laysan Island's teeming birdlife in 1906 (**below, right**). An entrepreneur who mined the Laysan guano for fertilizer harvested the eggs in the hope of selling them to companies that used albumen in making photographic paper.

One of his five children born on the island was Tillie Laysan Schlemmer, second from left, nicknamed "Birdie." Outside her Honolulu home today (**below**) she recounts a disaster: "I wanted a pet; that was one reason Dad brought the rabbits." The proliferating pests destroyed the birds' habitat, and as a result three endemic varieties—the Laysan millerbird, rail, and honeycreeper—became extinct.

In 1923 an expedition directed by ornithologist Alexander Wetmore, now a Trustee Emeritus of the National Geographic Society, exterminated the rabbits. Vegetation recovered, and the 1.5-square-mile island (**above, far right**) today is home to some six million birds, including an estimated 250 Laysan teals. Perched on a rock, one tucks up a leg as in a ballet (**above, right**).

HAWAII STATE ARCHIVES (RIGHT)

Research on a reef: a rough way to go

There is nothing glamorous about spending several weeks on a remote Pacific atoll, tagging animals and studying their behavior. All too often, the heat is unbearable, the work is grueling and the isolation is nerve-wracking.

Like the other scientists doing research in the Northwestern Hawaiian Islands, these four biologists frequently endure bad food, primitive living conditions and blood-sucking insects to get the job done. And yet they all agree that the rewards of doing fieldwork far outweigh the hassles. Following is a sampling of their experiences.

Mark J. Rauzon

SHEILA CONANT

"Like being in an oven"

Though located only about 300 miles northwest of Honolulu, Nihoa Island is completely cut off from the outside world. Uninhabited and barely accessible from the sea, the 150-acre pinnacle is the only habitat in the world for two endangered land birds: the Nihoa finch, a honeycreeper which numbers about 1,500, and the Millerbird, a small warbler numbering less than 300.

For the past few years, University of Hawaii scientist Sheila Conant has spent her summers on the treeless island, counting the birds and attempting to understand their needs and habits. "I enjoy being away from people from time to time," she says, "and I've learned how to live on Nihoa without most creature comforts."

The 37-year-old zoologist, who has stayed as long as three months at a time with an assistant on the island, finds hot weather to be the biggest problem. "There's no shade on Nihoa," she notes, "and when you sit in a tent, it's like being in an oven. It's not the kind of place for someone who can't stand being dirty." Because the seas surrounding the island are shark-infested, Conant never goes swimming. And with fresh water at a premium, showers are a luxury. During her expeditions, the scientist lives primarily on freeze-dried foods and "lots of crackers."

Eons ago, Nihoa was a major Hawaiian island and, Conant believes, the two endemic birds she is studying are merely two remnants of that island's former avian life. Today, only the very tip of the eroded volcano sits above the ocean surface.

Undoubtedly, one of the greatest difficulties Conant encounters on each trip is getting on and off the island. Nihoa has only one suitable landing site: a narrow beach that is constantly pounded by heavy surf. To get to the island, Conant hires a fishing vessel, then enlists the crew to take her ashore in a motorized rubber raft. At an appointed time, they pick her up.

"Last year," she recalls, "there were 20-foot waves all around the island on the day the boat arrived for me, and I had to wait three days to get off Nihoa. Even then, it was pretty scary fighting the surf."

GEORGE BALAZS

"The good guys won"

"Loneliness," says George Balazs, "comes in surges. But most of the time, I'm so busy that I forget about being out there by myself." The 39-year-old University of Hawaii biologist, who took the photographs for this article, first ventured to the Northwestern Hawaiian Islands in the early 1970s to study green sea turtles, and he has gone back every nesting season since.

"Once you start monitoring turtles," he points out, "you can't stop or miss a day." As a result, Balazs stays up all night measuring and tagging female turtles as they come ashore to deposit their eggs. His study site is 12-acre East Island, where more than half of all breeding by Hawaii's green turtles takes place every spring. "This is one of the few places on earth where turtles can bask on a beach without people bothering them," adds the scientist.

Balazs has also visited other remote Hawaiian islands in search of turtles, and occasionally, he has run into problems. "Once," he recalls, "I was on Necker Island—a big rock in the middle of the Pacific. I had arranged for a fishing crew to pick me up, and they were waiting offshore. The surf was too high for them to get close, so I had no choice. I jumped off a cliff into the sea, and it turned into a race over who would get me first: the sharks or the sailors. Fortunately, the good guys won."

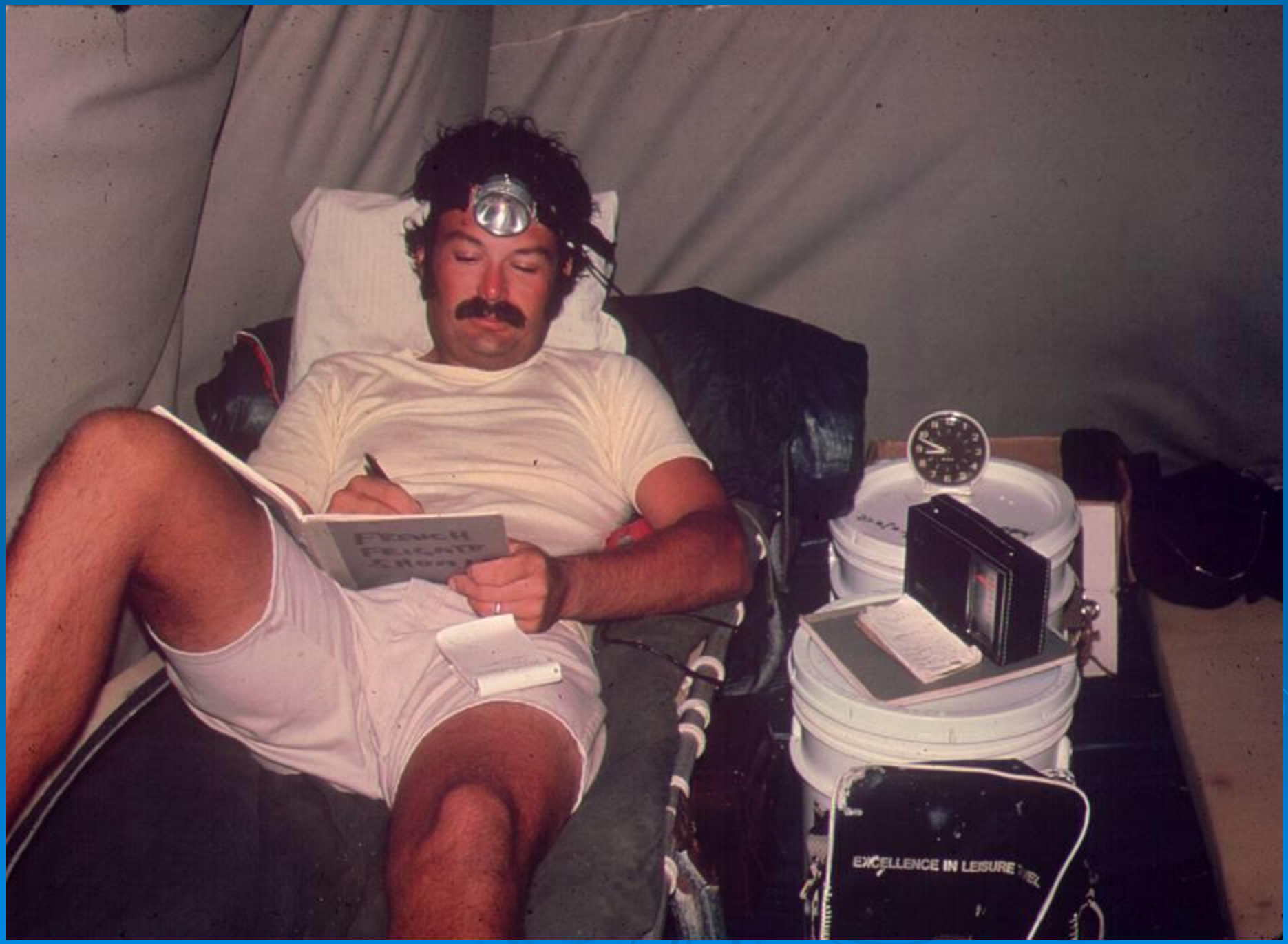
Though he's not yet ready to give up fieldwork, Balazs is tiring of spending long periods away from home. "Now that my son is growing up," he says, "it's getting a lot harder on all of us. But there's still so much turtle work to be done."

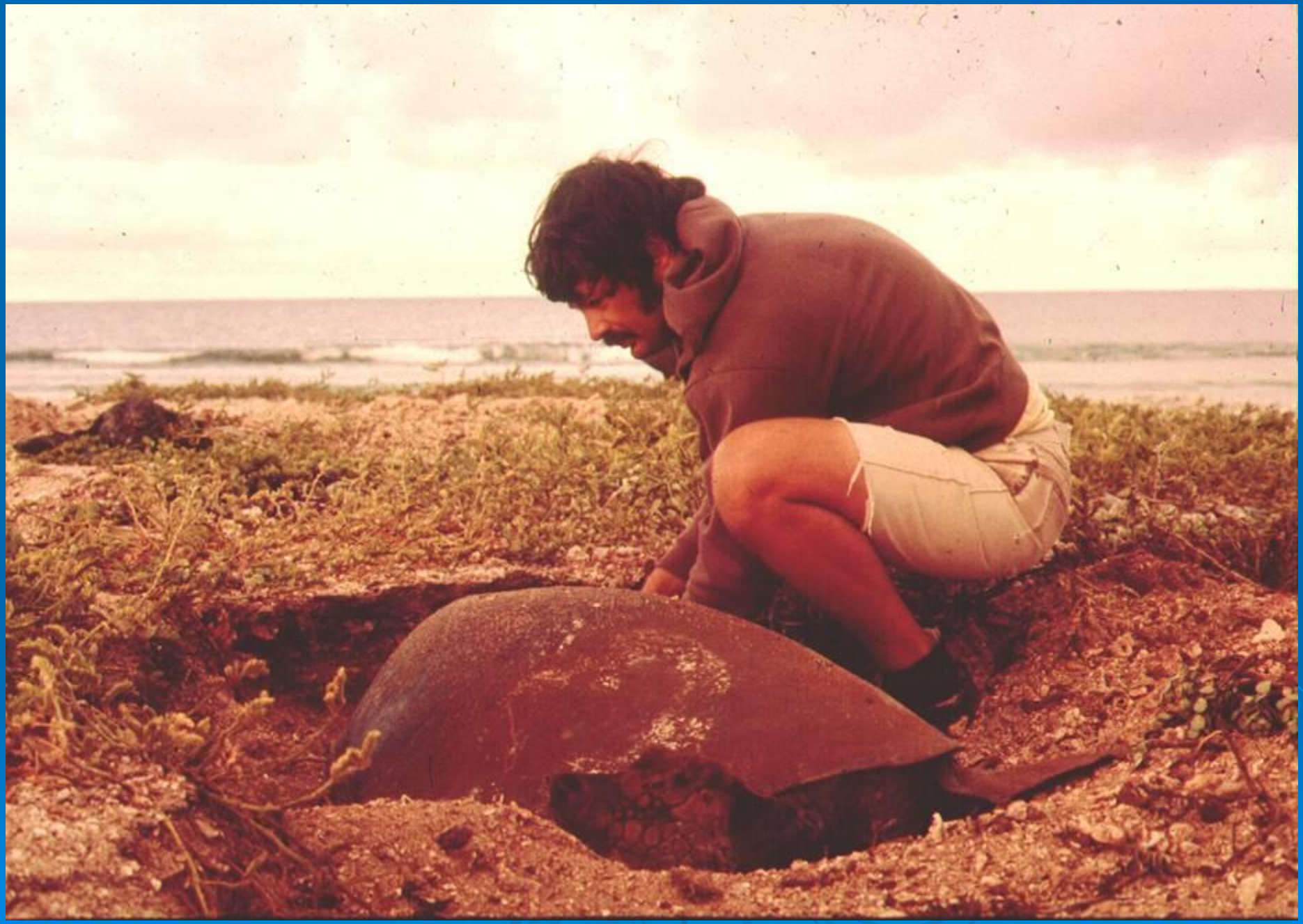
Greg Vaughn

ROBERT SHALLENBERGER

"Never trust the place"

"Now that I'm in administration, I find myself craving more time in the field," says Robert Shallenberger. The 37-year-old native Californian, who is refuge manager for all 12 U.S. National Wildlife Refuges in the Pacific, still sets aside some time for behavioral studies. "But I no longer have the 'luxury' of spending days on end in total discomfort observing animals," he muses. "Instead, one day I can be counting waterfowl on Oahu, the next day turtles and seabirds in the Leewards."


EXCELLENCE IN LEISURE



1983

TREASURED ISLANDS

BY MARK WEXLER
PHOTOGRAPHS BY GEORGE H. BALAZS

EAST Island is a mere speck of land—a tiny, 12-acre sandbar that sits in an isolated Pacific lagoon, 500 miles from Honolulu. Surrounded by coral reefs and turquoise seas, it is the kind of place that some people dream of visiting. But East Island is no heavenly tropical gem. Throughout much of the year, the sun beats down on the treeless Northwestern Hawaiian Island with unrelenting fury, and steamy trade winds whip across the sand like a blast furnace. With no natural water supply and a steady stream of sharks swimming offshore, the islet is hardly an ideal spot to pass the summer. Yet that's exactly what George Balazs has been doing, on and off, for the past decade.

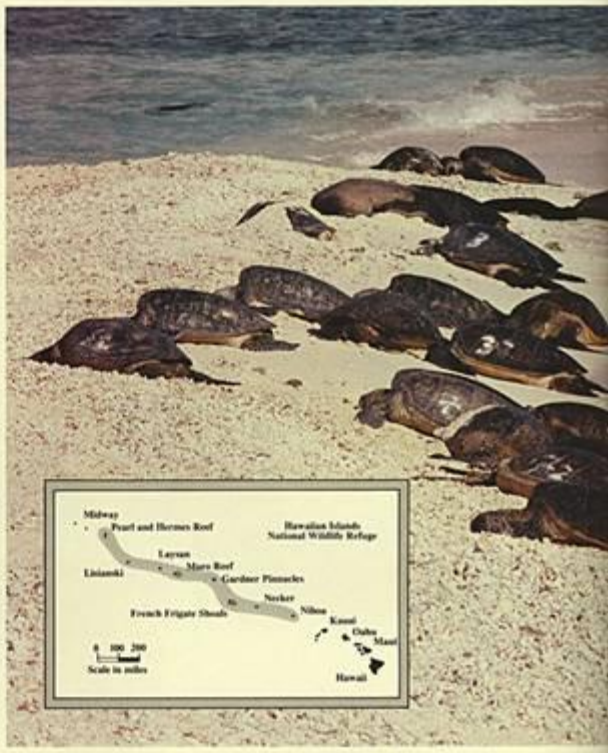
"I've spent many a moment asking myself what the hell am I doing here?" says the affable, 39-year-old University of Hawaii biologist. In truth, however, Balazs wouldn't trade back one minute of the time he has spent on the remote sandbar. That's because East Island is the last major nesting site of the green turtle in the United States, and Balazs is a turtle scientist.

Each year, about 300 of the green turtles that range in Hawaii breed at East Island, and Balazs is frequently there to record their behavior. "He's responsible for most of what we know about green turtles in Hawaii," notes Robert Shallenberger, a U.S. Fish and Wildlife Service (FWS) official. "And we urgently need that kind of data to justify our management decisions."

Shallenberger should know. As refuge manager for the Hawaiian Islands National Wildlife Refuge—of which East Island is included—he finds himself increasingly under pressure to keep the region's vast wildlife resources protected. Balazs is one of several scientists working with Shallenberger to gather the data needed to do so. Currently, the waters in and around the refuge are the focus of a debate between state and federal authorities over their jurisdiction—a debate that could affect huge numbers of animals.

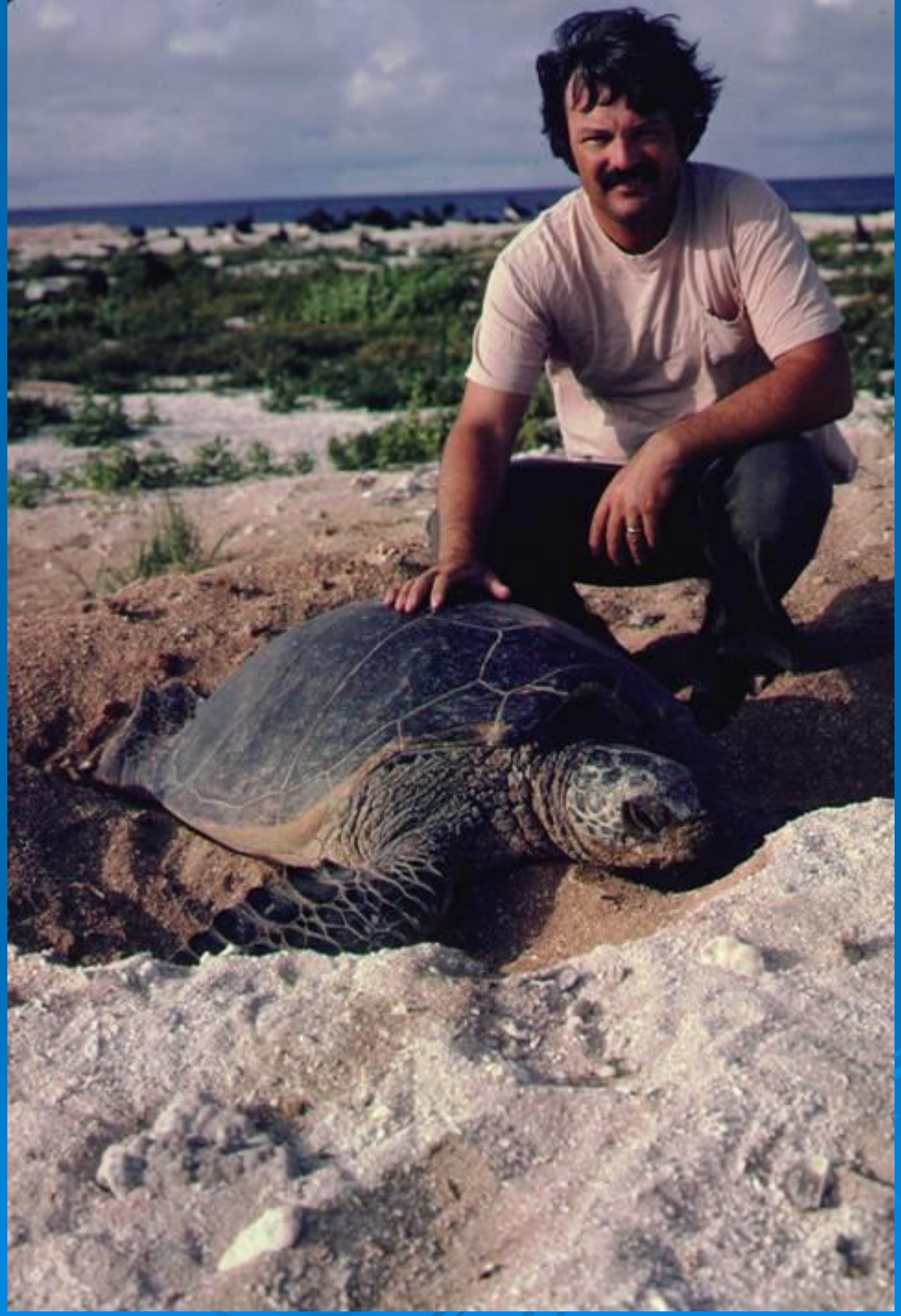
The Northwestern Hawaiian Islands, or Leewards, as they are commonly called, spread out over some 1,100 miles of the Pacific, and include about 100 tiny islets, atolls, shoals and rocky pinnacles. Since 1909, when President Theodore Roosevelt established a national bird sanctuary in the region, most of these islands have been included in the National Wildlife Refuge System. "There are creatures on those islands found nowhere else on earth," says Sheila Conant, another University of Hawaii researcher who is studying two species of endangered land birds on the remote island of Nihoa.

In all, there are four species of endangered birds in the Leewards, and the area is one of the world's most important seabird nesting sites. Each year, millions of terns, petrels, boobies, albatross and frigatebirds compete for every square inch of space on these is-



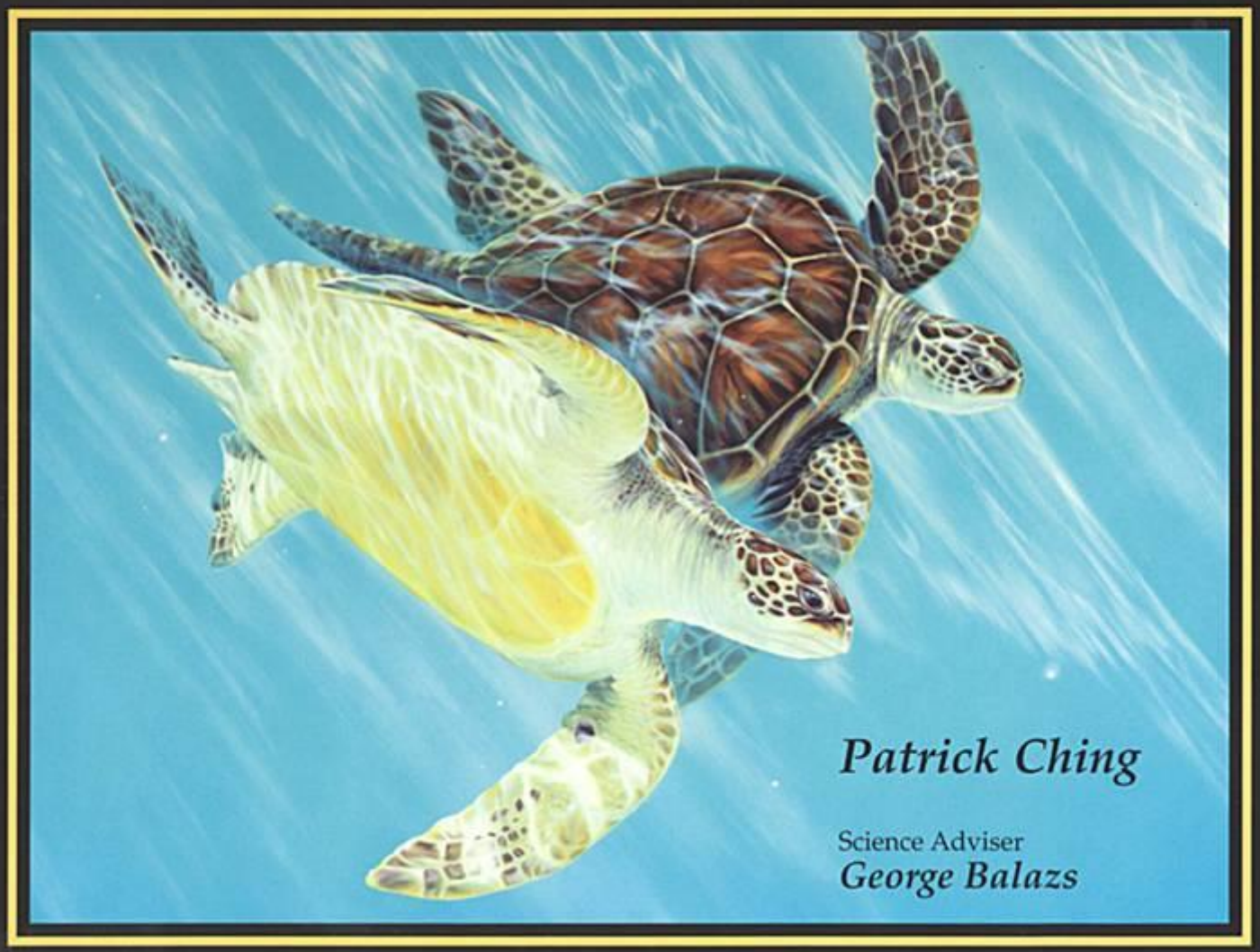
"This is one of the few places on earth where turtles can bask on a beach without people bothering them," says biologist Balazs of tiny East Island (above). The 12-acre sandbar—one of a dozen islets located in an atoll called French Frigate Shoals—is the last major nesting site of the green turtle in the United States. Like most of the Northwestern Hawaiian Islands, it is now included in the National Wildlife Refuge System (see gray area in map). Spanning some 1,400 miles, the Hawaiian Islands represent the world's longest and most isolated archipelago.


NATIONAL
WILDLIFE
REFUGE




Hillary

Sea Turtles of Hawai'i



Courtesy of the U.S. Fish and Wildlife Service

French Frigate Shoals is where more than 95 percent of Hawai'i's mature green turtles nest. East Island shown here is the most important nesting islet within the shoals.

© Tim Clark

After the *honu* has dug her initial pit, she proceeds to dig an egg chamber within the pit. Using her rear flippers, she scoops out a cylindrical hole roughly one foot deep, where she deposits about one hundred leathery eggs, each slightly larger than the size of a golf ball. Egg laying takes twenty to forty minutes, depending in part on the number of eggs. Once she has started dropping eggs, the *honu* does not stop until she is through. When the eggs are laid, she covers her nest by scooping and pulling soil with her hind flippers and then throwing sand behind her using her strong front flippers. She then heads straight back to the ocean, leaving her distinctive tracks behind her.

© Jake R. Rocho

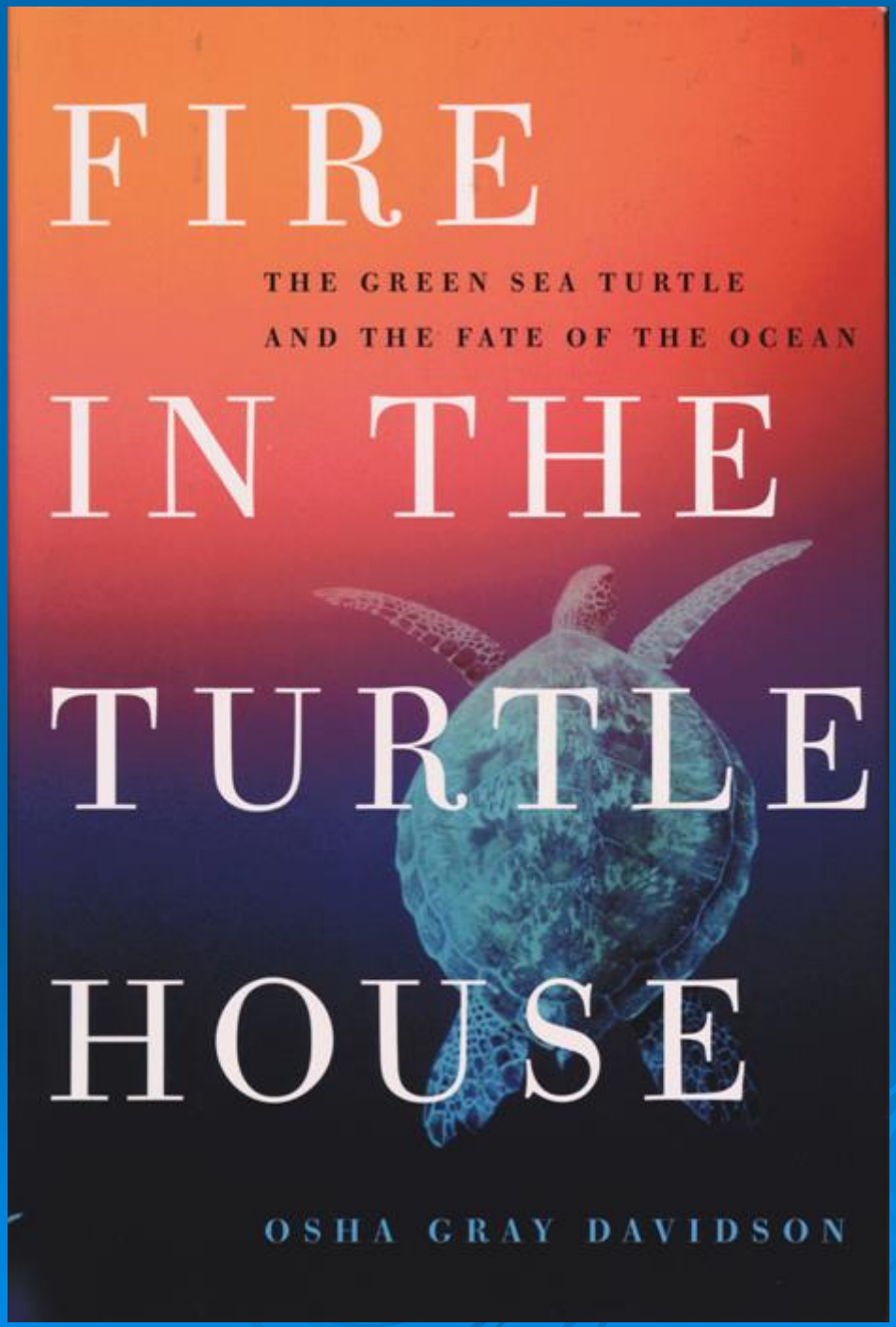

Dedicated to all of you who've
helped make the world better
for all God's creatures

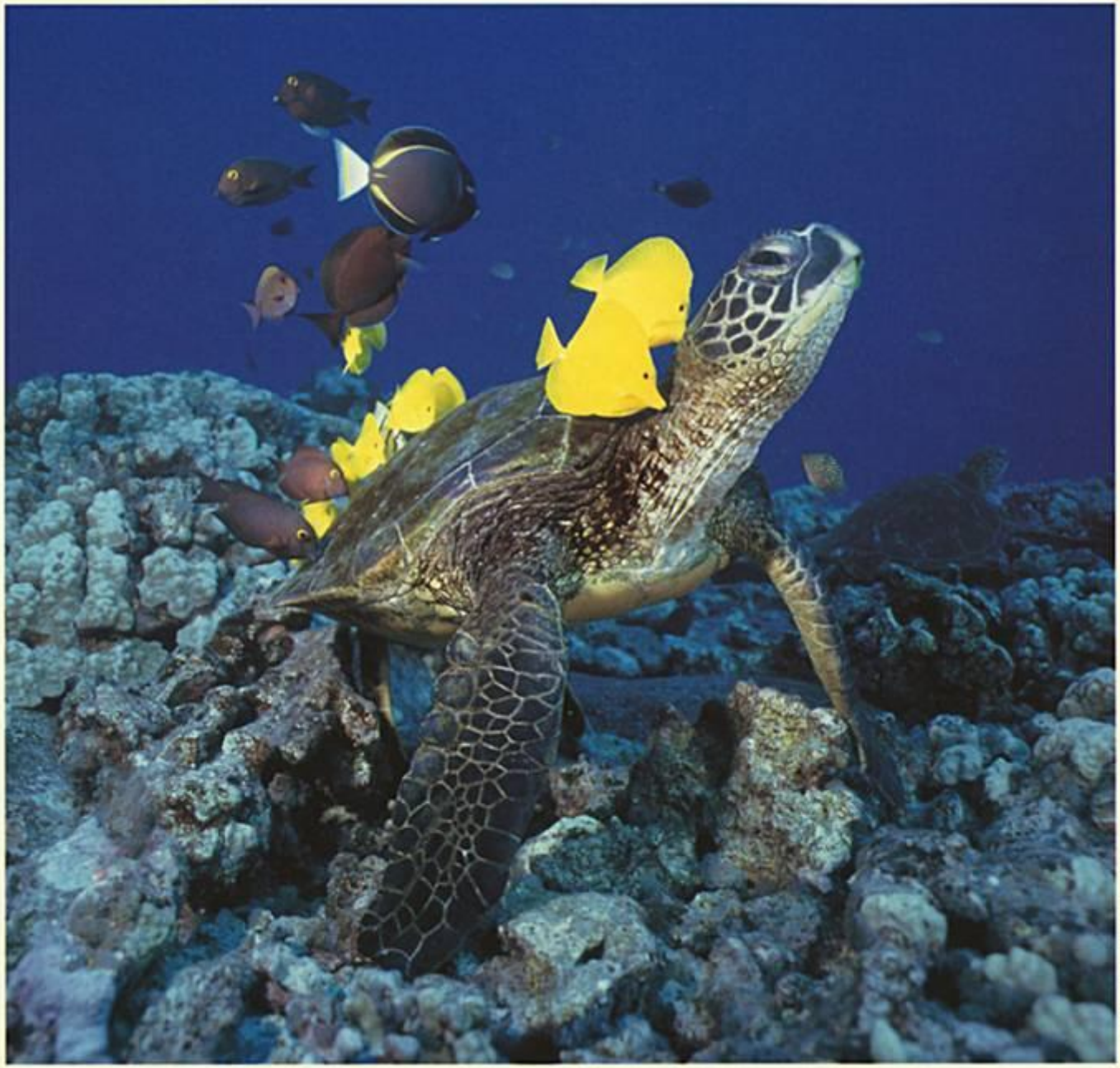
For centuries Native Hawaiians have included the *honu* as an important part of their diet and culture. In recent decades that resource has been forbidden to them.

Citing that other indigenous peoples are permitted to utilize traditional resources that are otherwise protected by law, certain Hawaiian groups would like to establish protocol and resume native gathering practices. With the increasing number of turtles and a growing Native Hawaiian voice in politics, this idea may soon become a reality; however, the subject of native gathering rights is one that must be dealt with carefully.

There are many issues to consider, and though it may seem that *honu* are becoming abundant, history has shown us how quickly that trend can be reversed. Hawaiians understand this, and it is surely in their best interest to conserve the precious *honu* as their ancestors did by placing strict *kapu* (restrictions) on the taking of turtles. Many Hawaiians look forward to a time when the *honu* population can be maintained at a sustainable level, and their families can once again utilize a resource that has long been an integral part of their heritage.

Artwork © Patrick Ching


FIRE
THE GREEN SEA TURTLE
AND THE FATE OF THE OCEAN
IN THE
TURTLE
HOUSE
OSHA GRAY DAVIDSON



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Thirty-year recovery trend in the once depleted Hawaiian green sea turtle stock

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Abstract

The green sea turtle is one of the long-lived species that comprise the charismatic marine megafauna. The green turtle has a long history of human exploitation with some stocks extinct. Here we report on a 30-year study of the nesting abundance of the green turtle stock endemic to the Hawaiian Archipelago. We show that there has been a substantial long-term increase in abundance of this once seriously depleted stock following cessation of harvesting since the 1970s. This population increase has occurred in a far shorter period of time than previously thought possible. There was also a distinct 3–4 year periodicity in annual nesting abundance that might be a function of regional environmental stochasticity that synchronises breeding behaviour throughout the Archipelago. This is one of the few reliable long-term population abundance time series for a large long-lived marine species, which are needed for gaining insights into the recovery process of long-lived marine species and long-term ecological processes.

Keywords: Green sea turtle; Abundance; Population recovery; French Frigate Shoals; Hawaii

1. Introduction

The green turtle (*Chelonia mydas*) has a circum-tropical distribution with distinct regional population structures (Bowen et al., 1992) and is the most abundant large marine herbivore (Bjorndal, 1997). Globally, the green turtle has been subject to a long history of human exploitation with some stocks now extinct and others in decline (Frazier, 1980; Witzell, 1994). Yet despite being recognized as globally threatened (National Research Council, 1990) there are few reliable assessments of abundance status and trend of any green turtle stock (Chaloupka and Limpus, 2001). Reliable long-term estimates of population abundance trends are needed to support recovery planning (Foin et al., 1998), model sea turtle demography (Chaloupka, 2002) and are essential for developing a better understanding of long-term ecological processes (Inchausti and Halley, 2001).

For sea turtles, such population abundance estimates are based preferably on foraging ground capture–mark–recapture programs that can provide more detailed sex- and age-class-specific demographic information (Limpus and Chaloupka, 1997; Chaloupka and Limpus, 2001, 2002). However, capture–mark–recapture programs in the marine environment for large and highly mobile species such as sea turtles are very difficult and expensive to conduct and so are rarely undertaken (Limpus and Chaloupka, 1997; Bjorndal et al., 2000). Nearly all assessments of sea turtle population abundance have been based on trawl based catch-per-unit-effort estimation, aerial survey based density estimation or, more commonly, by monitoring the number of females that come ashore each year to nest at stock-specific rookeries (see review in Chaloupka and Limpus, 2001).

Monitoring beach nesting is by far the easiest and least expensive means to assess green turtle population abundance but short-term surveys (<10 years) are inadequate for several reasons (Chaloupka and Limpus, 2001). Most notably because green turtles are long-lived (Limpus and Chaloupka, 1997; Zug et al., 2002) and females skip several nesting seasons due to nutritional constraints (Bjorndal, 1997). Hence, long-term nesting beach surveys are essential if this form of assessment of

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1976

GREEN TURTLE MIGRATIONS IN THE HAWAIIAN ARCHIPELAGO

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ABSTRACT

In order to understand better the natural history and conservation status of the unique land-basking Hawaiian green turtle population (Chelonia *sp.*), *intensive tagging studies were conducted at French Frigate Shoals* (24°N 160°W), *a wildlife sanctuary comprising the only aggregate breeding site remaining in the* 2600 *km long Archipelago. Additionally, newly captured* Chelonia, *as well as individuals held for extended periods in display aquaria, were tagged and released around the large islands in the southeast. Tag recoveries of adults identified during the* 1973 *and* 1974 *nesting seasons documented migrations from French Frigate Shoals to the islands of Kauai, Oahu and Maui, distances of* 713, 936 *and* 1069 *km to the southeast, respectively, and to French Frigate Shoals from Lisianski Island and Pearl and Hermes Reef, distances of* 834 *and* 1075 *km to the northwest, respectively. A captive-held female released off Niihau travelled* 658 *km to French Frigate Shoals where nesting was recorded. Other animals released from captivity showed movement between the large islands, while those released shortly after capture remained in the same coastal area for up to* 11 *months. Combined results from the present study and previous intermittent taggings made since* 1961 *by Federal and State wildlife management personnel indicated that breeding colony members are derived from widely separated feeding areas within the archipelago and appear to be reproductively isolated from other Pacific* Chelonia. *Northwestern areas of the archipelago are thought to serve as important migratory stations for early life stage development.*

INTRODUCTION

A complicating factor in the conservation of remaining populations of *Chelonia* is the periodic migrations which occur between feeding pastures and aggregate breeding grounds, locations which may be widely separated and not well known.

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RESEARCH ARTICLE

G. H. Balazs · M. Chaloupka

Spatial and temporal variability in somatic growth of green sea turtles (*Chelonia mydas*) resident in the Hawaiian Archipelago

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Abstract The somatic growth dynamics of green turtles (*Chelonia mydas*) resident in five separate foraging grounds within the Hawaiian Archipelago were assessed using a robust non-parametric regression modelling approach. The foraging grounds range from coral reef habitats at the north-western end of the archipelago, to coastal habitats around the main islands at the south-eastern end of the archipelago. Pelagic juveniles recruit to these neritic foraging grounds from ca. 35 cm SCL or 5 kg (~6 years of age), but grow at foraging-ground-specific rates, which results in quite different size- and age-specific growth rate functions. Growth rates were estimated for the five populations as change in straight carapace length (cm SCL year^{-1}) and, for two of the populations, also as change in body mass (kg year^{-1}). Expected growth rates varied from ca. 0.2–5 cm SCL year^{-1}, depending on the foraging-ground population, which is indicative of slow growth and decades to sexual maturity, since expected size of first-time nesters is ≥80 cm SCL. The expected size-specific growth rate functions for four populations sampled in the south-eastern archipelago displayed a non-monotonic function, with an immature growth spurt at ca. 50–53 cm SCL (~18–23 kg) or ca. 13–19 years of age. The growth spurt for the Midway atoll population in the north-western archipelago occurs at a much larger size (ca. 65 cm SCL or 36 kg), because of slower immature growth rates that might be due to a limited food stock and cooler sea surface temperature. Expected age-at-maturity was estimated to be ca. 35–40 years for the four populations sampled at the south-eastern end of the archipelago, but it might well be >50 years for the Midway population. The Hawaiian stock comprises mainly the same mtDNA haplotype, with no differences in mtDNA stock composition between foraging-ground populations, so that the geographic variability in somatic growth rates within the archipelago is more likely due to local environmental factors rather than genetic factors. Significant temporal variability was also evident, with expected growth rates declining over the last 10–20 years, while green turtle abundance within the archipelago has increased significantly since the mid-1970s. This inverse relationship between somatic growth rates and population abundance suggests a density-dependent effect on somatic growth dynamics that has also been reported recently for a Caribbean green turtle stock. The Hawaiian green turtle stock is characterised by slow growth rates displaying significant spatial and temporal variation and an immature growth spurt. This is consistent with similar findings for a Great Barrier Reef green turtle stock that also comprises many foraging-ground populations spanning a wide geographic range.

Communicated by P.W. Sammarco, Chauvin

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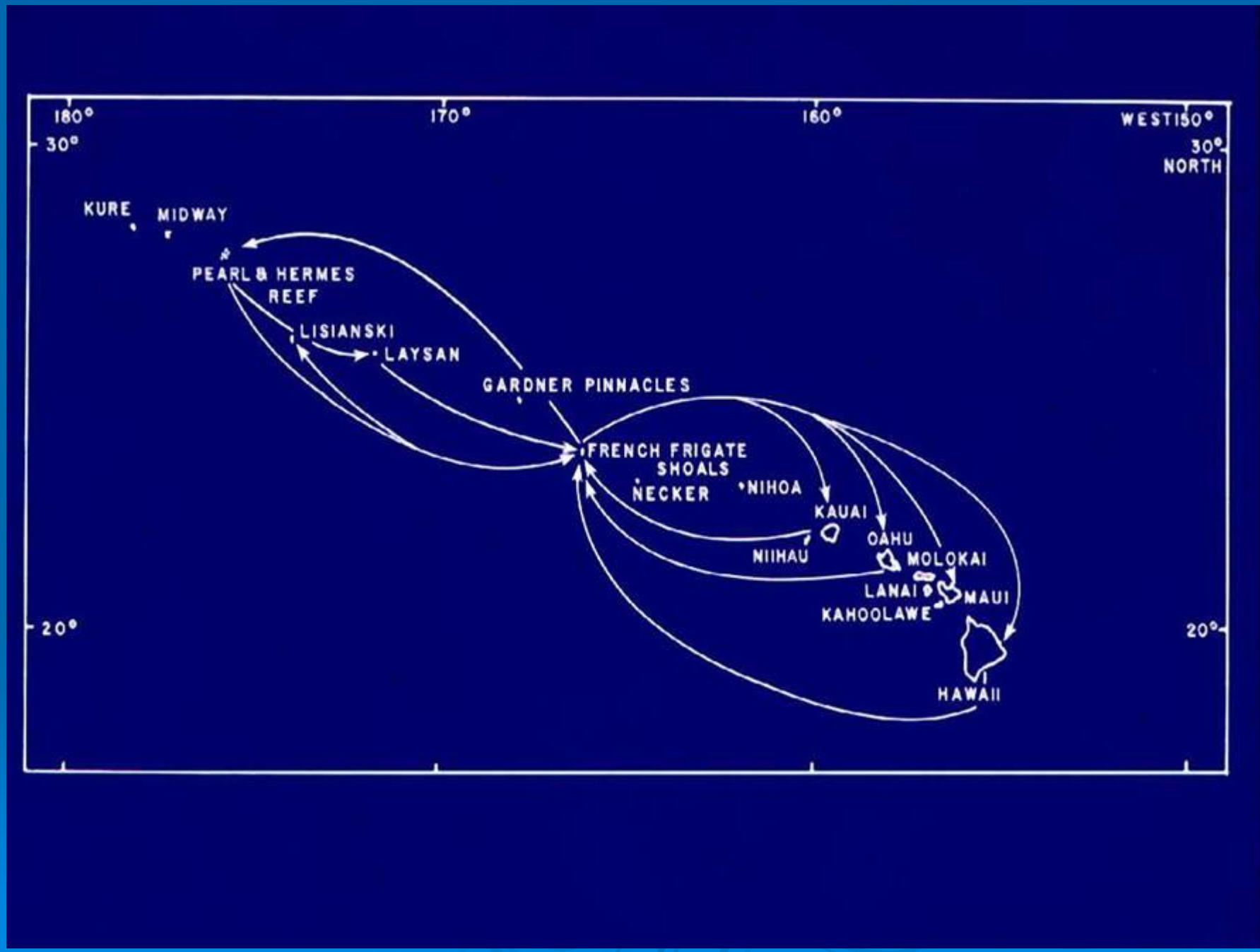
Fax: +61-7-33657299

Introduction

The green sea turtle (*Chelonia mydas*) is a threatened marine turtle species with a broad pan-tropical distribution and distinct regional population substructures (Bowen et al. 1992). Green turtles are the most abundant large, long-lived marine herbivores (Bjorndal 1997) and have a long history of human exploitation for meat and eggs (Parsons 1962; Frazier 1980; Witzell 1994). Many green turtle stocks in the Pacific region are in serious decline (Seminoff 2002), with the populations resident in Great Barrier Reef and Hawaiian waters representing some of the few remaining stocks with apparently viable


WILL ROBOTIC CAMERAS MONITOR
NESTING SEASONS OF THE FUTURE?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LAYSAN
GARDNER PINNACLES
FRENCH FRIGATE
SHOALS
NECKER
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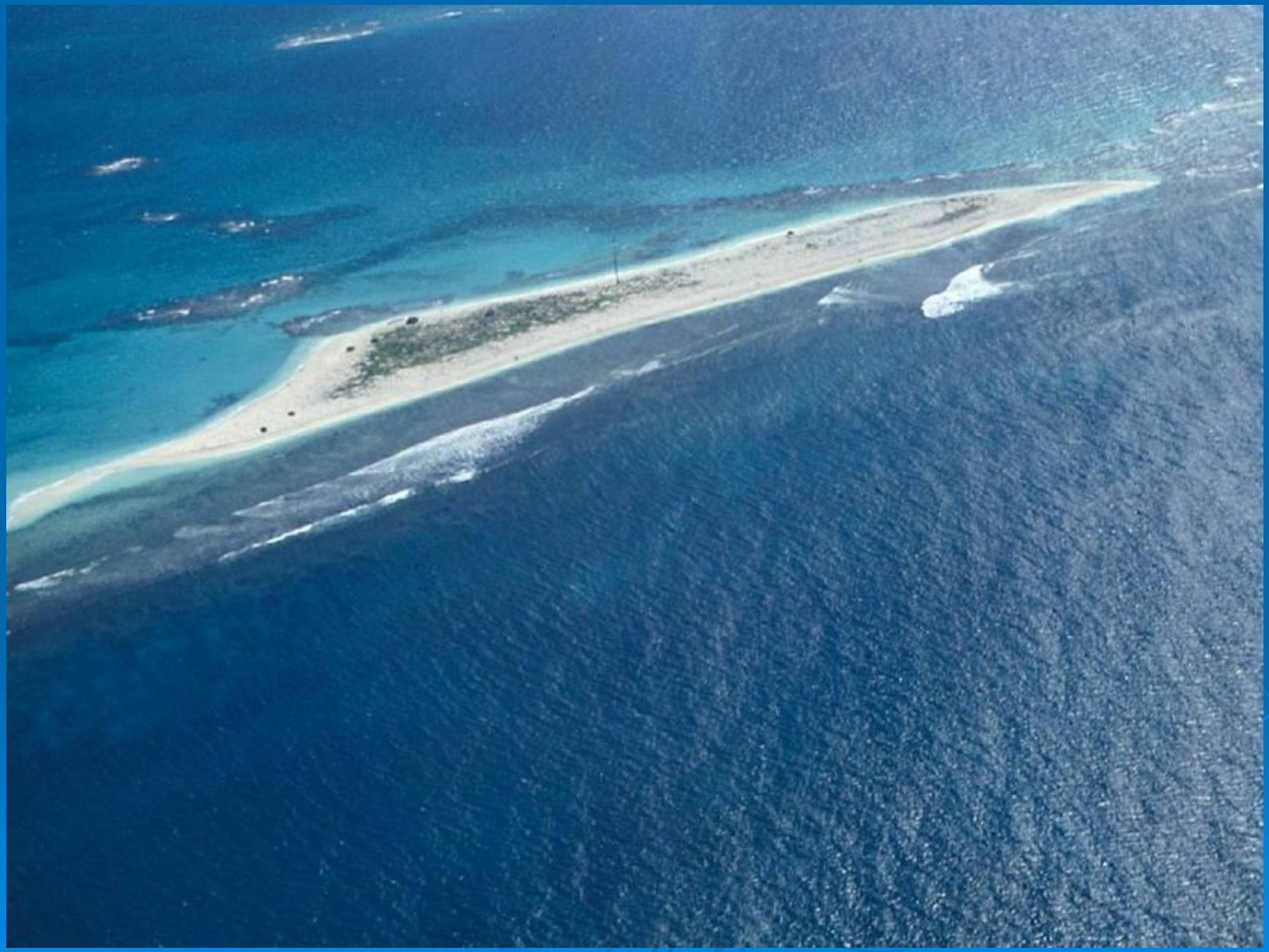

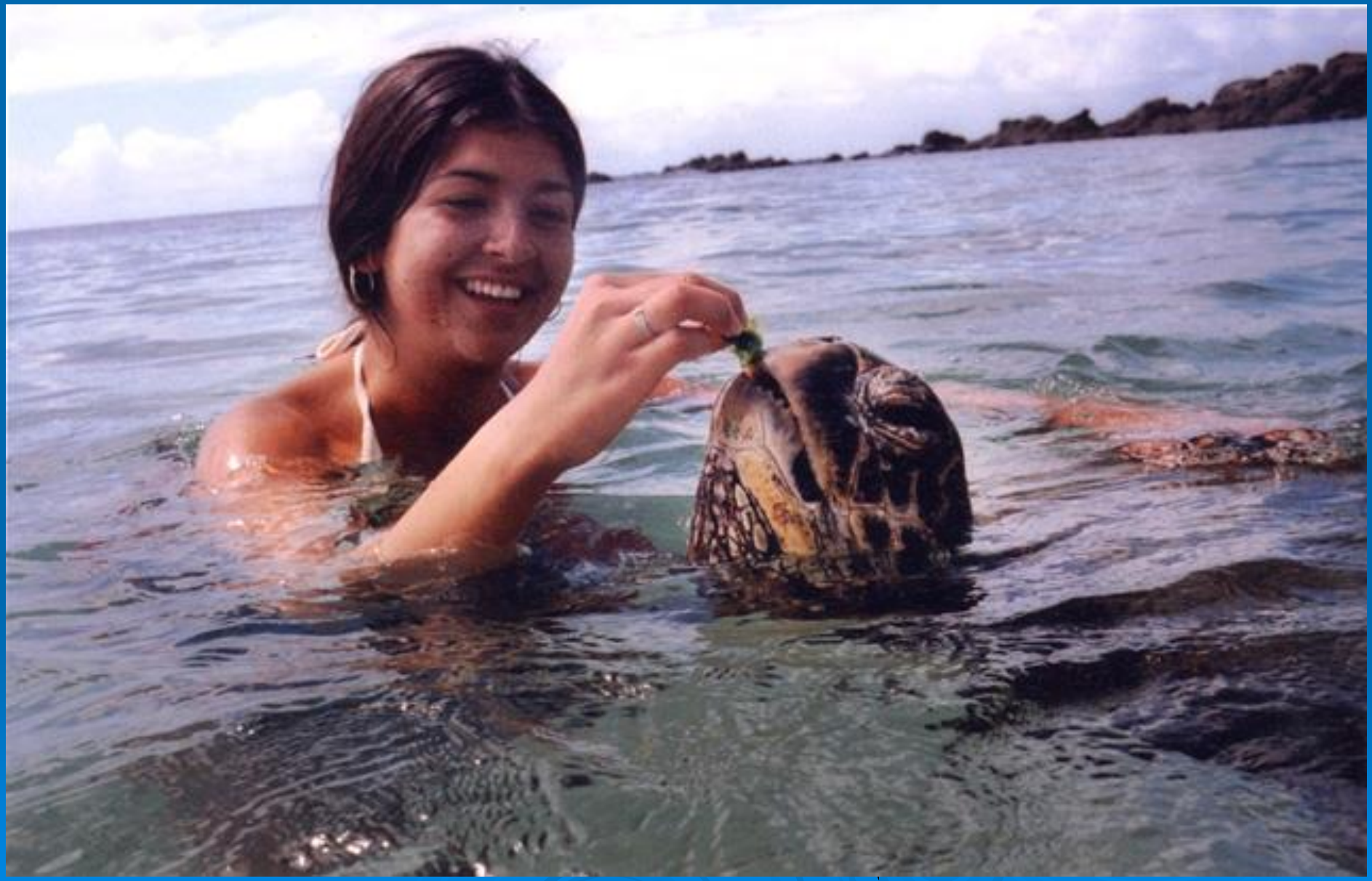


NOAA SEA TURTLE
URGENT CARE

Necropsy


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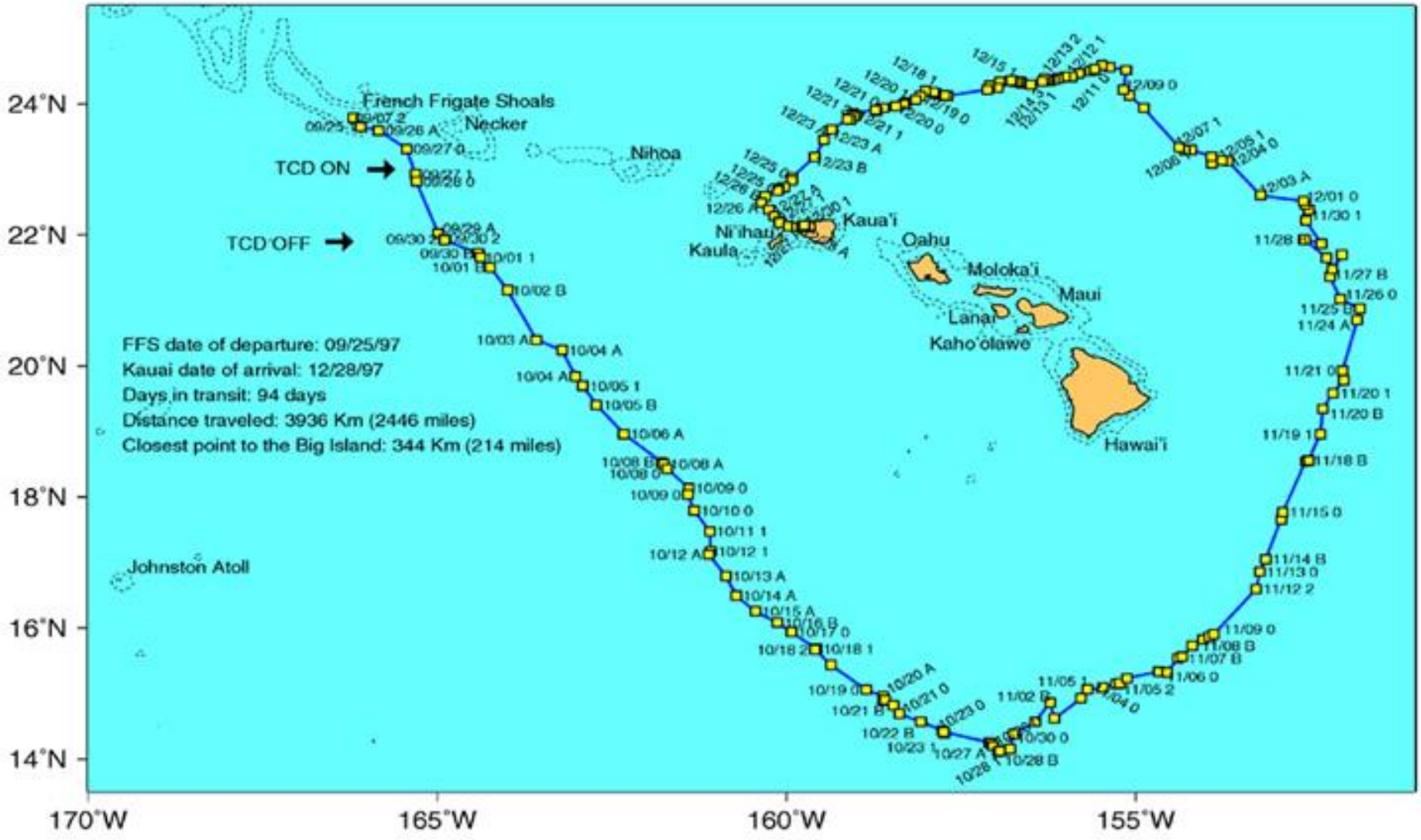
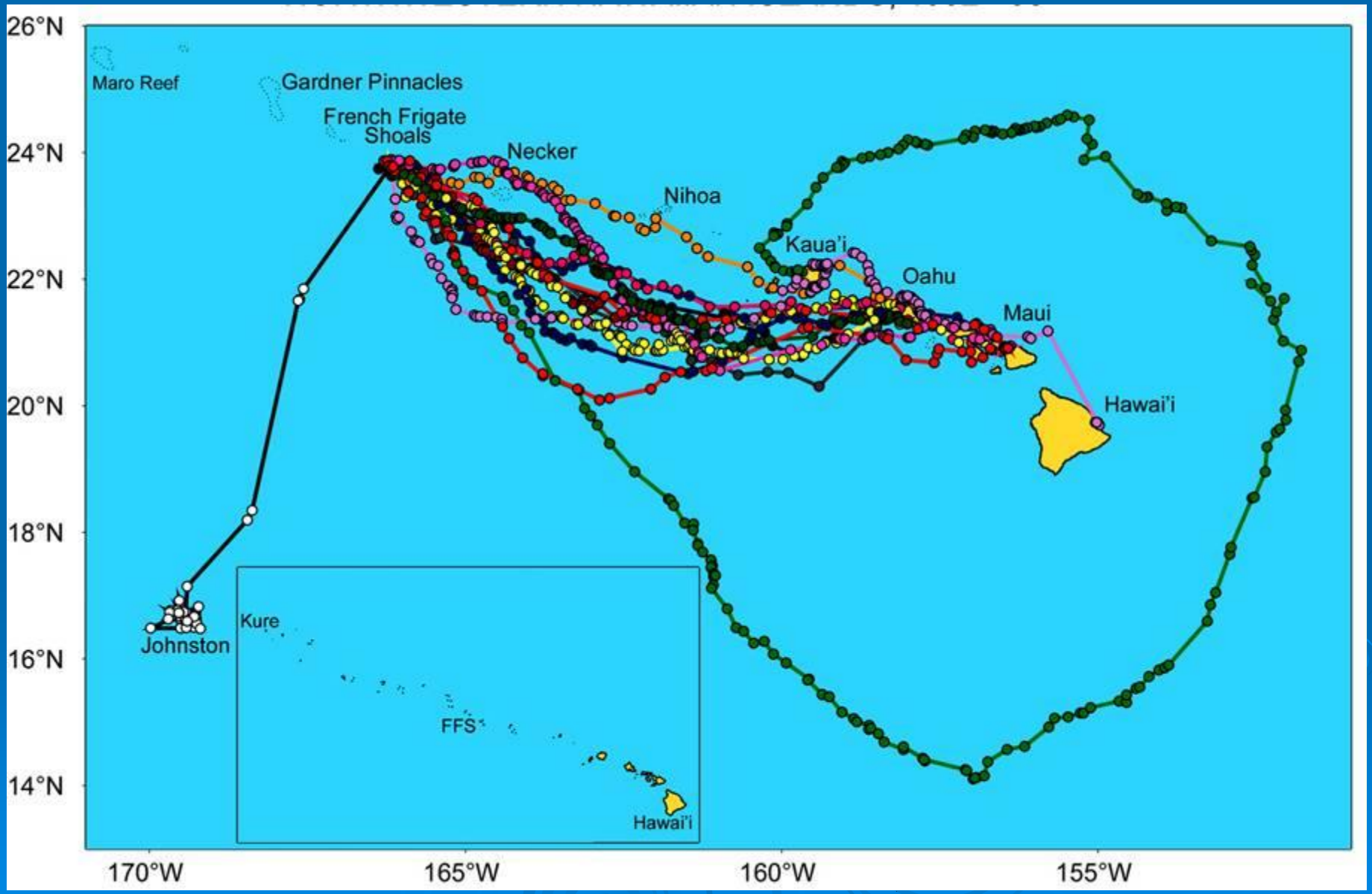
Post-nesting migration of green turtle 24195 from French Frigate Shoals to Makaha Point on the Island of Kauai, 1997




26°N
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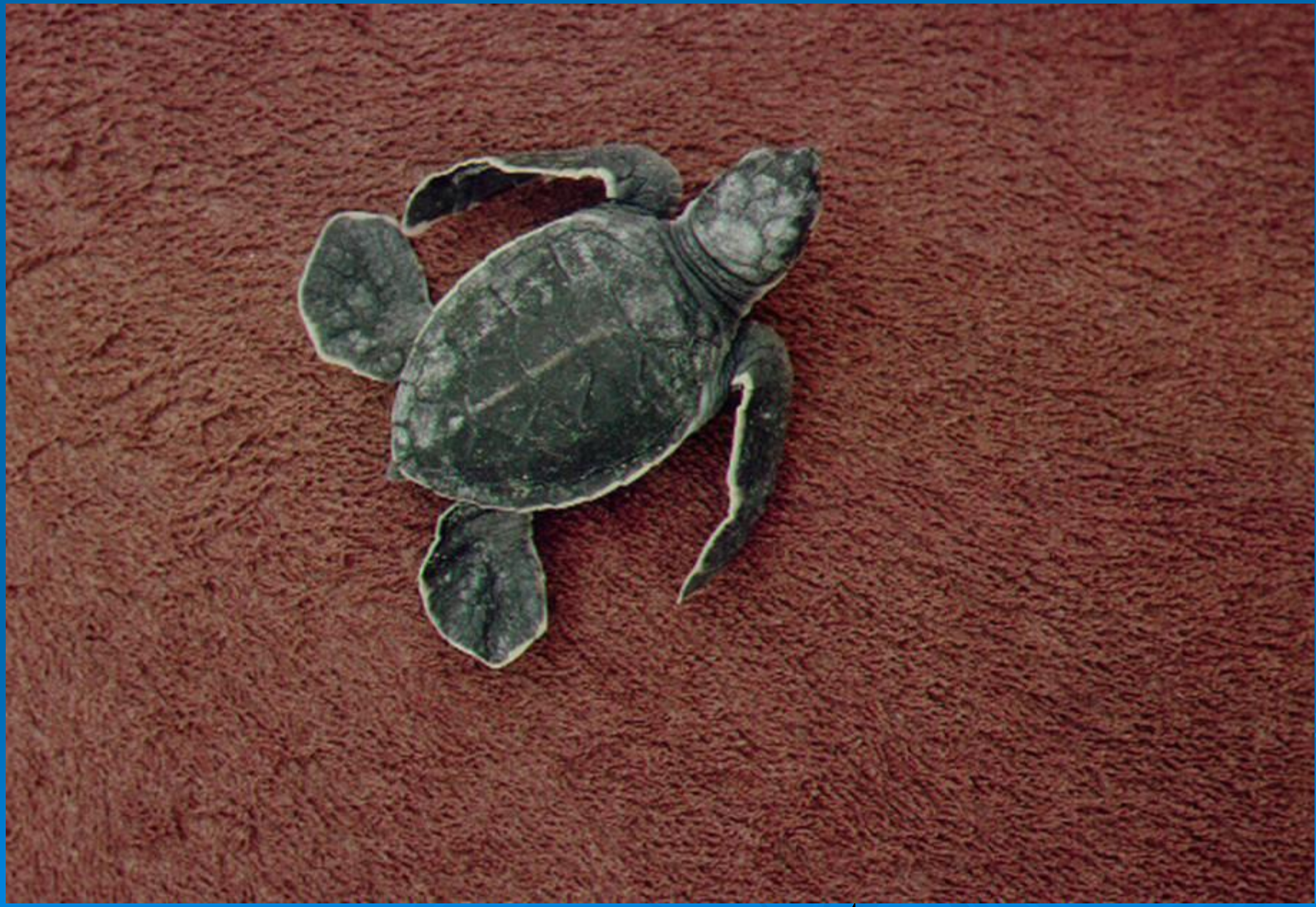
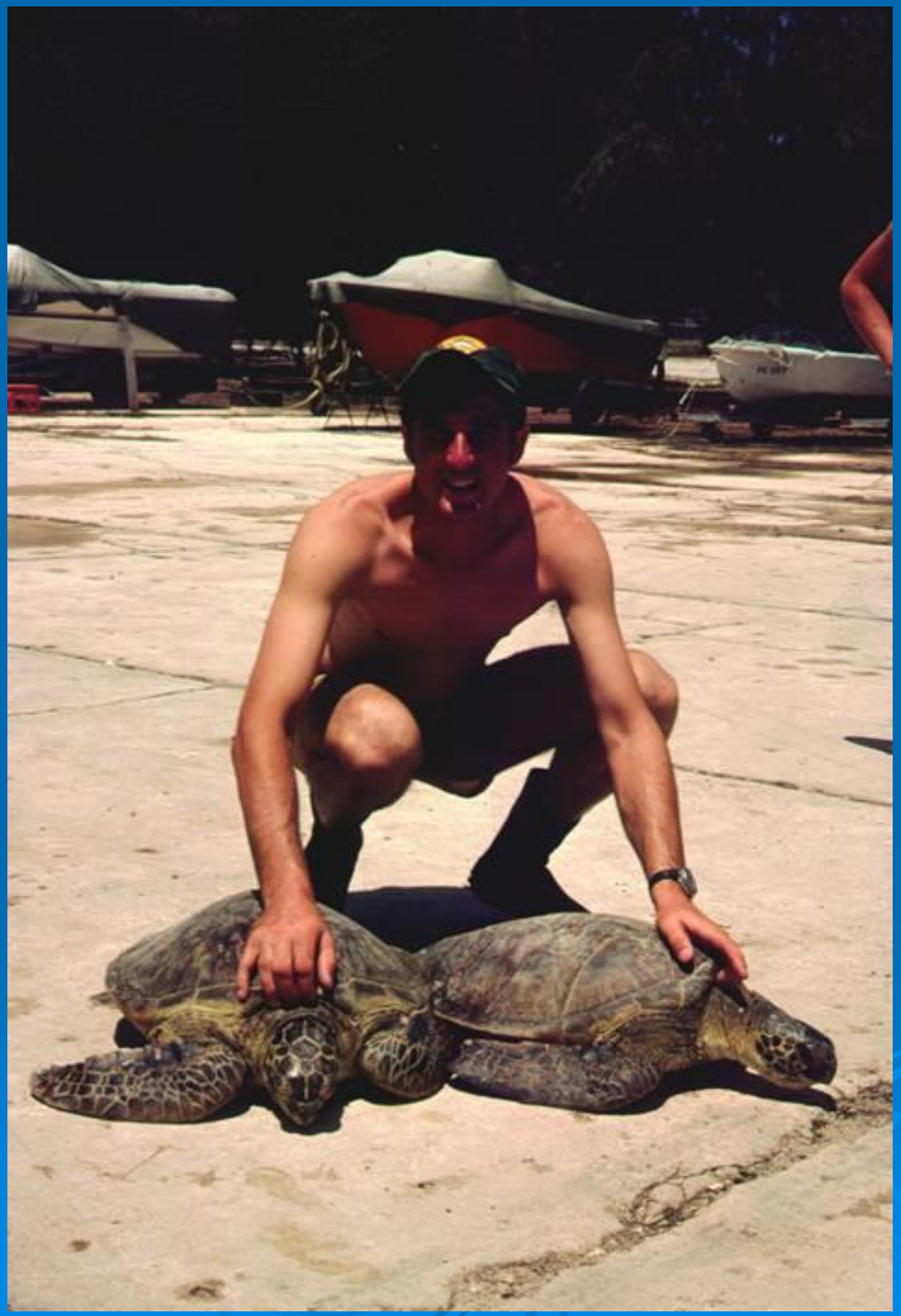
Maro Reef
Gardner Pinnacles
French Frigate Shoals
Necker
Nihoa
Kaua'i
Oahu
Maui
Hawai'i
Johnston
Kure
FFS
Hawai'i


Honli Ohana
Hawaiian Islands
1971 - 2001



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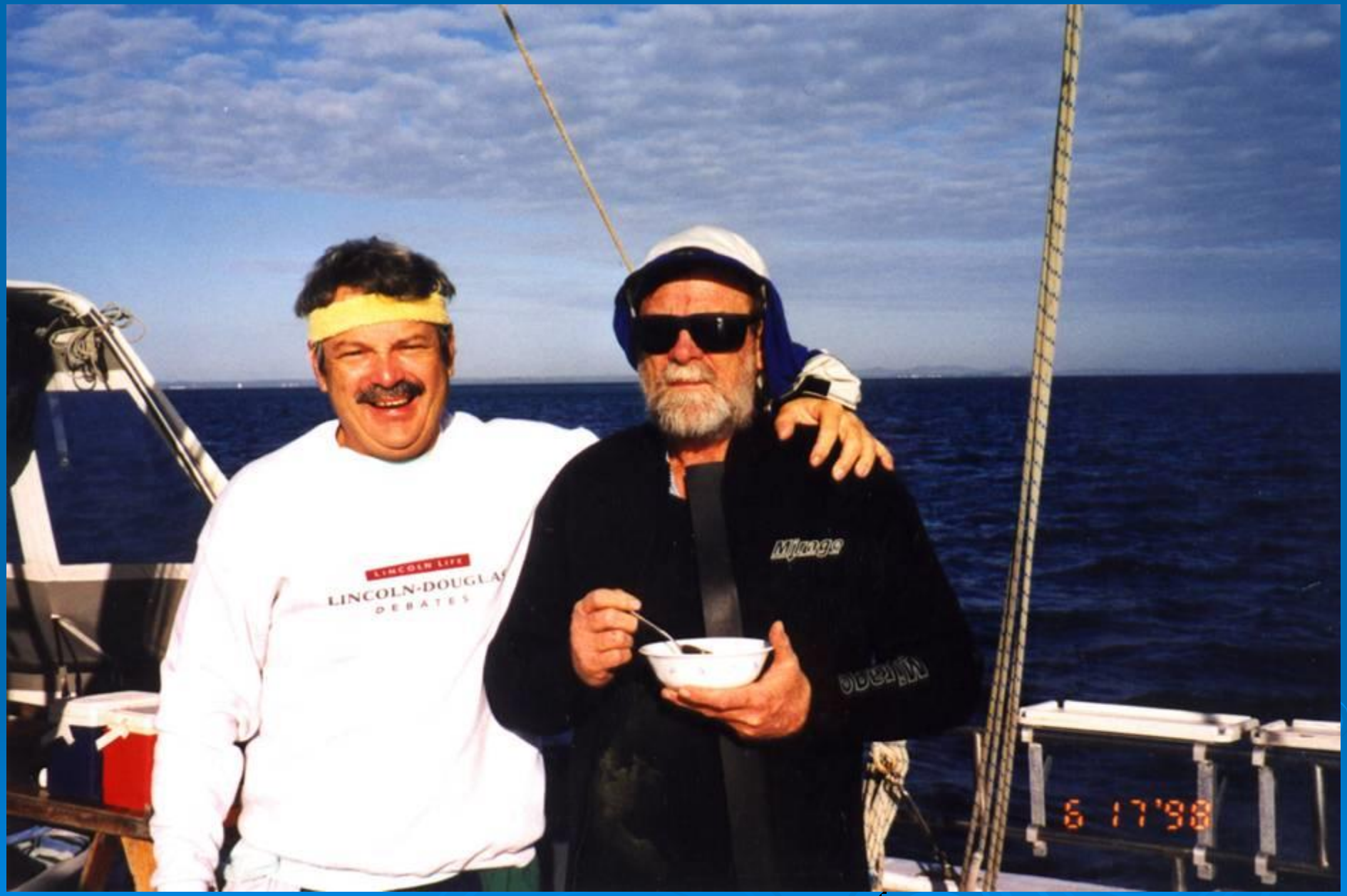
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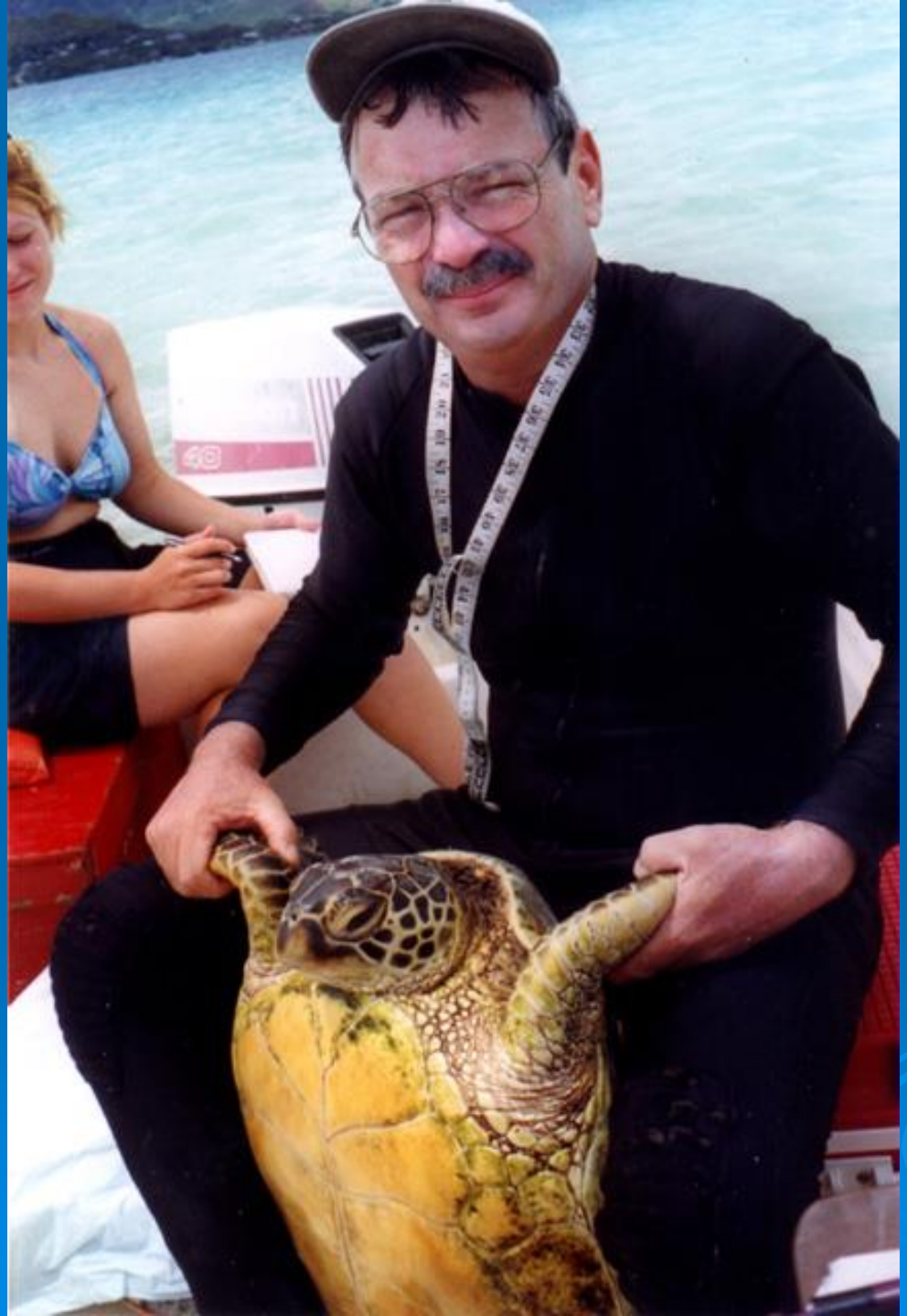

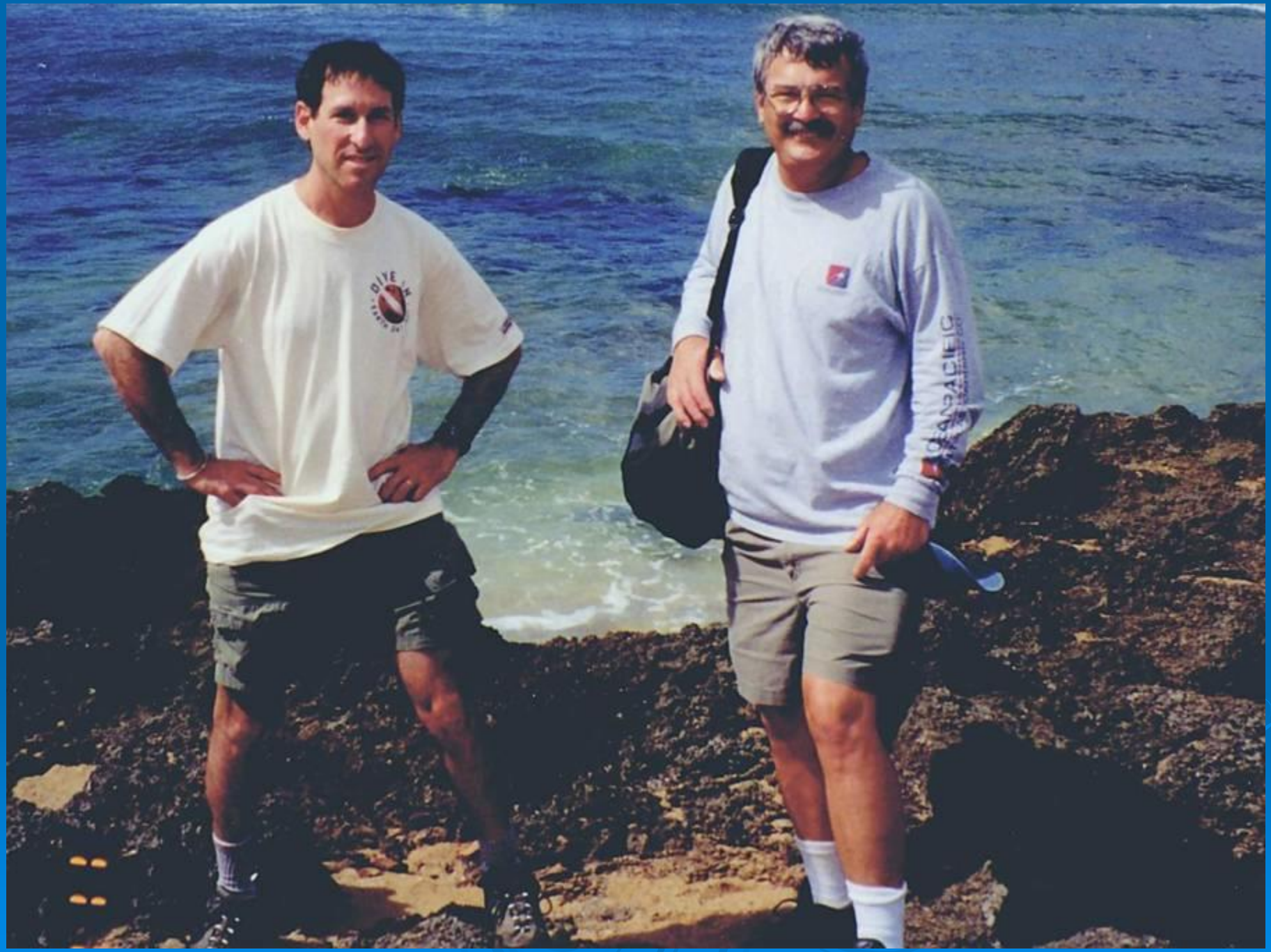


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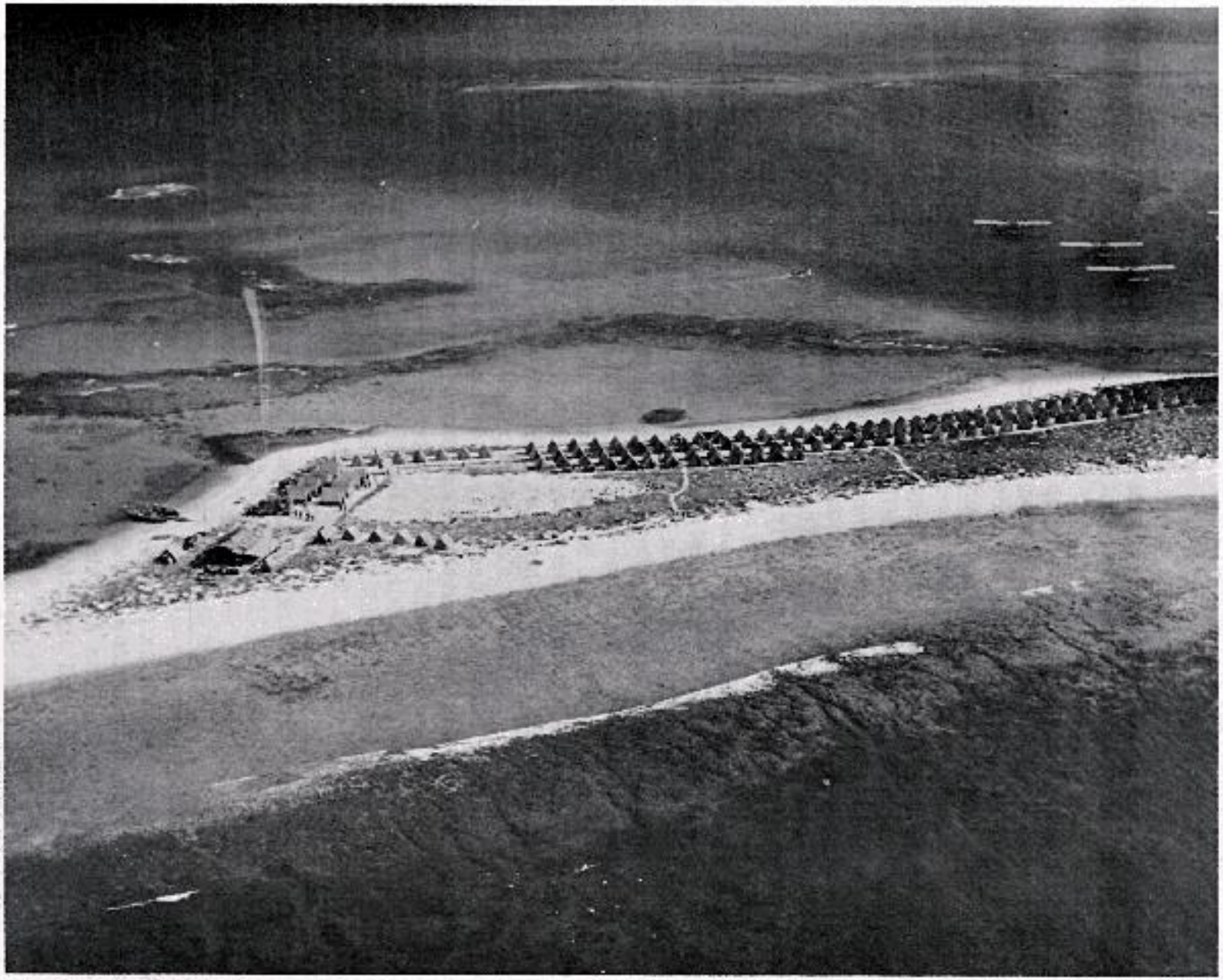

Figure 31. East Island "tent city" 11 November 1935. Official U. S. Navy photograph.

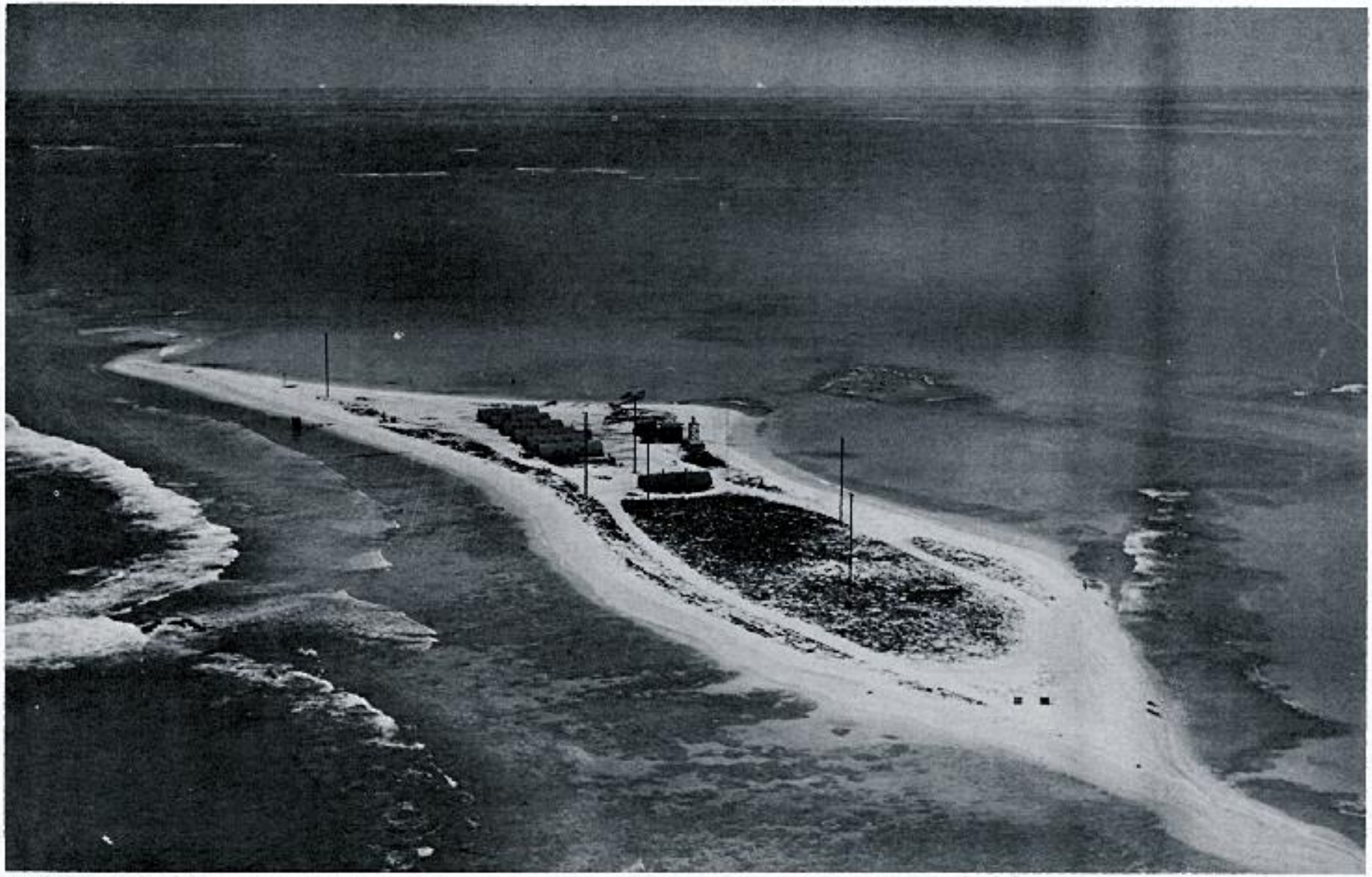

Figure 34. Newly constructed East Island Coast Guard LORAN Station, 24 April 1945. Official U. S. Navy photograph.

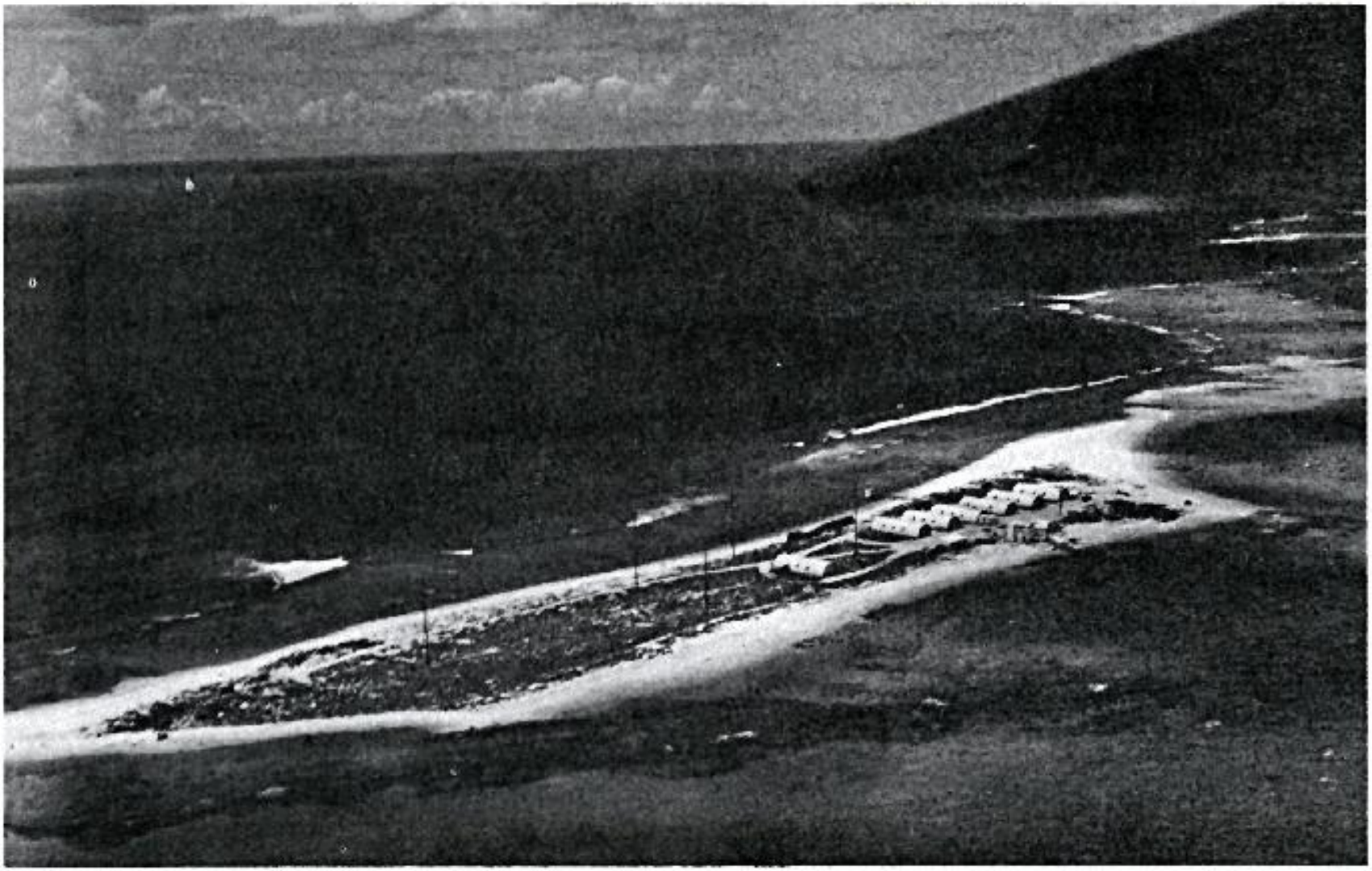

Figure 42. Aerial view of East Island Coast Guard LORAN Station, circa 1949, showing extent of vegetation. Official U. S. Coast Guard photograph.

Figure 43. East Island's vegetation, June 1962. Hawaiian Division of Fish and Game photograph by David B. Marshall.

GREEN TURTLES NESTING AT EAST ISLAND

600
500
400
300
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0

73

Where can we go from here?

GREEN TURTLES NESTING AT EAST ISLAND FRENCH FRIGATE SHOALS

808

700
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1973 77 79 81 83 85 87 89 91 93 95 97 99 01 03 05 07 2011

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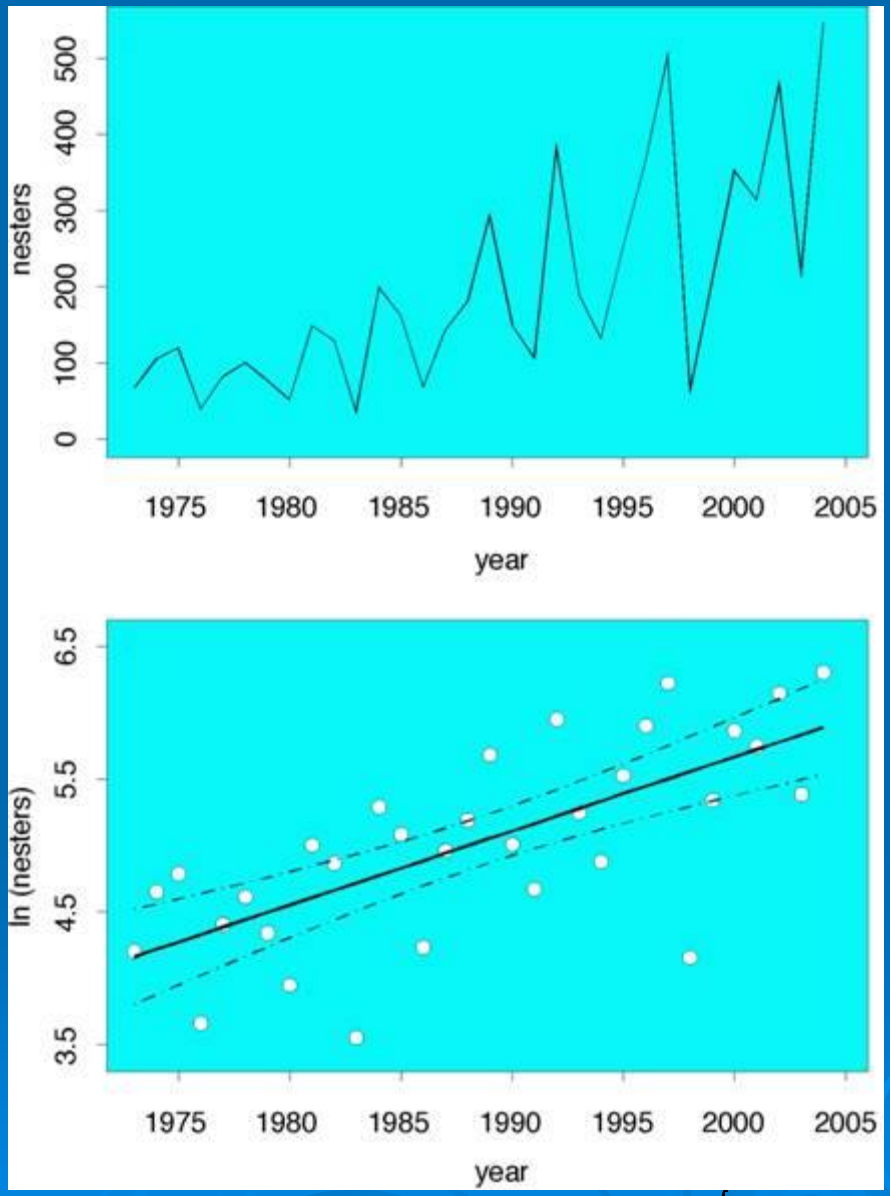
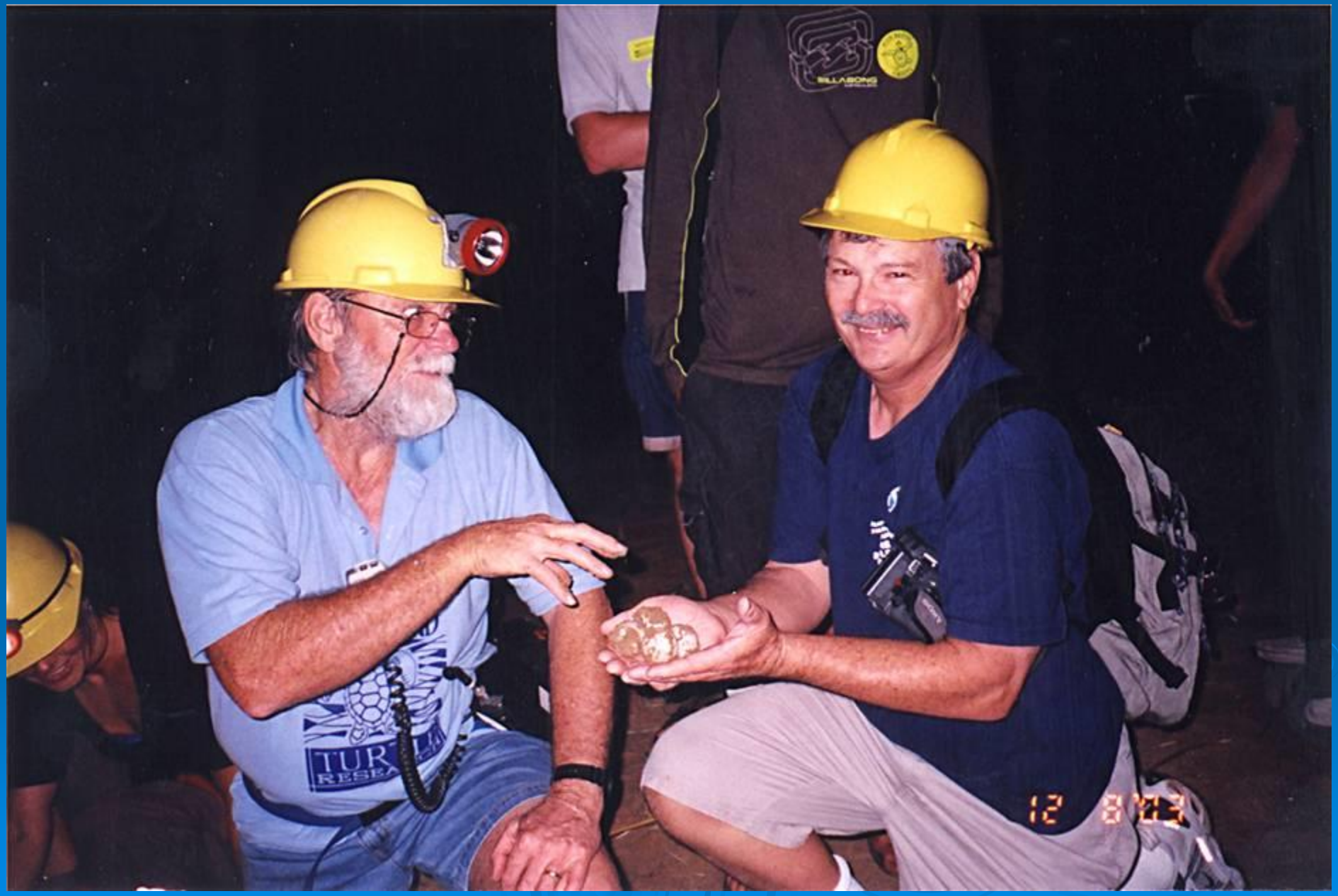
Pacific Islands Fisheries Science Center
National Marine Fisheries Service

Trends in nester abundance



East Island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SEA TURTLE RESEARCH
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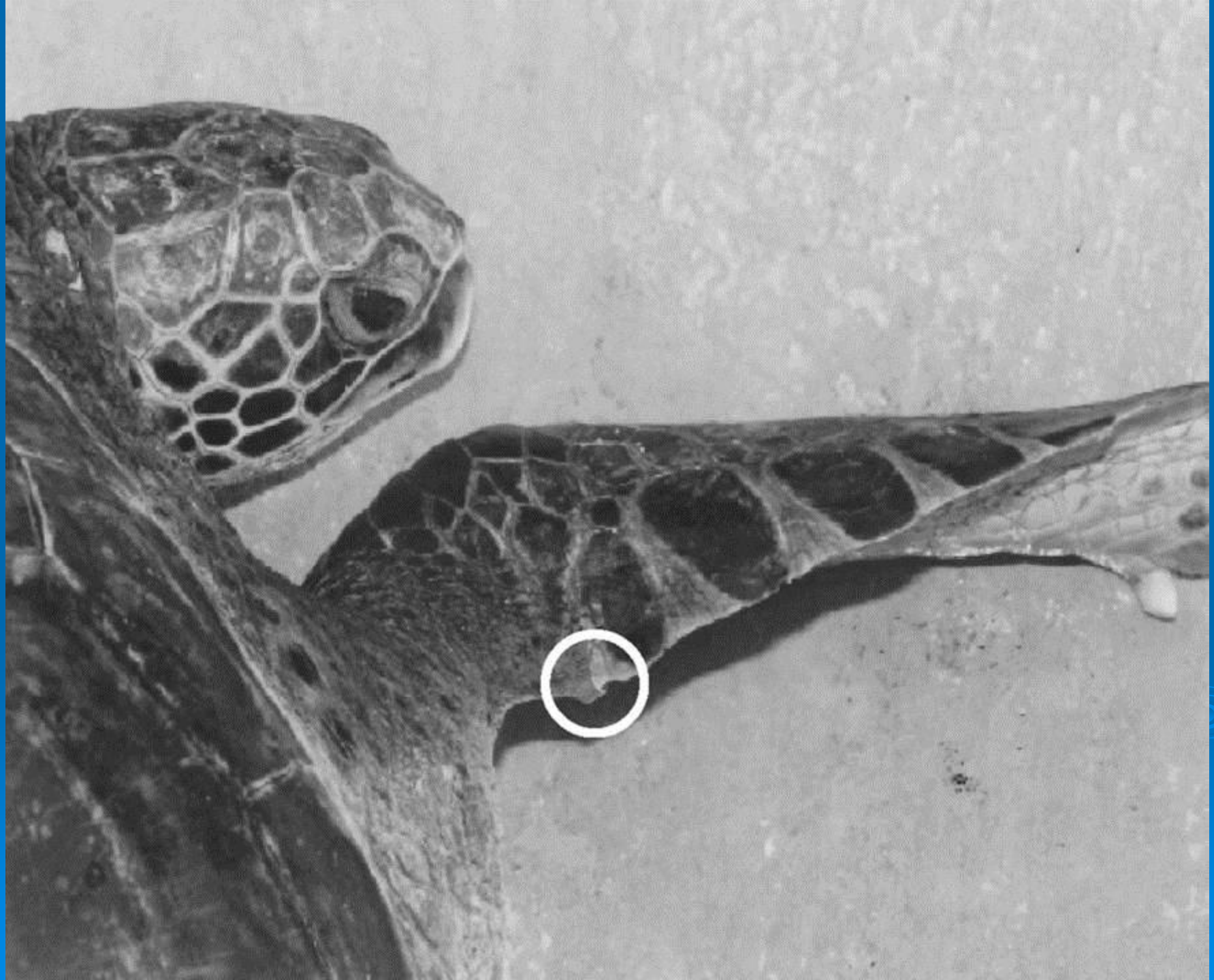

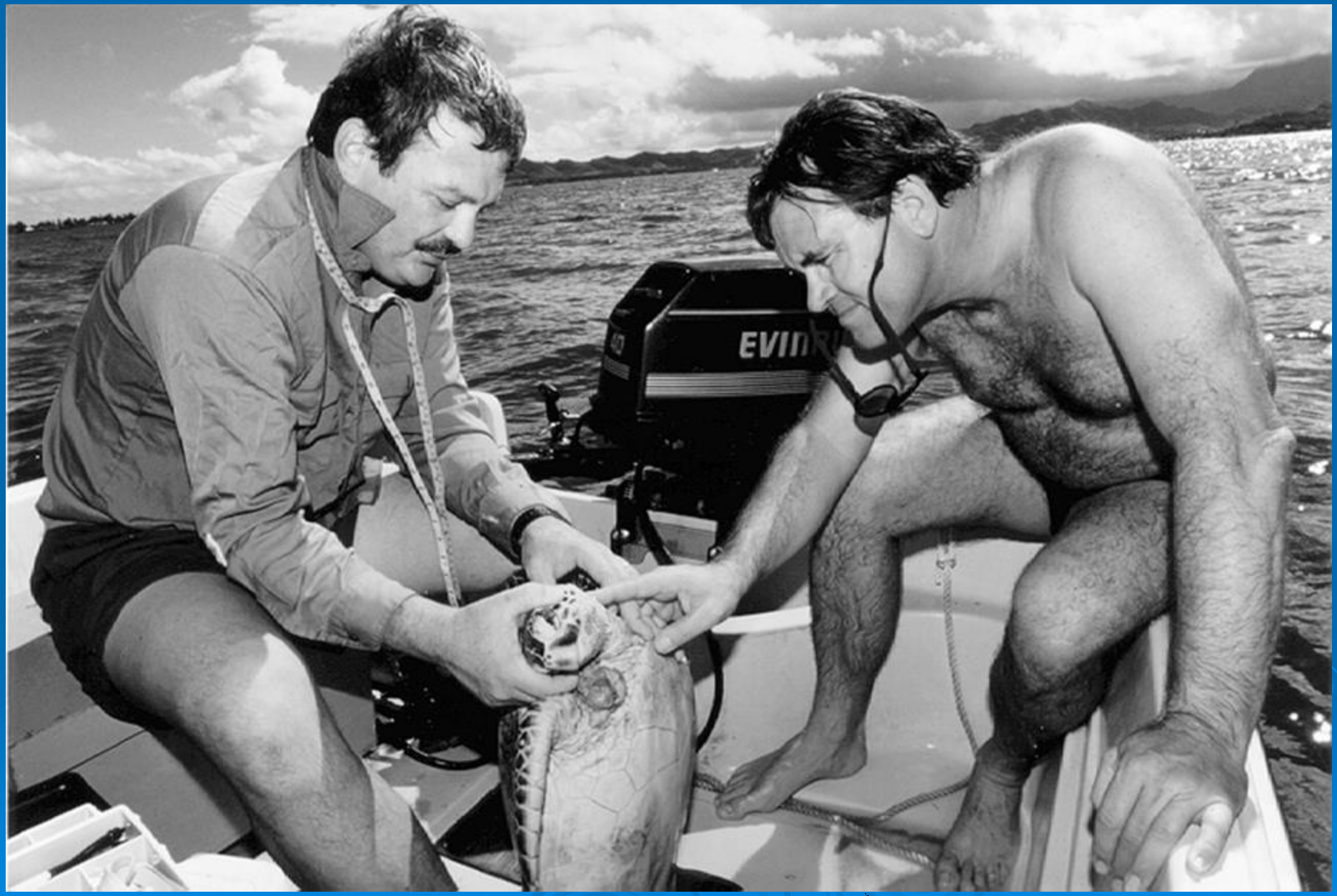
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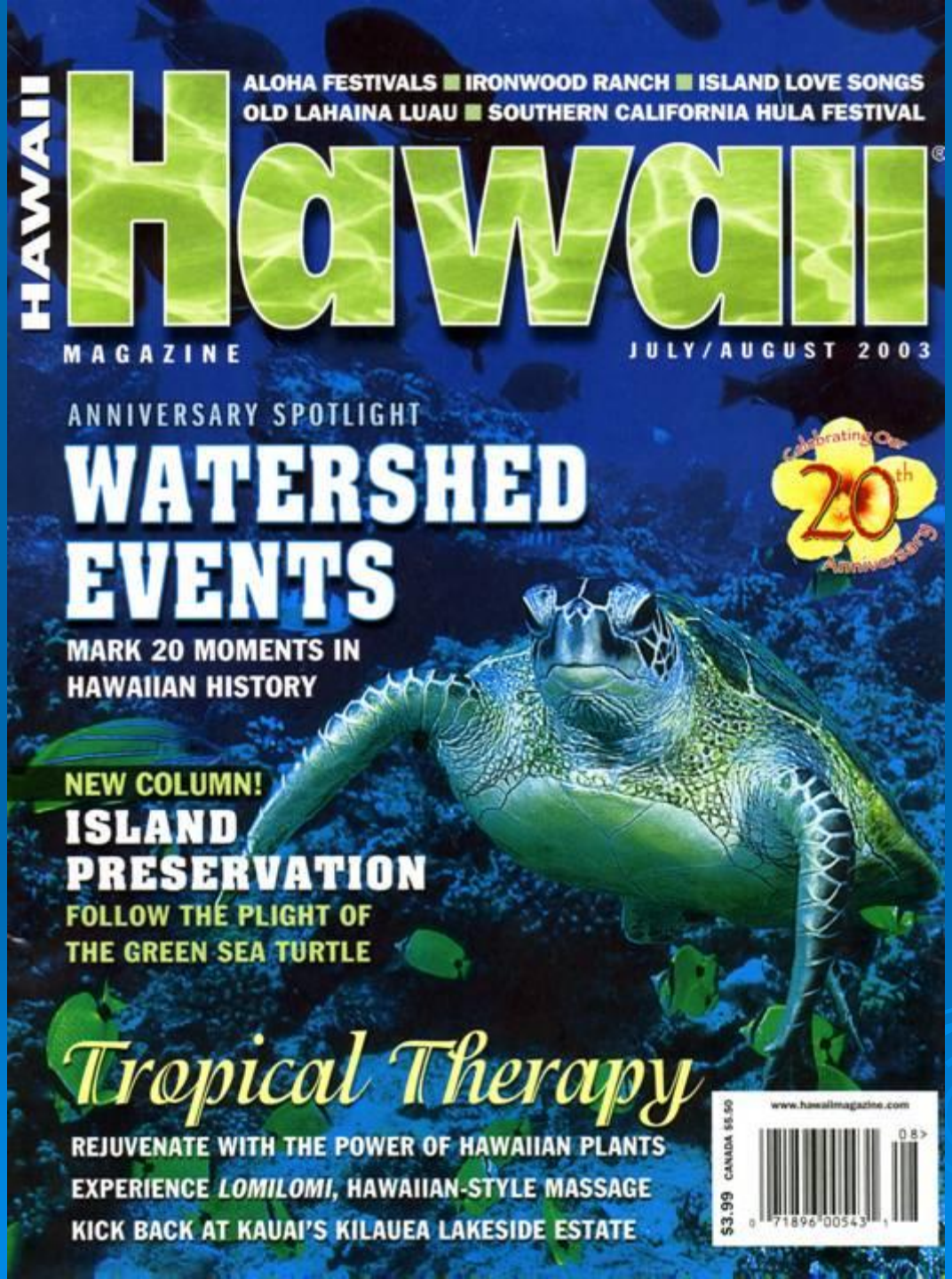
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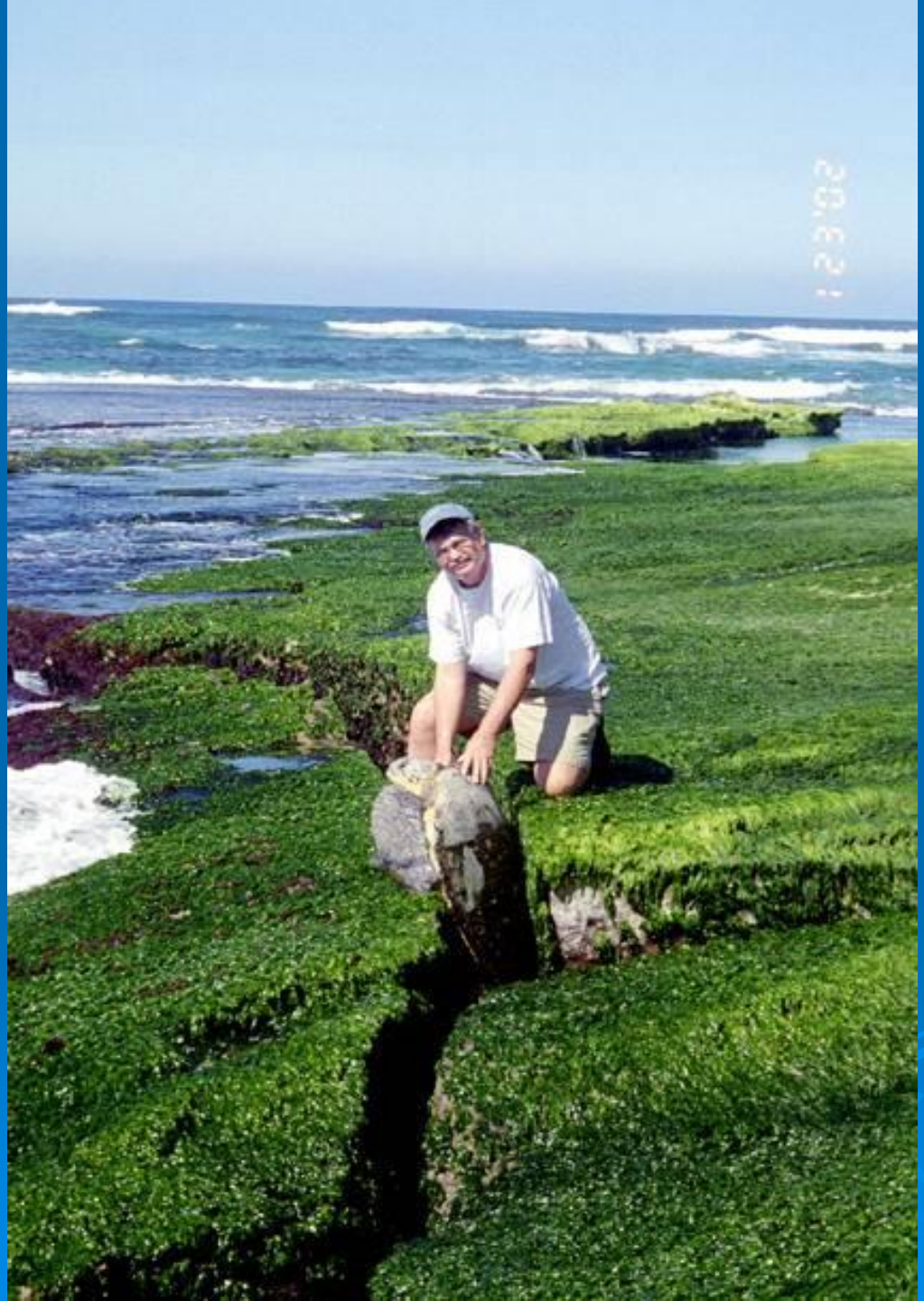
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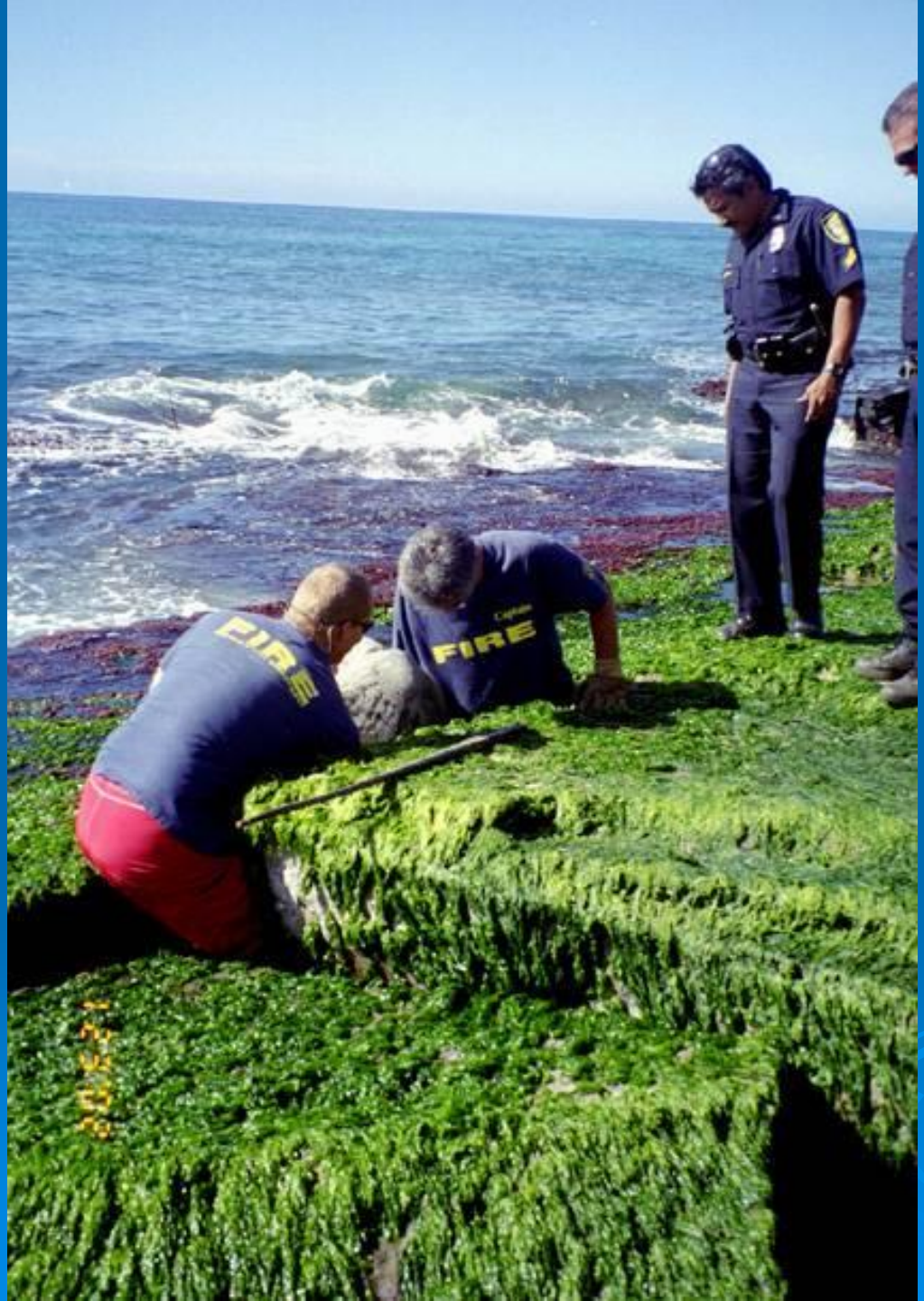
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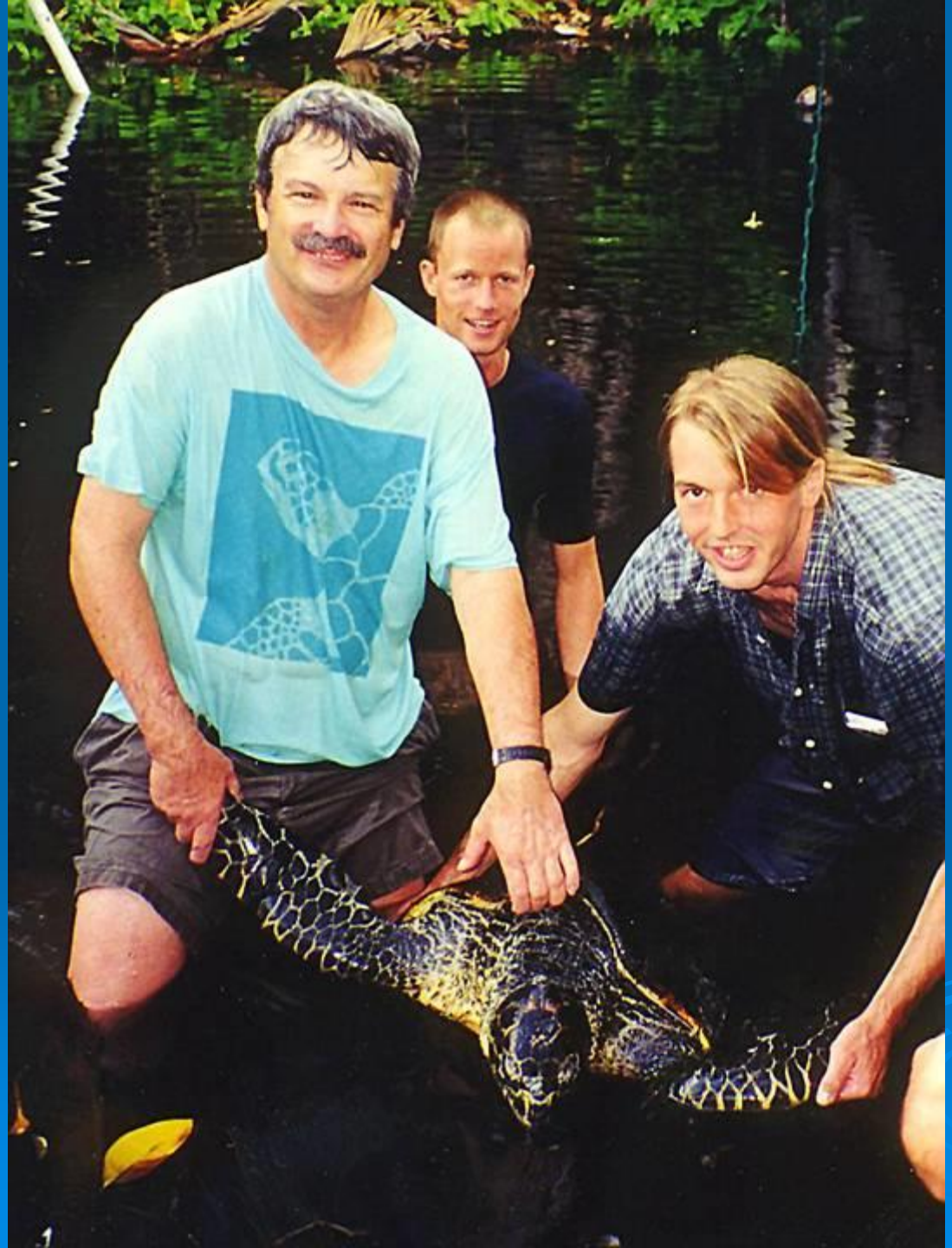
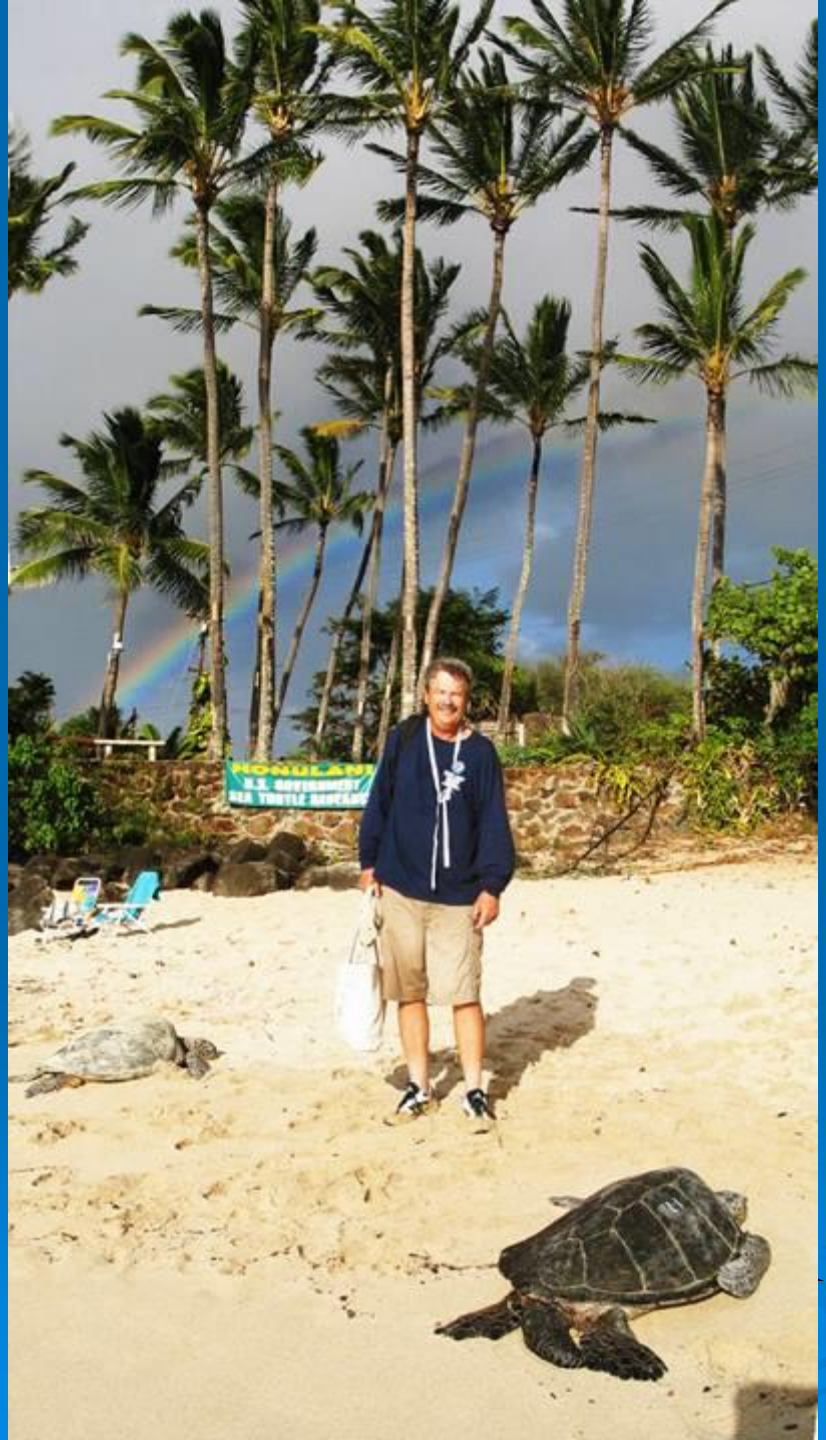



Pacific
olive ridley sea turtle
simulation model
Dr Milani Chaloupka

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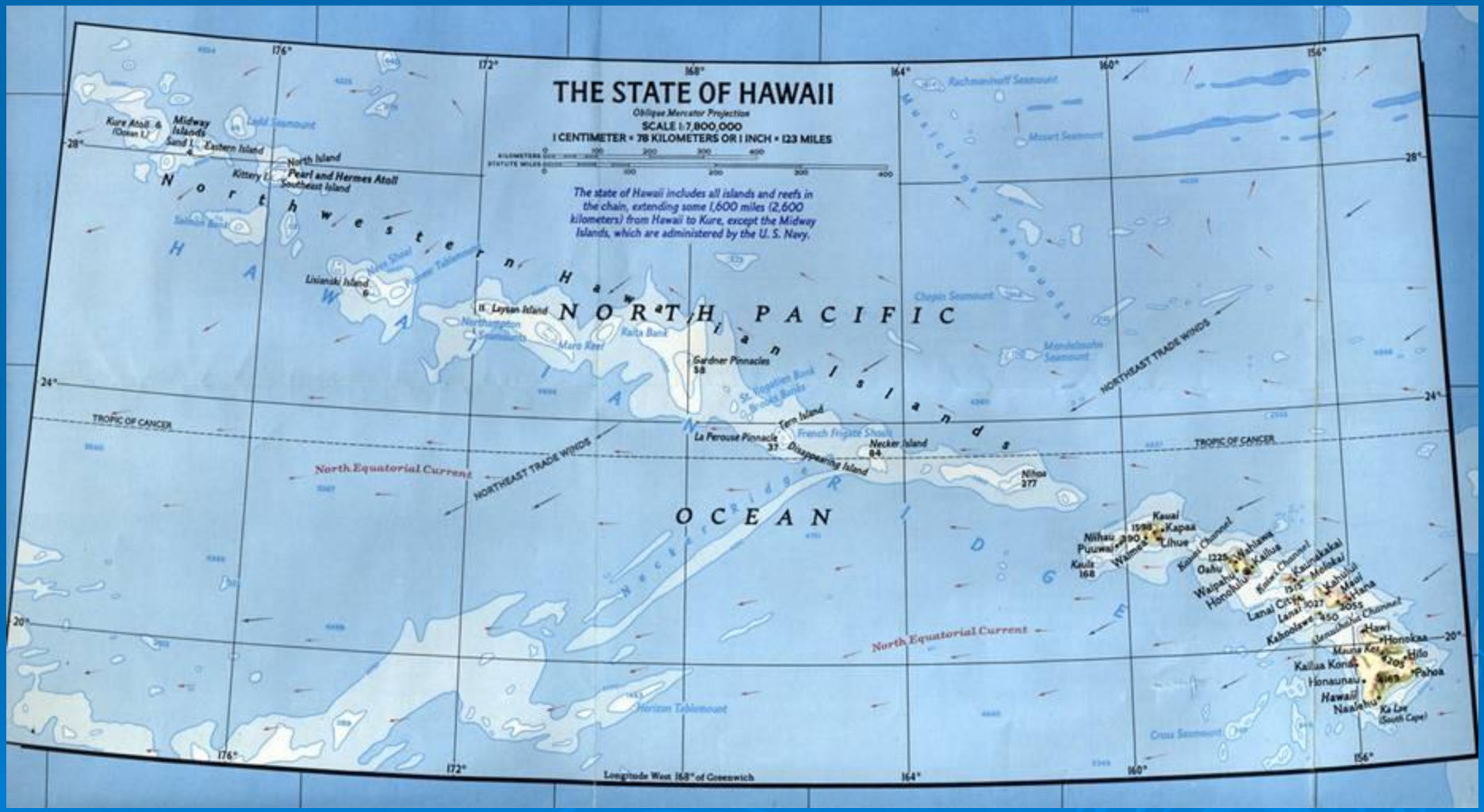
THE STATE OF HAWAII
Oblique Mercator Projection
SCALE 1:7,800,000
1 CENTIMETER = 78 KILOMETERS OR 1 INCH = 123 MILES
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NORTH PACIFIC OCEAN
Hawaiian Islands
Northwestern Hawaiian Islands
Kure Atoll
Midway Islands
Sand I.
Eastern Island
North Island
Pearl and Hermes Atoll
Southeast Island
Kittery I.
Laysan Island
Lisianski Island
Gardner Pinnacles
La Perouse Pinnacle
Tern Island
French Frigate Shoals
Necker Island
Nihoa
Disappearing Island
Kauai
Kapaa
Lihue
Niihau
Puuwai
Waimea
Kaula
Oahu
Waianae
Honolulu
Kailua
Waialua
Kaiwi Channel
Kauai Channel
Molokai
Maui
Lanai City
Lanai
Kahoolawe
Hana
Alenuihaha Channel
Hawi
Honokaa
Hilo
Pahoa
Kailua Kona
Honaunau
Hawaii
Naalehu
Ka Lae (South Cape)
Mauna Kea
Mauna Loa
NORTHEAST TRADE WINDS
North Equatorial Current
TROPIC OF CANCER
Longitude West 168° of Greenwich
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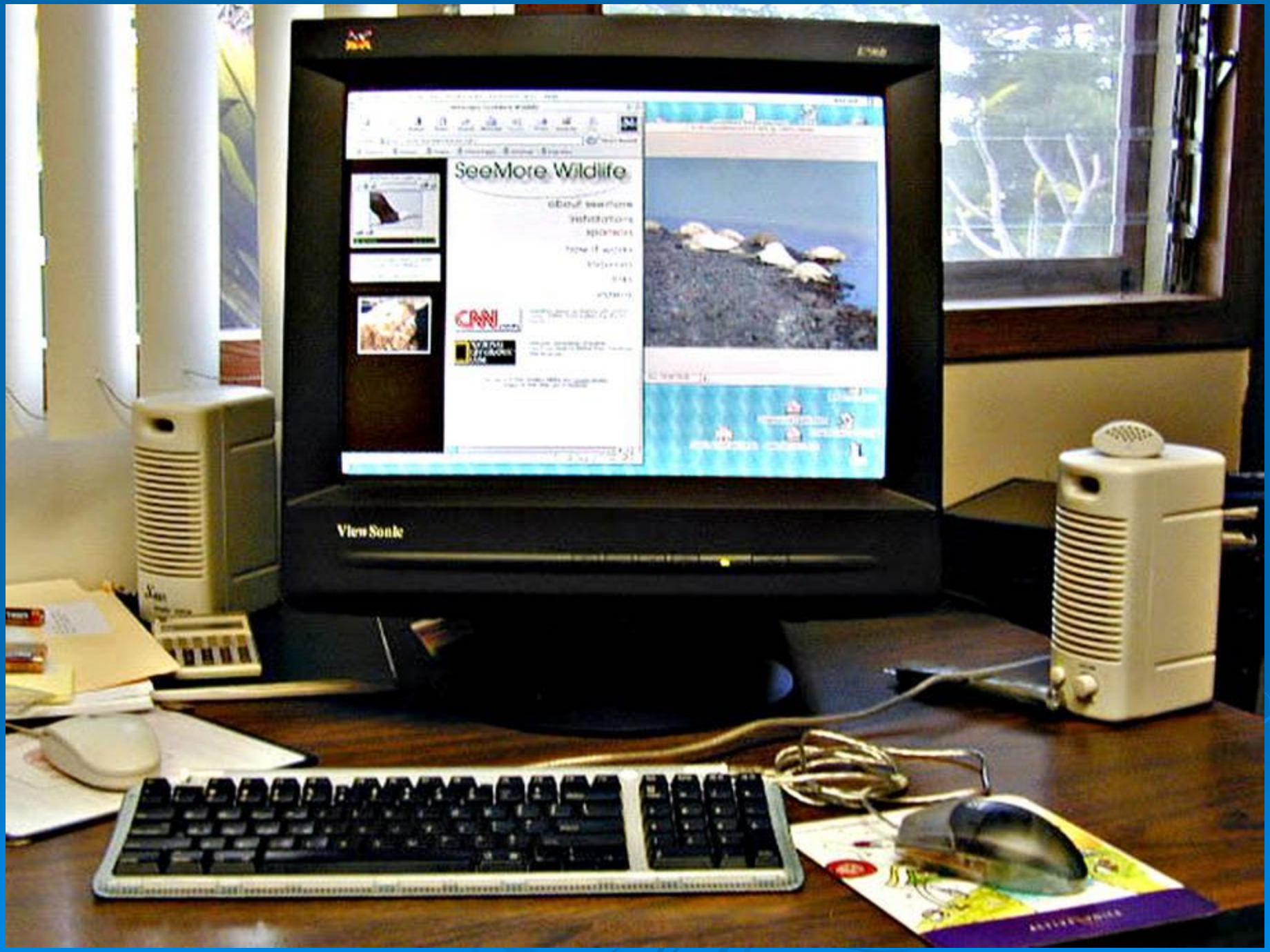
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1982

Pacific Science (1982), vol. 36, no. 2

Basking Behavior of the Hawaiian Green Turtle (*Chelonia mydas*)[1]

G. C. Whittow[2] and G. H. Balazs[3]

ABSTRACT: Observations were made on green turtles basking on the white sand beaches at French Frigate Shoals in the northwestern Hawaiian Islands. The highest rectal temperature recorded from the basking turtles was 31.3°C, but the surface temperature of the carapace attained values as great as 42.8°C. During basking, the turtles flipped sand onto their carapaces, but they did not appear to orientate their position in relation to the sun. The duration of basking was inversely related to the mean temperature of a black globe, and the basking beaches were relatively cool. The pattern of breathing during basking consisted of periods of breath-holding alternating with single breaths. The amount of time that the turtles basked varied from 0.3 to 7.5 percent of the total time they were under observation. The biological significance of basking and the advantages that might accrue to Hawaiian green turtles from their unique basking behavior are discussed.

Terrestrial basking is common in freshwater aquatic turtles, and its biology has been described by several authors (Boyer 1965, Moll and Legler 1971, Terpin, Spotila, and Foley 1979). Among sea turtles, however, basking on land is comparatively rare. Only the green turtle (*Chelonia mydas*) has been reported to bask, and it does so only in certain parts of the world, notably in the northwestern Hawaiian Islands. One of eight breeding colonies that have been designated for high priority by the World Conference on Sea Turtle Conservation (1979) is located at French Frigate Shoals in the northwestern Hawaiian Islands.

Little is known about the basking behavior of Hawaiian green turtles. Balazs and Ross (1974) showed that 6-month-old turtles kept in a tank at the Hawaii Institute of Marine Biology basked when given the opportunity, although turtles of this age have not been observed to bask under natural conditions. At French Frigate Shoals the incidence of basking was highest during the breeding season, when, presumably, the number of turtles present was greatest. Balazs (1980) showed further that during the nesting season, the number of basking turtles declined as the egg-laying season progressed. However, there is not a month in the year when turtles have not been observed to bask. Both male and female turtles have been reported to bask (Balazs 1980). Turtles that formerly basked off the coast of Mexico and in the Galápagos Islands were predominantly female (Fritts 1981) and so also are the turtles that presently bask in Australia (Bustard 1973). In another report, Balazs (1977) described the nocturnal basking behavior of green turtles at Necker Island in the northwestern Hawaiian Islands. This latter behavior points to the possibility that the function of basking may not be that of acquiring heat by solar radiation, although this is believed to be one of the principal functions of basking in freshwater turtles (Boyer 1965).

[1] This study was supported by a grant from the National Geographic Society. Manuscript accepted 21 January 1982.

[2] University of Hawaii, John A. Burns School of Medicine, Department of Physiology, and Pacific Biomedical Research Center, Kewalo Marine Laboratory, Honolulu, Hawaii 96822.

[3] University of Hawaii, Hawaii Institute of Marine Biology, Kaneohe, Hawaii 96744.

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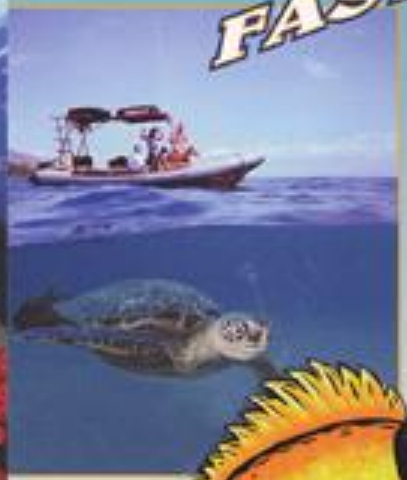

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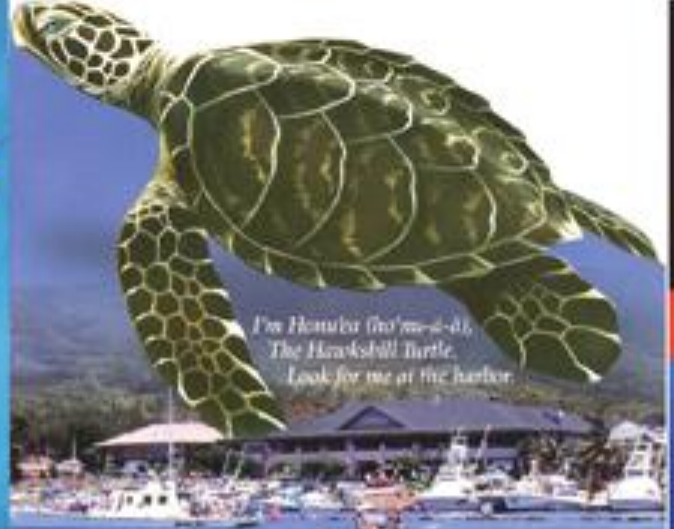

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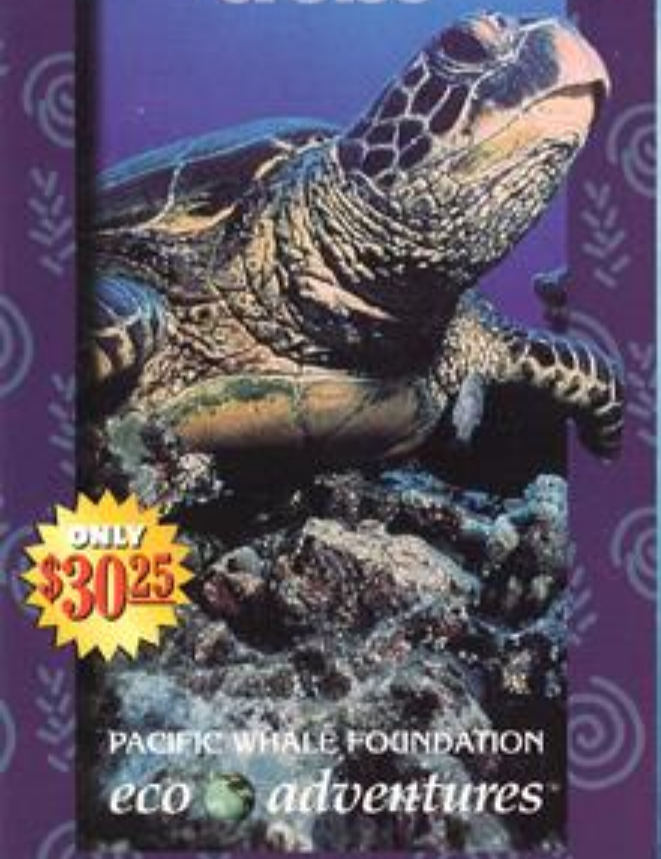

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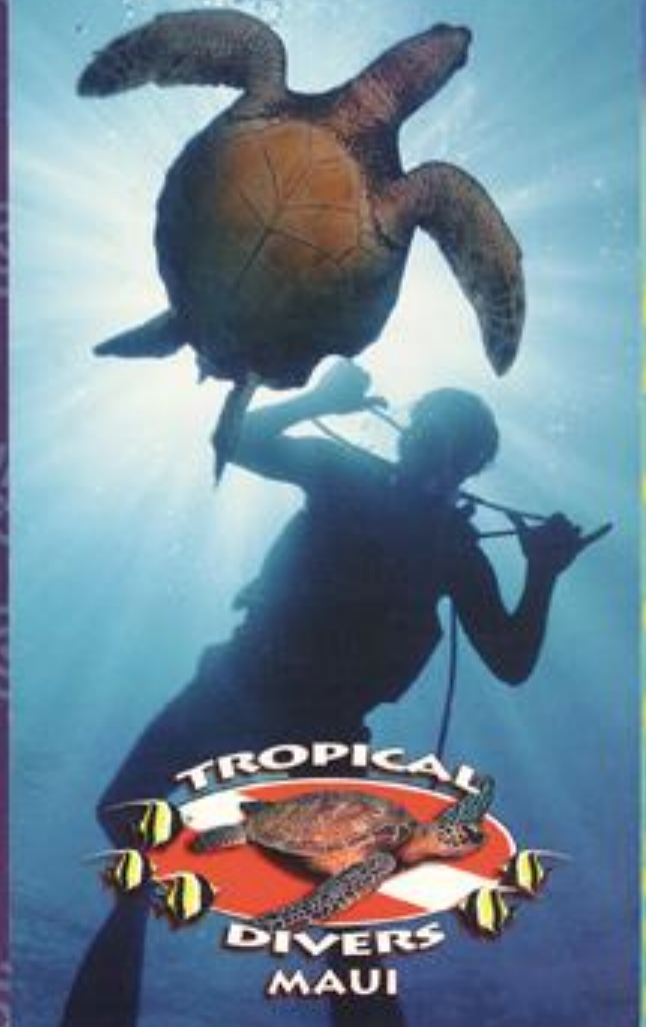

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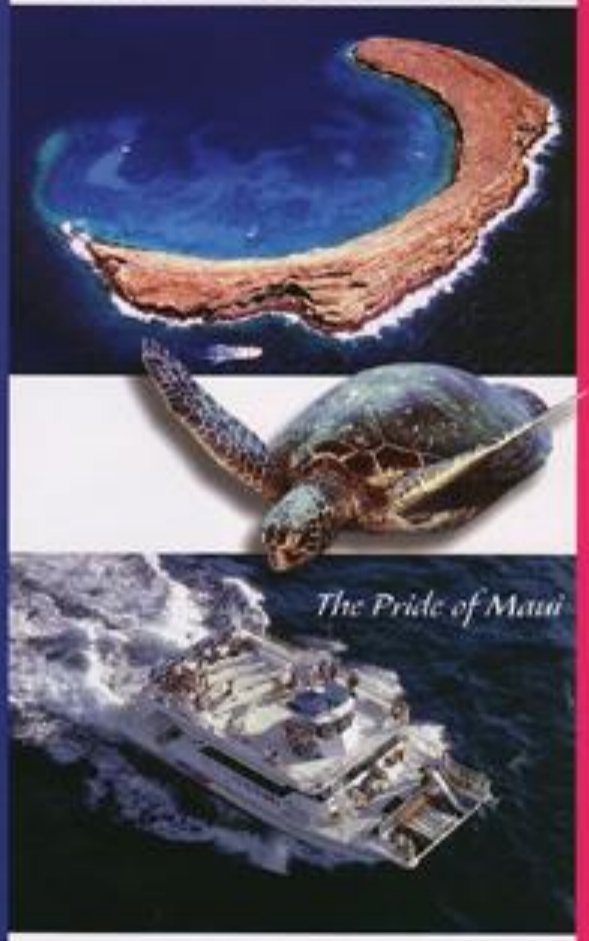

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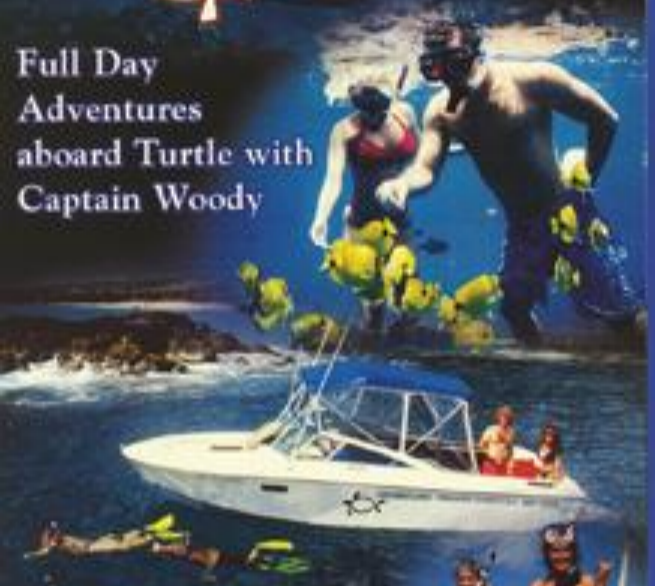

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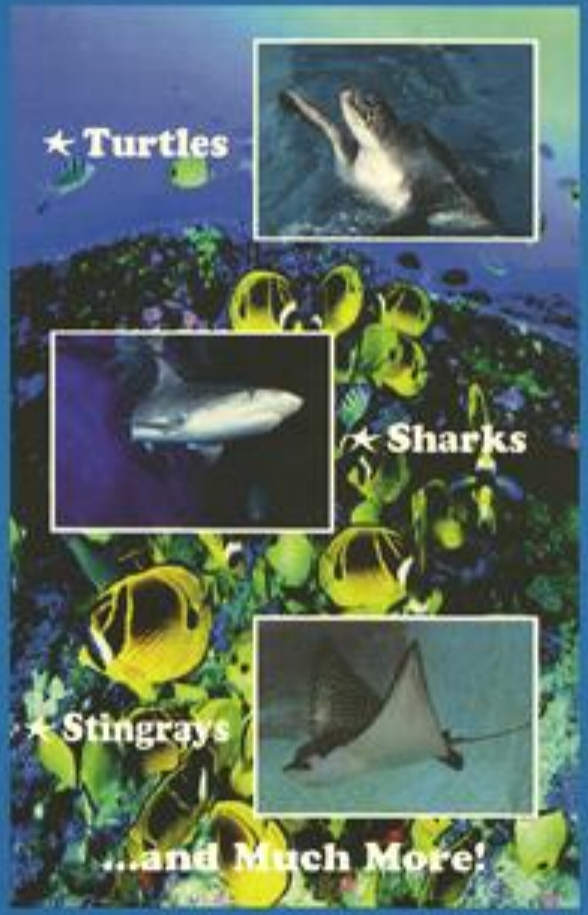

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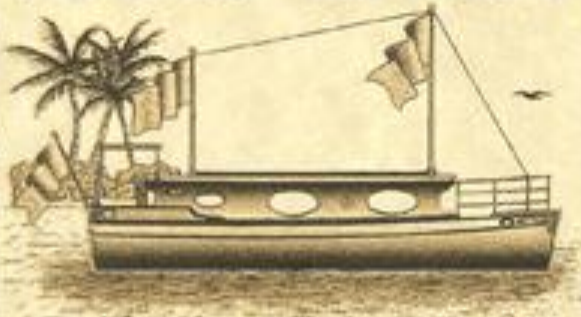

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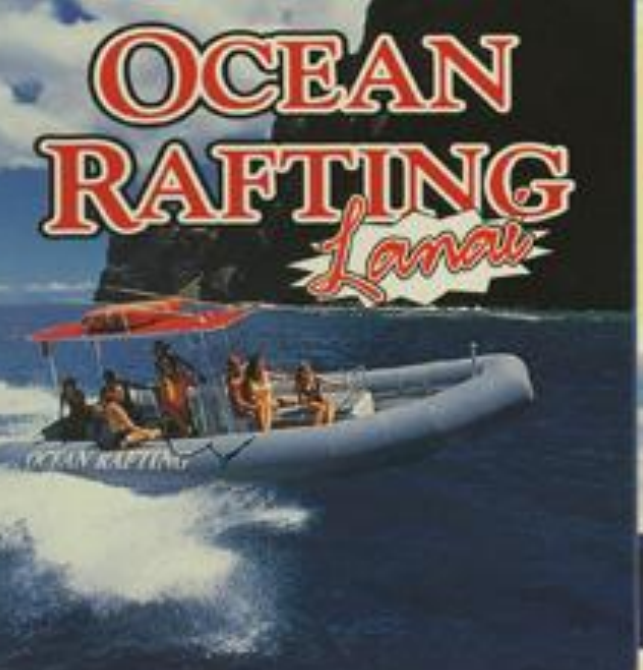

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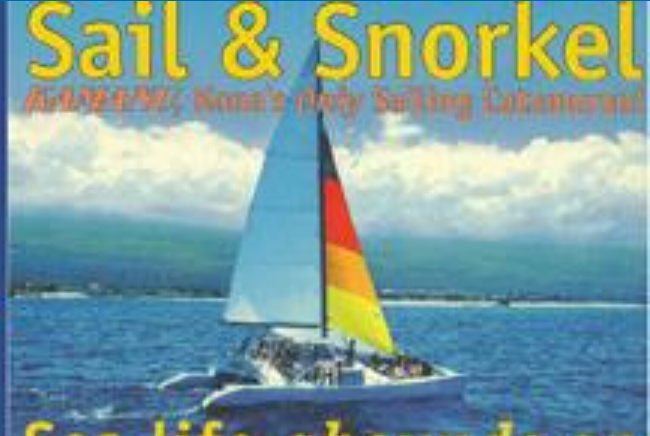

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