Hawaiian Turtles

1970s - 1990s ARTICLES
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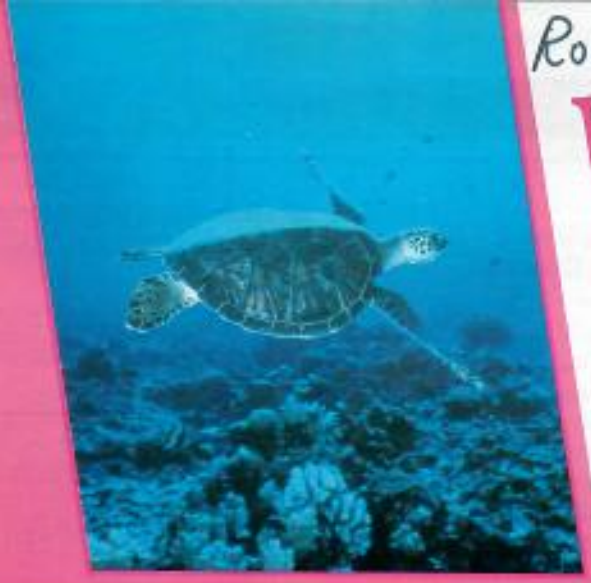
Roberts, Kim

HAWAII'S NEW AGE MUTANT HULA TURTLES



Text and photography by Kim Roberts

In Hawaii the turtles don't have names like Donatello or Michaelangelo but the turtles and names you will find are equally imaginative.

The Hawaiian Islands are one of the primary areas in the world for finding and diving with the graceful green sea turtles (*Chelonia mydas*). From the northernmost atolls of the Hawaiian Island archipelago to the main islands of Niihau, Kauai, Oahu, Molokai, Lanai, Maui and Hawaii, these animals are experiencing a welcome resurgence in population and popularity. Long desired by native Hawaiians, and later tourists, as a food source, these marine reptiles are now protected by both state and federal law and make terrific dive buddies.

While visiting Oahu, divers will find a large community of turtles in areas as frequented as the reef at Waikiki. Just off of the Hilton Hawaiian Village Resort, there lives Scarlet, Sid Vicious, Barney and Baby. Apparently, Scarlet rules the roost, even to the extent of sitting in a diver's lap if given the chance. Since Sid Vicious and Baby are small young turtles, they need to come up for air more frequently. The team at Atlantis Reef Divers have named one of this duos maneuvers, "The Stealth." These two little turtles pop up to the surface for air and then glide back down in attack formation towards any diver in sight. Turtles are generally as harmless an animal as you could ever meet, but apparently Sid Vicious acquired the moniker because he's a "little nipper."

When diving in Maui, a favorite beach or boat dive is the **Hyatt Reef** off Kaanapali. The coral gardens of this shallow reef are rich with fish as well as turtles. Lahaina Divers Marine Awareness Team has named one little guy Tripod, and although he's missing a fin, he seems to be as graceful and at ease in the reef as all the others.

Across from Maui is the island of Lanai and a special dive site named **Turtle Town**. Again, because of the turtles love of the coral gardens, this is a shallow and sunny dive site that is simply teeming with turtles. This dive area and several others like it will host up to twenty animals at a time. Even in the early seventies when turtle sightings were rare around Maui, Turtle Town was home to at least a dozen individual animals. Today, turtles are also found at many of the better known dive sites along "the backside" of Lanai, including **Shark Fin, Fish Rock** and **Second Cathedrals**.

Probably the most famous of all Hawaii's green sea turtles is the effervescent Miss Piggy, who resides year round on the Kona Coast off the Big Island of Hawaii. Just as her name suggests she is a star of renown and has been featured in numerous magazines and videos. The folks at Kona Coast Divers say that you can usually find her at a dive site called the **Golden Arches**. And although she is aptly named, since she eats everything in sight, she is estimated to weigh in at only 35 pounds.

Another female turtle of similar size and character is Ninji, she sneaks around **Red Hill** for silent attacks on fingers! One of the reasons attributed to these animals apparent sense of freedom and safety is the legislation enacted to protect them.

Kauai also has a well-known resident population of turtles and another turtle-rich

Important Information

WHAT CAN YOU DO TO HELP THE TURTLES?

1. While diving or snorkeling, enjoy their beauty and respect their space. Never attempt to touch or "ride" a turtle. These are air breathing animals and anything that we do that limits their ability to breath and move freely can harm them.
2. Report any incidence that you may see of turtles being taken from their habitat or if you see a turtle nesting. These animals are protected by the United States Endangered Species Act as "threatened" in Hawaii and "endangered" in Florida.
3. Make sure that when you are using the ocean environment that you pick up any trash you see and never leave any behind.
4. Continue to support legislation for a worldwide ban on drift netting. This practice of laying miles of net, some of which breaks loose and continues to "fish" indiscriminately, is not just a blight to turtles but also to marine mammals, sea birds and pelagic fish.
5. When diving, be sure to be aware of your effects on the habitat. Avoid anchoring on coral, never take broken coral as a souvenir of your dive, and make every attempt to practice good buoyancy control.
6. If you would like to contribute to efforts for the green sea turtles contact the Center for Marine Conservation at 1725 DeSales Street N.W., Suite 500, Washington, DC 20036.

Remember, as divers we can make a difference!

dive site. There is a set of caves just off the Kauai Sheraton, and, once your eyes adjust to the light, you realize the large boulders inside the caves are actually very large turtles.

The turtles seen while diving the Hawaiian Islands are actually travelers themselves. Most of Hawaii's green sea turtle population mate and hatch their young in a largely uninhabited set of islets named the French Frigate Shoals over 800 miles northeast of the main Hawaiian Islands. It is here in these desolate atolls that they begin their struggle to survive, soon leaving the nesting areas to live in the offshore ocean environment. Somewhere between three to five years of age, or more approximately when they reach a length of about 35-40cm, they move into the near-shore reefs of the islands. These animals are known to grow slowly and may live up to fifty years. During their sexually mature years they migrate back to their nesting grounds and mate every two to four years.

Despite some indications of increased hatching activity and certainly increased sightings in the Hawaiian Islands, these turtles continue to face some difficult challenges. Animals continue to be poached, they are certainly a favorite food of tiger sharks, they are often trapped in the gillnets of local near-shore reef fisheries, they are subject to entanglement in ocean debris, and they have been known to ingest and die from eating too much floating trash. Thankfully, these are generally areas in which we are able to make changes and help the turtles.

Unfortunately, they are now facing a new challenge. Since 1983 green sea turtles from Florida to Hawaii have been developing a disease called Fibropapilloma. When a turtle is afflicted the fleshy parts of its body can have tumor like growths that eventually impede their ability to function. Currently, researchers from National Marine Fisheries Service (NMFS) are attempting to find both a cause and a solution for this disfiguring disease. According to George Balazs of NMFS Southwest Fisheries Science Center in Honolulu, "the real concern today is that the epidemic facing the green sea turtles of Florida and Hawaii will spread to other areas of the world."

Kim Roberts is co-owner with her husband Blain, of Lahaina Divers, the Maui member of Dive Team Hawaii. In addition, she is the Maui Representative of The Ocean Recreation Council of Hawaii (TORCH) and is the state chairperson for the creation of artificial reefs.

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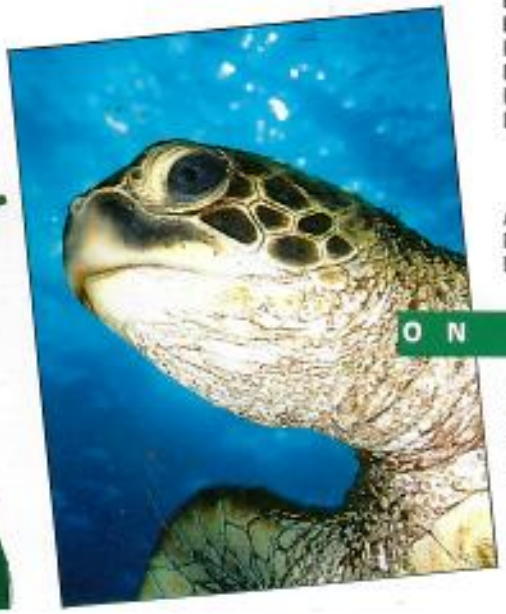

ON THE COVER

A friendly green sea turtle checks out divers visiting the Kona Coast on the Big Island of Hawaii. Photo was taken by Clay Wiseman, former captain of the *Kona Aggressor* and current captain of the *Belize Aggressor*.

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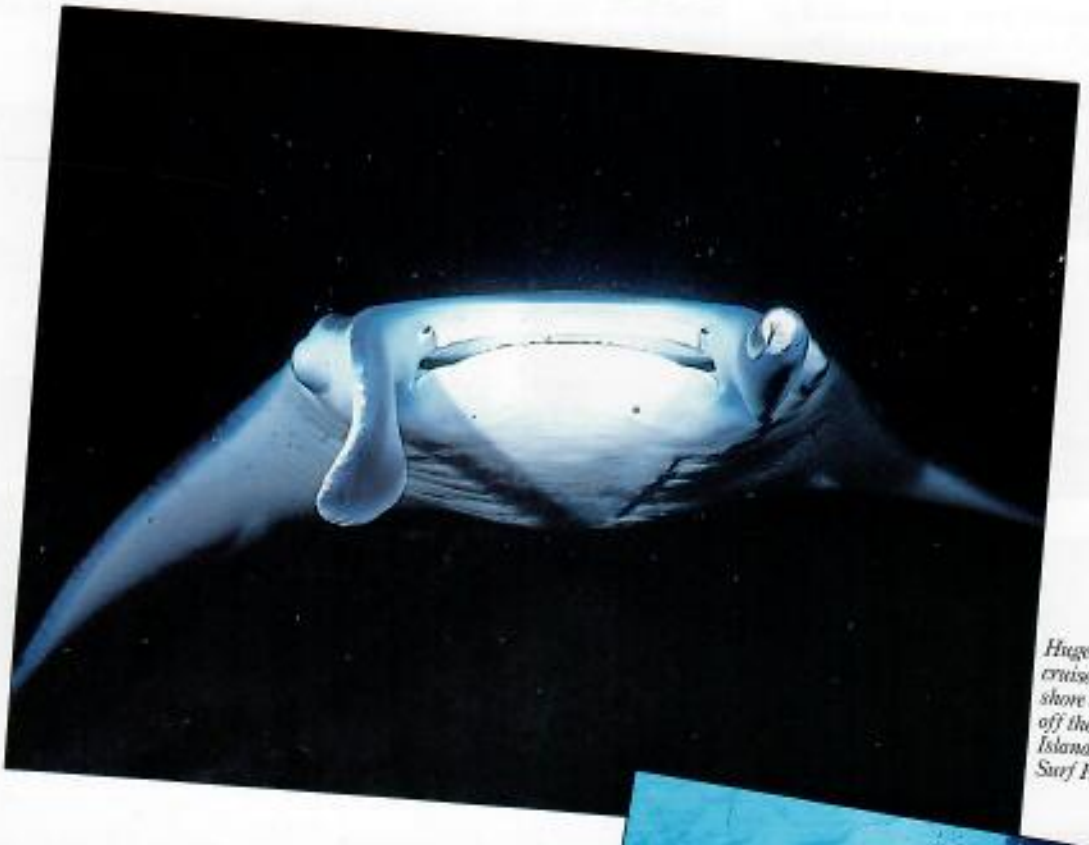
Advanced Dives



Huge mantas cruise into shore at night off the Big Island's Kona Surf Hotel.

Molokini Rock off the island of Molokai offers deep walls and strong currents.

MANTAS AND WALL DIVING — AND THESE ARE BEACH DIVES!

Along the Big Island's Kona Coast there are two fascinating dives that can be reached from shore. One is right off the **Kona Surf Hotel.** While not an "advanced" dive in the traditional sense of the word, it offers a nighttime underwater experience guaranteed to get even the most jaded travel diver's blood boiling.

The hotel sits on a lava rock shore a few miles south of the town of Kailua-Kona. Each night the hotel turns on a number of spotlights which shine into the water just below the hotel's main restaurant as well as on a small cove about 40 yards down along the lava wall. These spotlights attract plankton, and the plankton in turn attract manta rays.

On almost every night of the week you can find from as few as two to as many as 10 manta rays with wingspans reaching 12 feet in water as shallow as 15 feet. As long as there are only a few divers in the water the manta rays will continue to feed while performing their underwater somersaults and figure eights, sometimes gently pushing divers out of the way who happen to interfere with their ballet moves.

Another excellent shore dive on the Kona Coast is at the **Place of Refuge Park.** Located at Honaunau just a few miles south of Kealakekua Bay (Captain Cook's Bay), The Place of Refuge is probably the most protected shore dive along the Kona Coast, yet it offers more diversity than any other shore dive in the islands. There is easy access into the water via lava steps at the center of the bay. Off to the right of the entry point is a vertical wall that drops from a shallow shelf in 20 feet of water to a flat sandy bottom over

100 feet deep. Along this wall clouded with huge schools of baitfish you can swim with amberjacks and other large pelagic species.

LAVA TUBES HIGHLIGHT SOME SPECTACULAR TOPOGRAPHY

While boasting a few great beach dive sites, Hawaii's best diving is accessible by boat. And one of the Big Island's most spectacular boat dives is exploring the lava tubes found at **Cavern Point**, located on the northern edge of Laeokamimi Point on the Kona Coast, just south of Kealakekua Bay.

One of the Kona Coast's newest diving areas, there are actually a number of different dive sites in the Cavern Point area. The Kona Coast's two live-aboard dive vessels, the *Kona Aggressor* and the *Sun Seeker*, make regular stops at these sites, and they are also visited by some of the shore-based dive operations out of Kailua-Kona.

The primary attractions at Cavern Point are Twin Lava Tubes and Three Room Cave. At **Twin Lava Tubes** there are two parallel underwater tubes, one on top of the other, that extend over 200 feet straight into the lava rock wall. The tubes range from 10 to 20 feet in diameter and their walls are scored with cracks and crevices which hide a variety of cowries, shrimps and lobsters. Schools of soldierfish, solitary bigeyes and glasseye snappers also roam the darkness.

A rock column rising out of the water marks the entrance to the lava tubes. Just behind this rock there's a spacious cavern. Make sure to bring your dive light when exploring these caves. Except for the light at the entrance, which quickly fades as you swim back into the recesses of these natural pipelines, the only illumination you're going to have is what you bring with you.

Three Room Cave is located just south of Twin Lava Tubes. A vertical wall drops to about 25 feet. To find the entrance to Three Room Cave, swim toward shore along the vertical wall. The opening is fairly large. Inside you'll find three incredible caverns with high arching ceilings and interconnecting tunnels. The complex is so extensive that the *Kona Aggressor* always places a safety line in the cavern equipped with a strobe light and a spare scuba tank before allowing anybody to go inside. There's also a back door to the caverns that leads to another interesting lava tube tunnel.

Above and left: The channel between Maui, Lanai and Kahoolawe is a great place to run into humpback and pilot whales. Below: A school of Goatfish off Molokai.

The holes along the ceilings of the tunnels and caverns are home to bright orange Hawaiian lobsters, bullseye lobsters, slipper lobster, spiny lobsters and mole lobsters. Turkeyfish are also quite common, as are white-tip reef sharks, leaf scorpionfish, frogfish and other rare and interesting animals.

Elsewhere in the island chain, the southeastern side of Lanai also has some excellent lava tube diving. The best of these are First Cathedrals and the Second Cathedrals. **First Cathedrals** offers a huge underwater grotto inside a lava ridge that's full of arches, caves, tubes, crevices and interconnecting passageways. The rear wall of the main cavern is a latticework of holes, which gives the interior a cathedral-like appearance as sunbeams flicker into the cavern.

The **Second Cathedrals** is a massive hollow pinnacle rising from 65 feet deep to a flat plateau in 15 feet of water. The inner cavern is a gigantic room with several large tunnels providing rear exits. Both First and Second Cathedrals are full of marine life, including squirrelfish, nudibranchs, lobsters, cowries, moray eels and crabs. These Lanai sites are often visited by Lahaina Divers and other dive operations from across the channel at Lahaina, Maui.

Diver swims with a green sea turtle off Kauai's Turtle Hill.

Lanai's Cathedrals are the scenes of occasional encounters with white-tip reef sharks.

WHALES, SHARKS AND DOLPHINS ABOUND IN BLUE WATER

Some of the most exciting diving in the Hawaiian Islands is found in areas where the bottom is hundreds and even thousands of feet deep. Each year, between the months of November and April, humpback whales migrate to the warm Hawaiian waters to give birth to calves and to breed. As a result, whale watching has become a major pastime for visitors. Listening to the haunting songs of the whales, watching them frolic on the surface and the occasional unexpected underwater encounter are experiences you won't soon forget.

Humpback whales are protected by federal laws that strictly preclude boats and individuals from approaching within 100 yards of them. However, the laws do not prevent whales from approaching divers who happen to be in the water. Because the number of whales appears to be on the increase, encounters are becoming more and more frequent, but you still have to keep your fingers crossed to be able to actually get in the water with them. An excellent location for sighting humpback whales is in the channel between the islands of Maui, Lanai and Kahoolawe.

Of course, there are more than just humpbacks out in Hawaii's blue water. There are also pods of pilot whales, and where there are pilot whales there are invariably a few oceanic white tip sharks. This beautiful open water shark is known to be a curious animal, so don't be surprised if they approach very, very close.

Frequent encounters are also made with spinner dolphins. This small member of the dolphin family is easily recognized for its acrobatics. They seem to love leaping out of the water, spinning and doing somersaults in large numbers not far from shore.

Two of the best locations for blue water snorkeling and diving are the backside of Molokini Crater near the southwest side of Maui, and the deep water of the Kona Coast on the big island of Hawaii.

Ed Robinson's Adventure Diving out of Kihei on Maui also offers some exciting blue water diving in the waters off Molokai. And on the Kona Coast the *Kona Aggressor* and *Sun Seeker* are well-known for their blue water excursions. Several Kona Coast day boat operators, including Kona Coast Divers, Jack's Diving Locker and Dive Makai, also provide excellent opportunities for blue water diving and snorkeling.

Continued

During the summer months Bubbles Below runs a boat out of Hanalei Bay on the north shore of Kauai.

Snorkeler on the lookout for spinner dolphins, commonly seen in blue water dive sites.

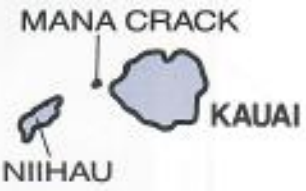
OUTSTANDING DIVE SITES AT THE REMOTE ISLANDS

One of the most exciting dive spots in the Hawaiian Islands is located off the eastern end of the island of Molokai, at **Mokuhooniki Rock**. Unfortunately, weather and ocean conditions permit access to this area only about 30 days a year. But if you're lucky and nature is cooperating, you'll find visibility consistently in the 100-plus range. During the day, it is one of the few areas where you can still see large schools of goatfish, pennantfish, pyramid butterflyfish and blue-striped snapper. Large titan scorpionfish are also common, often reaching lengths of 18 inches. Pelagics, such as eagle rays, Japanese barracuda, manta rays and large jacks, are seen on almost every single dive. There have also been frequent sightings of small schools of hammerhead sharks.

A Hawaiian lobster found at Three Room Cave on the Kona Coast.

A deep vertical wall on the east side of **Hook Cove** at Mokuhooniki Rock offers probably the best night dive you can find on the islands. At depths of 100 feet or more, octopuses and spiny lobsters can be seen almost everywhere you look. Unusually large triton's trumpet shells and tiger cowries are also common, as are Spanish dancer nudibranchs, moray eels, pufferfish and varieties of scorpionfish. However, even on those nights when the weather is calm, the extreme depths make this a dive for very experienced divers. In this remote area, surface squalls or heavy down currents can appear quite unexpectedly. Lahaina Divers and Central Pacific Divers, both out of Lahaina, Maui, offer the most frequent trips to Mokuhooniki Rock.

Mana Crack, a long underwater lava ridge running parallel to shore along the western end of the formidable Na Pali cliffs on the northwestern side of Kauai, can be reached via a two-hour boat ride from Port Allen. The diving is deep and the currents are strong. Wind direction can change at the blink of an eye, creating surface chop that will roil the stomach of even the most stalwart seamen. But if you can put up



The Kona Aggressor, *considered the finest live-aboard in the Pacific, runs seven-day dive trips up and down the Kona Coast.*

with all that, diving Mana Crack is pure magic.

Mana Crack is an animal lover's dream come true. Because of the currents, large pelagics frequent the area; it's not at all uncommon to see black-tip sharks and gray sharks and jacks and dolphins *and* rays. Aquatics Kauai offers frequent trips to the Mana Crack aboard its 43-foot

The Kona Coast offers two fine beach dives: the Kona Surf Hotel and the Place of Refuge Park.

Odysseus, the only large dive boat operating on the island of Kauai.

Trips to the nearby island of **Niihau** also promise some first-rate diving adventure. Although the island is only 12 miles from the nearest point on Kauai, the crossing can often be long and bumpy. Aquatics Kauai and Bubbles Below run one-day summer trips on an infrequent basis to the northeastern tip of Niihau. When the ocean is flat, the trip takes about three hours.

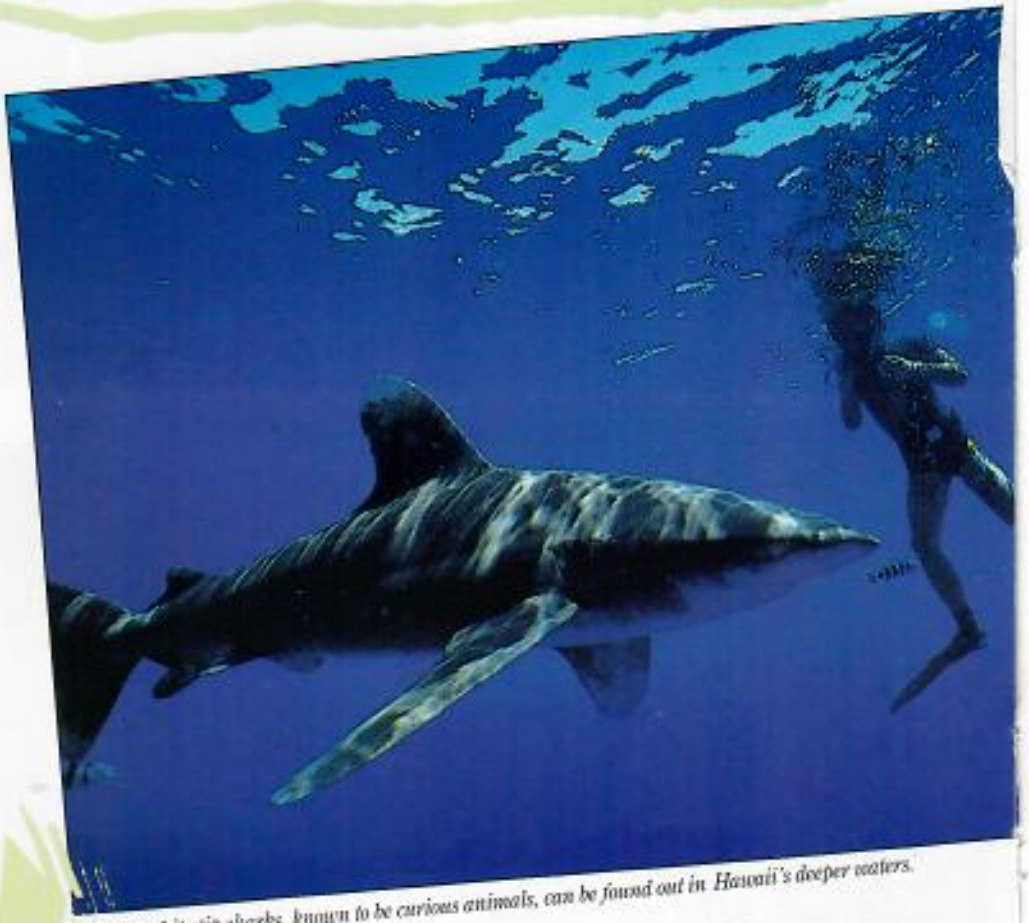
Because of its inaccessibility, the coastal areas of Niihau offer near virgin diving. While lacking a substantial amount of coral, the underwater sites offer spectacular vertical walls, canyons, giant arches and caverns along with a variety of pelagics that include rays, sharks, jacks, tuna, ulua and other game fish.

Hawaii is truly a unique diving destination. It is widely publicized as a great place for novice and intermediate divers to get their first warmwater diving experience. However, Hawaii is much more than that. It's also a place where advanced divers, by choosing dive sites carefully, can enjoy unusual marine animals and breathtaking underwater topography rivaling vacation dive destinations the world over. □

Steve Rosenberg is a professional writer/photographer/videographer based in Northern California. He is the author of the new Aqua Quest book Diving Hawaii *as well as many other books on sport diving.*

Hawaii's 12 Best

Here are a daring dozen guaranteed to get your adrenalin pumping.



Oceanic white-tip sharks, known to be curious animals, can be found out in Hawaii's deeper waters.

Article and photos by Steve Rosenberg

Hawaii is the number one vacation dive destination in the West. However, the majority of divers visiting the islands tend to be relatively new to the sport; consequently, most Hawaiian dive operations are set up primarily to meet the needs of novice to intermediate divers. So where does that leave advanced divers? Do underwater veterans have to look elsewhere for their vacation diving kicks?

Not necessarily. As it turns out, there are spots throughout the Hawaiian Islands that are guaranteed to pique the interest of even the most experienced sport divers, and there are a number of Hawaiian dive operations ready and willing to arrange special trips for divers with some experience under their belts who are craving something a little different.

For the sake of this article, let's define "advanced" dive sites as those requiring a higher level of diving skill due to deeper depths, stronger currents or open water; and those requiring enough underwater experience to enable you to safely react to unusual underwater terrain or the presence of large pelagics.

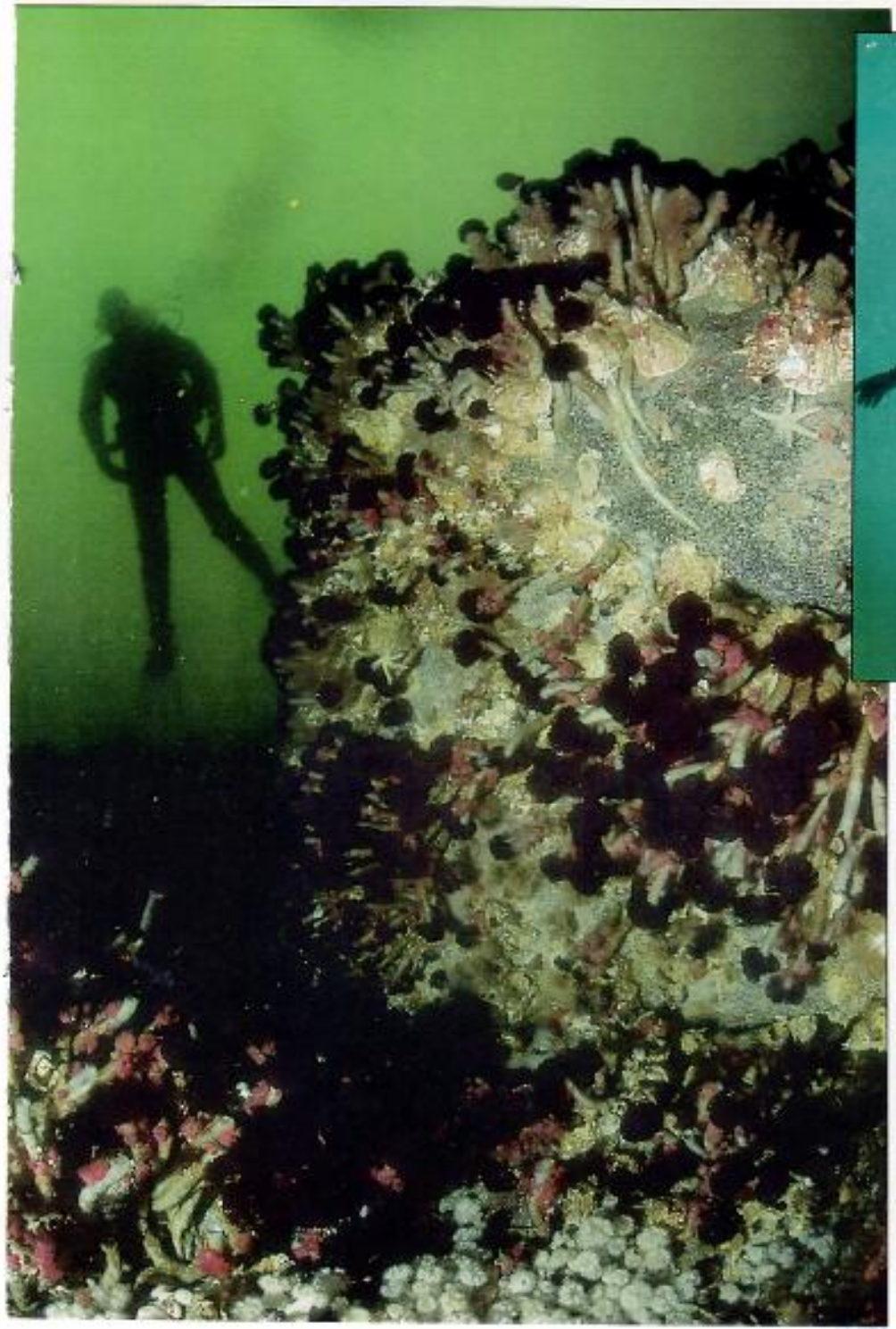
Many of Hawaii's advanced sites are remote; to get to them you need either a live-aboard dive vessel or day boats that are fast enough to get to the out-of-the-way spots. But still others are close to heavily populated areas, and some of them can even be reached from shore.

The MV *Clavella* generally visits the Nakwakto Rapids between April and October. The vessel has dived the area for the past eight years without incident.

For more information contact John de Boeck, Magna Yachting Ltd., Box 866, Station "A", Nanaimo, B.C. Canada V9R 5N2; (604) 753-3751.

MV Clavella *at anchor near Turret Rock.*

Rita Britnell descends into the temporarily placid waters for a quick visit before the tidal change.



It's difficult to understand how any creature could withstand such punishing tides.

the lee side of Turret Rock, waiting to haul divers out of the water. He swung out into the current and headed toward us.

Moments later we were sitting in the warmth of *Clavella*'s salon sipping hot chocolate and swapping stories. Usually only one dive is made at Turret Rock since there's a six-hour wait between slack water periods. So as *Clavella* weighed anchor to head for a second dive site somewhere in Slingsby Channel, we turned to see the Nakwakto Rapids once again boiling around Turret Rock, trying to shake the island's foundation, leaving its mark on our memories. □

Jett Britnell is a Vancouver-based free-lance photographer and writer who specializes in natural history and travel subjects.

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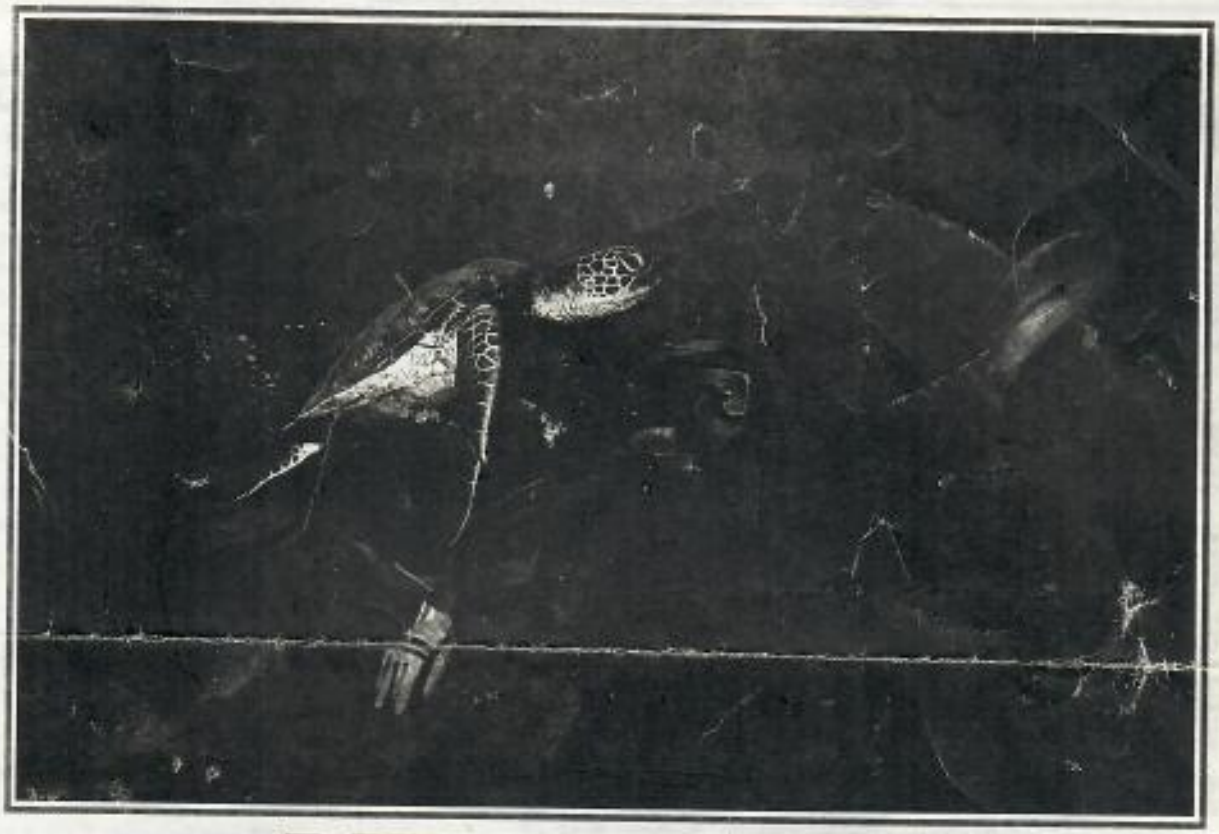

DIVING WITH TURTLES IN HAWAII

Bringing home good photographs requires more than seeing something in passing or in the distance–in Hawaii you can be assured of seeing turtles and of getting close enough to get them on film.

Text and photography by Steve Rosenberg

The success of dive trips is often measured in terms of encounters with interesting marine animals. Sea turtles are certainly among those creatures that can make or break a dive trip. This is especially true for underwater photographers. Of course, bringing home good photographs requires more than seeing something in passing or in the distance. You have to have the opportunity to get close, really close! There are few places in the world where you can actually be assured of not only seeing turtles, but getting close enough, long, enough, to take a series of exposures.

The warm blue waters around the major Hawaiian Islands offer a unique opportunity to dive with sea turtles. Encounters with green sea turtles have become a fairly common event for sport divers. At some dive sites, such as Oolawalu and the Hyatt Reef on the west coast of Maui, divers can almost count on seeing 10 tp 12 turtles on a single underwater excursion. These shallow sites are easy to get to by boat. Most of the diver operators in Lahaina regularly visit these areas on afternoon dives. The nearby island of Lanai has a similar site, usually referred to as the turtle farm, which is frequently dived on multi-tank morning charters.

I have been to a lot of places in the world where dive guides have said, 'This is a great spot for turtles' or 'You will probably see a turtle here.' More often than not, this translates to 'You may see a turtle if you are the first one in the water.' I rarely dive with the express purpose of photographing turtles because you usually can't count on them being there.

Hawaii, however, is an exception. When I jumped into the water at the Hyatt reef with my dive buddy, Roger Hess, we were optimistic, but not overly so. The dive guides from Central Pacific Divers and Lahaina Divers had practically guaranteed green sea turtles. We descended on top of a fairly unimpressive coral reef in about 45 feet of water and we were amazed when we started moving around. As we swam, we could begin to distinguish large, oval shapes that blended in with the coral.

Green sea turtles are medium-sized turtles, averaging 40 inches in length but growing as large as five feet. Their shells are mottled brown and olive green, but their name is actually derived from the colour of their body fat. Green turtles can be distinguished by the single pair of scales on the front of the head, between the eyes.

These turtles frequent shallow coastal waters, especially in rocky areas and coral reefs. Turtles are active during the day and sleep at night. At night, when they can usually be found settled down in sandy channels between the

Turtles

coral. It is believed that when turtles sleep underwater, they can close their nostrils and survive for up to five hours without oxygen. During the day they are often seen out in the open on top of and blending in with expanses of coral.

At any one time in the 80-foot visibility, few could see two or three turtles perched on top of the coral. Most of the turtles lifted off as we approached and slowly swam in circles. Some even allowed us to swim side by side with them. We observed others munching

"It is important to consider that many turtles are now on the endangered species list."

on sponges and algae exposed by the anchor. Green turtles become mostly herbivorous when they reach maturity, but will still eat meat when they get a chance.

Turtles can also be found on the Kona coast of the Big Island of Hawaii. There is a grouping of boat access dive sites to the north of Kailua-Kona, which include Hoover Pinnacle and Golden Arches. A small, female green sea turtle has adopted this area, and will invariably show up to greet dives at some point during the dive. Puako is an excellent beach dive location farther north, which has a great reputation as an area where turtles are commonly seen on night dives as well as day dives.

It is important to consider that many turtles are now on the endangered species list. The green sea turtles in the mid-Pacific are currently listed as threatened species. Divers should appreciate the unique opportunity that Hawaii affords, but should never touch, grab or otherwise harass these wonderful animals. The experience of seeing turtles underwater is one of those things that makes diving so rewarding. For more information on diving with turtles in Hawaii contact Jim and Julie Robinson at Kona Coast Divers, 75–5614 Palani Rd., Kailua-Kona, Hawaii. 96740. (808) 329-8802, In Honolulu–Jackie James at Aloha Dive Shop, Koko Marina, Hawaii Kai, Ph (808) 395-8882 ■

LETTER TO THE EDITOR

April 15, 1989

Mr. Peter Vassilopoulos, Editor
DIVER MAGAZINE
295-10991 Shelbridge Way
Richmond, B.C. CANADA V6X 3C6

Dear Editor Vassilopoulos:

As a 25-year resident of Hawaii with a special concern for sea turtles, your article "Diving with Turtles in Hawaii" (Jan/Feb 89) left me with mixed emotions. On the one hand, photography can certainly play an important role in enhancing the public's awareness and appreciation for marine life, as in the case of our sea turtles protected under the U.S. Endangered Species Act. To my knowledge, no turtles here, or elsewhere, have ever died from being "shot" with a camera. On the other hand, great numbers of scuba divers with cameras repeatedly intruding into sensitive underwater habitats, such as places where turtles rest on the bottom, could easily constitute a harmful activity. Sea turtles breathe air, just like we do. When disturbed or provoked to swim when they don't want to, turtles are forced to rise to the surface to breathe more often. Unlike the camera-carrying diver out to get a picture, the turtle has no scuba bottle on its back.

What is the solution? The best guidelines, in my opinion, are common sense, self-restrain, and regular reminders to dive tour operators that Hawaiian sea turtles are threatened and endangered species stringently protected by law. Take pictures, but from a distance, and in such a manner to not disturb, harass or alter the turtles normal behavior. Going home with good photos is a rewarding part of any vacation. But doing so at the expense of a gentle sea turtle would surely only result in an ugly reminder of poor judgement having been made. At least to those divers with any sense of ecological responsibility. As a diver myself, I know that most of us are included in this category <u>if</u> we have accurate information on how to properly conduct ourselves while underwater. The recommedation in your article of getting "close, really close" to a turtle is misguided advice. I hope that by publishing this letter a more enlightened attitude will be realized.

Sincerely,

George H. Balazs

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THE ELEPAIO

Journal of the Hawaii Audubon Society

For the Better Protection of Wildlife in Hawaii

Volume 14, No 9

March 1954

AUDUBON SCREEN TOURS

As we go to press, the closing-in time for the second lecture-movie is at hand. We have had the pleasure of success with the first picture, with Laurel Reynolds, and now look forward to Bert Harwell and his "Canada West" - with zest. Reports of his movie given to the schools are enthusiastic.

Mr Harwell avvived several days ago, spent a couple of days in Honolulu, then went off to see old friends - Mr John Wosky and Mr. George Ruhle - at the Hawaii National Park. He "shot" some nene, and various other less advertised birds, and spent enough time on Maui to give two performances of his "Canada West". It makes us particularly happy to have other islands begin to enjoy these superb pictures.

We hope Mr. Harwell will take away as pleasant a picture of Hawaii as we have of him, a most gracious, friendly man.

Fran William Hall and his wife come in April, the moment not yet announced. We shall enjoy them, we know, and try to make their promised eight weeks here full of picture opportunities and happy acquaintances.

NOTES ON THE BIRDS OF FRENCH FRIGATE SHOAL
Part I: General account of visit of October 1953. By Frank Richardson

French Frigate Shoal is a large shallow area some 500 miles west-northwest of Oahu and includes some twelve small, flat, coral sand islands, and one small, double volcanic remnant - La Perouse Pinnacle. This group of islands, although part of the Hawaiian Archipelago, is widely separated from other islands of the chain, being some 100 miles beyond Necker Island and about 150 miles this side of Gardner Pinnacle. Although the avifauna of French Frigate Shoal is similar in many ways to that of the rest of the so-called leeward islands of Hawaii, so little has been published and from so many years past that recent observations may be of interest or value.

Two trips to French Frigate Shoal were made in late 1953. My first trip was taken on the Japanese fishing boat Osprey, owned and piloted by Mr Shinsato. I was accompanied by Ivan Rainwater of the Department of Agriculture and our goal was a ten-day stay on Nihoa Island for ornithological and archaeological study. We were not able to land on Nihoa, due to rough seas and approaching darkness, and so two days later were dropped off Tern Island of French Frigate Shoal where we stayed from

October 26 to November 2, making side trips to a number of the other islands of the Shoal. Tern Island is the only inhabited island of the group for it has a Coast Guard Loran Station with some 13 men. The Coast Guard very kindly offered us living quarters during our stay - and movies and an occasional meal aquarer than we could prepare from our Nihoa rations!

Following are general accounts of observations on different French Frigate islands. Numbers of birds, except where small, are rough estimates. On Tern Island they represent the maximum number of a species seen any day.

Tern Island.- This island of the Shoal was leveled and extended to form a landing strip several years ago. A year ago (fall 1952) the Coast Guard Station with its various buildings was transferred from East Island, several miles away, to Tern. All bird nesting, especially of Sooty Terns, was then largely eliminated or discouraged so that right now only a few shearwaters seem to represent the sea bird residents. Wild and even well-fed house cats, of which there are four or five on this small (a little over half a mile long) island, further discourage bird nesting and have killed hundreds of Golden Plover. We found large accumulations of plover wings as sad testimony of this.

Plover, turnstone, and sanderlings often congregate on the plane runway and seem to prefer this hard open area for resting and also use rainwater pools for bathing and drinking. These species all forage in the low, sparse vegetation above the beaches. The most common insect they may be getting is a small moth.

Species of birds seen:

Wedge-tailed shearwater	4	Western Gull	1
Frigate Bird	2	Sanderling	10
Blue-faced Booby	2	Golden Plover	14
Pintail Duck	1	Ruddy Turnstone	8
Mallard Duck	6	Common Noddy Tern	2
White Tern	2		

Trig, Skate, and Whale Islands - October 28, 1-5 P.M. - These three islands are two to three miles east of Tern Island and are all very low, rather barren, small (3-5 acres), and rarely visited. Each has low vegetation scattered on the coarse coral sand and gravel - chiefly clumps of grass, Boerhaavia, Tribulus, and Portulaca. Two large sea turtles weresleeping on the beach of Trig and one dead, newly hatched turtle was found on Whale. A large (7-8 feet) Hawaiian Monk Seal was sleeping on the beach of Skate Island and allowed approach to within a few feet. It then lumbered quickly into the water but stayed a little way off shore.

Species of birds seen:

Black-footed Albatross	75	Common Noddy Tern	250-350
Wedge-tailed Shearwater	85	Ruddy Turnstone	a few
Frigate Bird	500-700	Bristle-thighed Curlew	1
Blue-faced Booby	100-150		
Red-footed Booby	1		

East Island - October 31, 1:30 - 3 P.M. - There are many deserted buildings and a good deal of junk on this island. The species of birds seen were about the same as those on Trig, Skate and Whale. There were two curlews, some 30 albatrosses, and several hundred dead Common Noddy Terns, perhaps mostly full-grown young

deserted at the end of the past breeding season. A Tree Heliotrope about eight feet high, the only specimen of a tree or real bush in all of French Frigate Shoal (except a few small things now planted on Tern Island), is on this island. It was covered with nesting Red-footed Boobies, the only place where this species was found nesting..

La Perouse Pinnacle - October 31, 3:30 -4:30 P. M. - In spite of rough water, I was able to swim ashore and climb onto the west end of La Perouse without any trouble and then explore the cliff faces around its west end. I was not able to climb quite to the top without taking serious chances. It seems likely, though, that all the species of birds on the rock were seen and all nesting observed except perhaps of Frigate Birds. The occurrence here of three species (Hawaiian Noddy and White Terns, and Brown Boobies) and not on any of the coral islands of French Frigate Shoal is of much interest, as is the fact that they are all nesting now. Habitat preference is undoubtedly shown by the Hawaiian Terns with their predilection for cliffs. Perhaps the White Terns prefer rocky cliff ledges when trees are absent, as they are on the nearby coral islands. Why though has the ground-nesting Brown Booby come out to this great rock? Because of competition with Blue-faced Boobies or because of occasional molestation on other islands? Terns and Brown Boobies were nesting on almost the same rocky ledge habitat but the boobies on slightly larger ledges. The young shearwaters were also nearby but were more apt to choose cracks or holes.

The Golden Plovers seemed particularly out-of-place standing around on rocky or guano-covered ledges. It is hard to see what they could eat but they primarily may be resting. No vegetation was present on the parts of La Perouse I saw.

NA LAAU HAWAII
(Plants belonging to Hawaii)
By George C. Munro

Na Laau Hawaii has reached a stage when it can be said with confidence that it can, without great outlay, be made an ultimate success. In the making it will provide information of scientific value and furnish much pleasure to those interested. That is, if the little area is made secure as a "living museum" of the xerophytic or dryland plants of Hawaii: if the Hawaii Audubon Society can and is permitted to take a perpetual interest in it; if we continue to bring seed of native plants and to spread the seed of those already there and to eradicate foreign plants. It will take a long time to bring it to perfection but it will be an extremely interesting study as it proceeds. My work with nursery raised plants is not essential but furnishes experience and occasionally there may be results of some value from it. It may, perhaps sooner than the seed planting, provide something to show to attract interest in the project. Many people taking an interest in it will insure success. Without the friends who collected seed for it Na Laau Hawaii would not have made nearly the progress that it has.

Since the idea for this living museum was put into action on December 28,1951 there has been a succession of droughts which has killed very old plants of several native species which were growing naturally on the side, but failed to destroy plants of wiliwili (Erythrina sandwicensis), seed of which was planted in 1950 and some in January 1951. The old native plants killed by the drought have seedlings growing by them. It these are killed, more seed, temporarily dormant in the ground, will germinate and the plants be established again on the spot. The natural cycle will work out if foreign plants are kept in check Plants from seed of alaweo (Chenopodium sandwichium) that had been broadcasted grew well last wet season. Thedrought killed much of it but a great many fine plants remain and some will probably seed this year. Seed of plants that ripen on the area will be spread until plants are sufficiently established.

The Commercial Fish Farmer and Aquaculture News
March 1978, Vol. 4, Number 3

'Systemculture' works on Oahu

Culture of phytoplankton provides feed for oyster farm

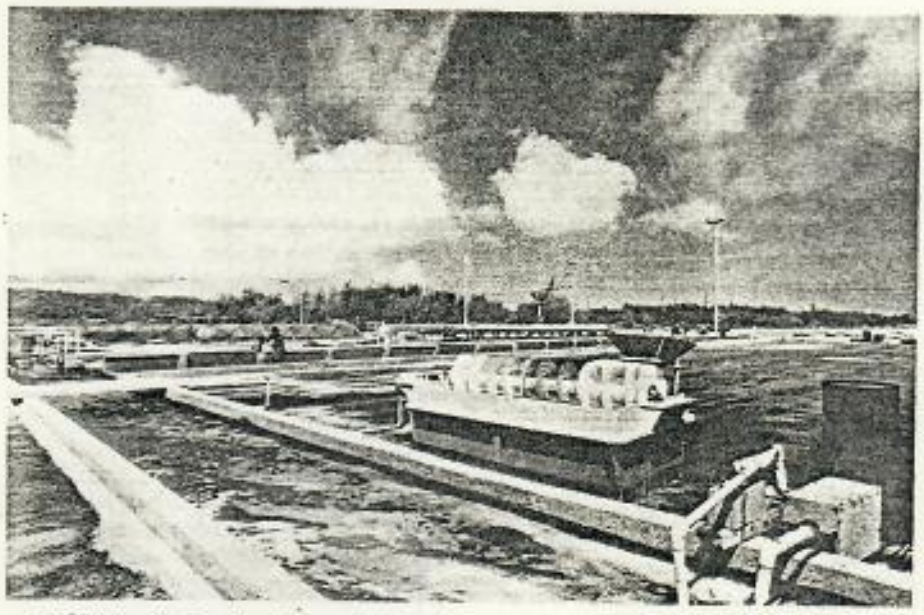
By Taylor A. Pryor

The high cost of imported farm feed to Hawaii makes it difficult to consider growing shrimp, lobster, or fish economically.

On the other hand, the 12 months of warm weather and sunlight make the islands an otherwise good place to produce aquatic crops. The solution is in concentrating on growing the feed locally, beginning with marine phytoplankton in large cultures.

In 1976, I built several 1-acre reservoirs on an abandoned airfield at Kahuku on the island of Oahu. Sinking wells into the limestone below, I brought up brackish water to flood the reservoirs with 750,000 gallons each. At that time I knew that no one had attempted to initiate or manage phytoplankton cultures on this scale. Not knowing much about it myself I turned the problem over to our technical director, Linda-Lee Watson, and to her senior field biologist, Craig Emberson. Within a matter of weeks they had trapped the appropriate phytoplankton species from wind passing from the surf zone and over the airfield, had generated cultures in small tanks, and had innoculated the big reservoirs and brought them to full bloom. They have been blooming to a rich brownish-green color ever since.

We harvest about 30 to 50 percent of each acre daily or an estimated 7,000 pounds of plankton cells per acre per day. The next step is to pass the plankton-laden water through what we call production trenches which are simple raceways 20 feet wide and 160 feet long which are stacked with trays of clams and oysters. These are, in effect, giant bio-filters and they do indeed remove over 90 percent of the feed so that mostly what leaves the trench is effluent.



The Kahuku Seafood Plantation at Kahuku on the island of Oahu, Hawaii, operates a new farm on an abandoned airfield, cultivating oysters. It will soon have clams, shrimp, lobster, mahimahi, octopus and turtles as well.

Effluent managed

Years ago, when we first spoke of aquaculture in Hawaii, one criticism, which we heard, was that the effluent of a farm might ecologically damage the reefs of our pristine coastal zone. Therefore, in designing the Kahuku Seafood Plantation, I felt from the outset that we should manage the effluent rather than let it run off. I decided to build seaweed ponds where the waste water from the bio-filter beds could be used beneficially to give us a seaweed crop. We now have a 10-acre pond in production and intend to add 10 more acres in the near future.

While there is a market for some forms of seaweed, such as *Eucheuma* which is used by the colloid industry, we believe that there is an even better market right at the farm. If we harvest our seaweed along with the tilapia fish that grow abundantly among it in a

Oysters, placed in stacked trays, are grown in a controlled environment.

Editor's Note — Taylor A. Pryor is a former Hawaii state senator and served as chairman of the Senate Committee on Agriculture, Forestry and Conservation. He is president of the Pryor Corporation and the Kahuku Seafood Plantation and the general partner in five oyster farm partnerships. From 1960 to 1973, he was president of the Oceanic Foundation. He also formerly served on the President's Commission for Marine Science, Marine Engineering and Marine Resources. He currently is a consultant to the United Nations Environmental Program.

The oysters are provided with a constant supply of food, a steady water temperature, and plenty of sunlight.

polyculture, we have the basic materials to make our own pelletized feed, one that should be a lot less costly than those that we might import from the mainland because it will be a by-product of an already profitable operation. When we have completed that next step, we intend to build additional production trenches (raceways) on our airfield and to begin growing lobster, shrimp, turtle, or fish, or all of these. In other words, anything that can feed on our pellet for which there is a hatchery source or capability.

I call this concept "Systemculture," since it is neither monoculture nor polyculture in the traditional meaning. The stress is on multiple species of marine plants and marine animals being maintained for the most part in separate impoundments but managed so that they are used as feed or to feed on each other but not in a natural ecobalance, rather in a balance that we manage them in series according to economic guidelines.

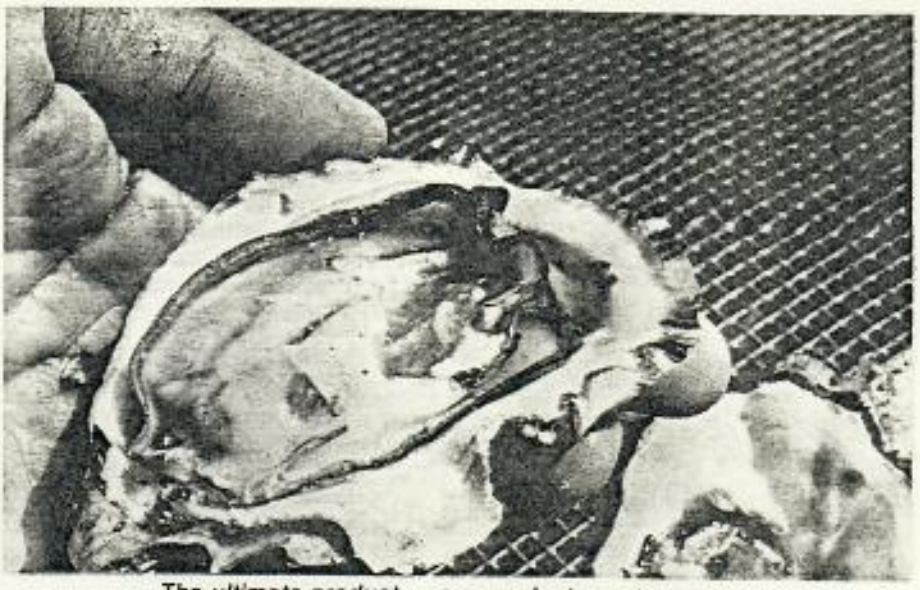
Market available

For the time being, however, I am pleased to be just an oyster farmer and am happy with the quality of our crop. I test marketed in Hawaii for most of 1977 (including the months without an "R") and got very good consumer and distributor response. As a result I intend to expand that phase of the farm five-fold this year with the help of a federally guaranteed construction loan. We will be harvesting on an average of 100,000 oysters per month until the fourth quarter when it steps up to 500,000 per month and doubles again in early 1979.

Since we can air ship to almost anywhere in the world we receive orders

Harvesters make frequent checks on the oysters for size and quality control.

and inquiries constantly from everywhere and believe now that our market is worldwide. Perhaps the reasons for such interest is in the unique character of our crop. Because we are using well water with stringent hygienic systems developed by the FDA and the State of Hawaii Department of Public Health which are imposed on the facilities and staff for the management of the water throughout, we can certify our oysters to be pure. (We call them Tap's Pure Hawaiian Oysters.) We can harvest daily for 12 months of the year. Finally because of the character of our plankton, the salinity of our water and the fully controlled system of producing, each oyster is not only rated excellent to eat but is uniform in both appearance and quality.



The ultimate product — a succulent, meaty oyster.

$10 million invested

By mid-1979, we will have invested over $10 million into the Kahuku Seafood Plantation. That seems a lot for a new venture but, in fact, we feel like old-timers in this business, having taken it from a very small laboratory unit, step by step through a demonstration farm and a big prototype on the airfield. I am confident of our projections and look forward to feeding a lot of oysters to a lot of people in the months and years ahead.

I think that a commercial cross of aquatic production with terrestial farming is a technological hybrid which will indeed prove to be an important solution to the world food need. I am happy to see many others are waking up to the fact that aquatic production has much to offer at a time when neither the world's fisheries nor agriculture can hope to expand by much. I am hopeful that the example of many existing aquatic farms will soon be followed by many others. □

The green turtle, though known throughout the Pacific Islands, does not appear to be found in major concentrations anywhere among them. In most of the islands the taking of a turtle is an event sufficiently rare to call for a community celebration. There are indications, however, of a few more favored nesting beaches and feeding grounds and there were many more in the past.

A modest turtle fishery exists in the Hawaiian Islands, especially off the islands of Oahu, Molokai, and Maui. Between 1948 and 1958 official statistics indicate a catch averaging some 10,000 pounds a year, most of which finds its way to Honolulu restaurant tables. *Chelonia mydas*, however, is not known to nest anywhere on the main islands nor are specimens smaller than ten to fifteen inches in diameter ever taken by local fishermen.* Circumstantial evidence points to French Frigate Shoal (23° 45′ N.) and the other islands of the remote Leeward group as the home of most of the turtles found in Hawaiian waters. Of this string of tiny islands stretching northwest for more than 1,000 miles from Honolulu, only Midway and French Frigate Shoal are inhabited, the latter by a small Coast Guard detachment. All but Midway are in the Leeward Islands National Wildlife Refuge, so that the turtles are protected along with other wildlife. Even though there is no patrolling or supervision of these islands, they are so infrequently visited that violations must be extremely rare.

Most reports of green turtles in this area are of individuals basking on the shore during daylight hours, a behavior pattern that has been previously suggested as distinguishing the Indo-Pacific population from its Atlantic counterpart. While it is apparent that certain of the Hawaiian Leewards must be targets for nesting females during the fall of the year, the favored beaches do not seem to have been identified except in the case of French Frigate Shoal, where both nesting and basking populations have been reported. Dale Rice, who made numerous flights over the Leewards during 1957 and 1958 and spent time ashore on several of them observing the Hawaiian monk seal, reports having seen especially large concentrations of basking green turtles on Pearl and Hermes Reef, always on the same beaches, namely, on the north side of Southeast Island (usually twenty to fifty turtles) and a small bight on the south side of North Island (nor-

* Personal correspondence, Vernon Brock, Director of Division of Fish and Game, Territory of Hawaii, November 28, 1955; see also *160*.

...ually ten to twenty turtles). Smaller numbers were present on Lisianski and Laysan atolls.* On more remote Midway juvenile greens are occasionally taken in the lagoon by skin-divers from the naval base, but adult turtles do not appear to haul out there today, undoubtedly because of the considerable human activity ashore.

The extent to which the Hawaiian Leewards may have been exploited for turtles in the past is conjectural. One account, at least, suggests that it was more than a casual matter. In the spring of 1882 a Japanese-chartered vessel for which we have a record took at least 390 turtles, including an undetermined number of hawksbills, in the Hawaiian Leewards beyond French Frigate Shoal. Of these 10 were taken at Midway, 28 at Pearl and Hermes Reef, 126 at Lisianski, 17 at Marco Reef, and 191 at Layson. Some were turned on the beaches and others harpooned at sea, but it is not clear whether those taken on land were turned during daytime hours or as they came ashore at night to make their nests. At Laysan, where 61 were turned within a few hours, a sign was found on shore that carried an appeal for passing ships not to take more turtles than needed. Their abundance at this time must have been such as to have encouraged waste. The visitors, apparently in sympathy with the recommendation, repainted the sign and placed it on a pole before leaving. At French Frigate Shoal, where they slaughtered a part of the catch and dried the meat in the sun, they must have taken more turtles. The account left to us only states that 47 gallons of turtle oil and 1,500 pounds of shell were added to their stocks there, along with bêche de mer, albatross down, and shark fins. The entire product of the voyage was eventually transshipped to Hong Kong, from where the turtle was sent on to England. (See *110;* the log was kept for six months by George Mansbridge, an employee of the Mitsubishi Company of Madagascar.)

It seems generally agreed that green turtles are much rarer today than they formerly were in Hawaiian waters. It is even possible to speculate that they once congregated on the beaches of Honolulu itself. Although, according to W. A. Bryan (26:299-300), the name is generally agreed to have been derived from a Hawaiian word, *hono,* meaning harbor (Honolulu, "quiet harbor"), one cannot resist pointing out that the Hawaiians know the green turtle by the almost identical term of *honu* and that beaches such as Waikiki might

* Personal correspondence, Dale Rice, Richmond, California, August 14, 1959, and Karl Kenyon, Sand Point Naval Air Station, Seattle, August 13, 1959; see also *117.*

C1: Each bridge with three enlarged poreless inframarginal shields; limbs two-clawed. (See Pl. 91.)
ATLANTIC LOGGERHEAD TURTLE

C2: Each bridge with four enlarged inframarginals (see Pl. 93) with or without pores.

D1: Each inframarginal with a pore; more than five pairs of costals; limbs two- or one-clawed.
PACIFIC LOGGERHEAD TURTLE

D2: Inframarginal poreless; five pairs of costals; limbs three-clawed. KEMP'S TURTLE

A2: Shell covered with smooth skin; carapace with seven prominent longitudinal ridges. LEATHERBACK TURTLE

GREEN TURTLE

Chelonia mydas (Linnæus)

IDENTIFICATION. The limbs are paddle-shaped and each has one small claw (rarely two). There is a single pair of large shields, the prefrontals, on top of the head between the eyes. Four costal shields are present on each side, and the shields of the carapace are not overlapping (slight overlap evident in the very young).

SIZE. A cast made from a 700-pound Green Turtle caught in the Key West region is exhibited in the New York Aquarium; this turtle is said to be the largest ever taken by the Key West dealers. Babcock, however, gives 850 pounds as the West Indian record. Seventy-five to 150 pounds is the usual weight range of specimens caught at present in American waters. Where this turtle is little molested by man, breeding females have carapaces thirty-eight to forty-six inches long and weigh 300 to 500 pounds.

THE SEXES. In the adult the tail of the female barely reaches

beyond the margin of the carapace, whereas that of the male reaches even beyond the tips of the extended flippers.

EGG. The eggs are sometimes spherical, but more often one diameter is from 1 to 3 millimetres greater than the other. For example, the lesser diameters of six typical eggs from Brazil ranged from 40 to 42, the greater from 41 to 44 millimetres. The soft shell is white.

LONGEVITY. A specimen from the Pacific Ocean lived in the New York Aquarium for fifteen years.

GROWTH. Although the growth rate of the Green Turtle has never been fully determined, there is some reliable information on the subject. Moorhouse found that a carapace length of eight inches is reached in one year off the eastern coast of Australia, and Schmidt secured substantiating data in the West Indies. Judging by the findings of these men, this turtle during very early life adds every month about half a pound to its weight and half an inch to its carapace. Moorhouse tentatively states that a female first matures when its carapace is thirty-five inches long and that a length of forty-four inches probably indicates an age of at least ten years.

According to Flower, three specimens in the Aquarium of the Zoological Society of London increased from a weight of less than one to more than fifty pounds in about nine years and four months. Hornell reports a captive individual that reached a carapace length of one and a half feet in twenty-eight months.

DISTRIBUTION. The Green Turtle occurs throughout the Gulf of Mexico and northward along the Atlantic coast to the North Carolina sounds, in which it was abundant before being decimated by turtle-hunters during the nineteenth century. It has been taken as far north as Cohasset, Massachusetts, and is occasionally seen off New Jersey and Long Island coasts. It is now the commonest sea-turtle of Bermuda. In the Pacific it occasionally reaches the bays of San Diego County in extreme

southern California and is abundant as far north as southern Lower California.

This valuable turtle has a world-wide distribution in tropical and subtropical seas, usually remaining within 35° of the equator.

Pleistocene fossil remains from Florida prove that it has occurred in the Florida region for perhaps tens of thousands of years.

HABITAT. Shoals and lagoons of oceanic islands and continental shelves. Bays and sounds are often entered, especially in the vicinity of sand beaches. Coral reefs are avoided.

The browsing method of feeding is a strong determining factor in the habitat preference of the Green Turtle, which is prone to frequent fields of sea plants.

HABITS. Just where this turtle sleeps is the most interesting question about its habits. That it does sleep is a well-established fact, for many observers have seen relaxed individuals floating on the surface of the sea. In 1925 Wetmore presented indisputable evidence that great numbers sleep on remote Hawaiian rock ledges and sandy beaches, a fact contradictory to the general belief that sea-turtles die if stranded on their bellies, owing to the lack of sufficient support afforded to internal organs by the lower part of the shell. Breathing is said to be seriously impaired and specimens going to market are always turned on their backs.

Recent observations on the Galapagos Islands confirm Wetmore's evidence, so the beach- and ledge-sleeping habit cannot be considered a peculiarity of the Hawaiian turtles, and remarks on the belief that stranded individuals die unless lying on their backs are in order. Wetmore himself has suggested that the vibration of a ship's deck might have bad effects, but I think that the oxygen requirement of a sleeping turtle may be enough less than that of one struggling from fear and discomfort to account for survival in one case and ultimate death in

the other. In this connection it must not be forgotten that laying females of all sea-turtles often remain on a beach for many hours. During much of this time, however, most of the weight rests only on the edge of the carapace.

Deraniyagala states that loggerheads live on land longer than Green Turtles because the plastron and sides of the shell are more completely ossified and better resist the pressure of the upper parts.

Still another point calls for elucidation. Why has no one of the many persons interested in commercial fisheries ever seen Green Turtles asleep on a beach? Again Wetmore's experience is helpful; he noticed that the frequent appearance of human beings on the remote beaches where turtles rested soon caused the reptiles to take their siestas in still more remote places. The habit of sleeping on the strand probably has long since been abandoned wherever turtles have been even slightly molested by man. They must quickly learn that sleep on the bosom of the deep is far safer; certainly it sounds more comfortable and inviting! Fishermen long ago told Bumpus that Green Turtles occasionally sleep off Rhode Island shores with the head resting on lobster-buoys. Are these reptiles astonishingly resourceful or Rhode Island fishermen surprisingly imaginative?

The Hawaiian siestas may also be considered a form of sun bathing, as indeed similar excursions ashore have been called by Deraniyagala in reporting the midday landing of sea-turtles on an uninhabited island in the Maldives.

Although adults drag themselves along on land by laborious strokes of the front limbs moved together and aided (or not?) by alternate pushes of the hind flippers, the gait of the young is relatively nimble for they "walk like most four-footed beasts."

MIGRATION AND INDIVIDUAL RANGE. In spite of a general belief that Green Turtles regularly go back and forth from feed-

ing areas to breeding grounds, sometimes travelling hundreds of miles in doing so, there is no scientific evidence that such mass movements take place. Hornell has brought together the available information supporting the migration hypothesis, but it is not convincing. In fact, the only scientific investigation ever made, the marking experiments of young turtles by Schmidt in the West Indies, gave absolutely no evidence of extensive migrations. Among nine individuals marked and retaken, only one was found any great distance from its starting-point. That one was discovered fifty miles away after ten months. Others were captured much nearer to or at the common point of release. Although this evidence is limited and largely of a negative character, it is some indication that young Green Turtles are rather stationary.

The problem is a complex one, however, and cannot be so readily dismissed. Working on Heron Island, off the east coast of Australia, Moorhouse found that, although a canning factory had killed all the turtles seen on the island during the 1928–9 laying season, a new crop, including many large individuals, visited the same beaches the following year. Here is strong evidence that females either do not lay every year or else change nesting sites. Such a change would be in the nature of a migration.

A female that landed two consecutive nights on Heron Island was turned each night and actually taken to the factory the second one, before being released. Ten days later she was found laying on an island sixteen miles distant. This change in site was evidently the result of fright, which, however, did not prevent her from making subsequent nests on Heron Island.

Only prolonged investigation on a large scale can solve the many problems of sea-turtle wanderings and individual range.

MATING. The following facts about mating have been well established although actual courtship and copulation really remain to be described: Mating takes place off the nesting

beaches during the laying season; many males attempt to copulate at the same time with one female; the mated pairs are oblivious of danger and float on the surface, the male on top with his forelimbs stretched forward and pressing against the carapace of his mate; spent females returning to the sea at least sometimes accept the attention of waiting males and at once copulate.

Judging by Hornell's account, mating takes place not only during but for some time before the laying season, actually beginning with the gathering of the turtles off the nesting beaches. He also states that an ardent male occasionally follows a female a short distance ashore before realizing the futility of his effort and clumsily returns to the water.

Although only diurnal copulation is mentioned, the frequent references to males awaiting females returning from laying is indication of nocturnal mating. Probably the act, usually begun at night, often lasts well into the day.

NESTING. In the Seychelles, east of Africa and some five degrees south of the equator, the Green Turtle lays throughout the year, with a *very* decided peak during March, April, and May; off the west coast of Borneo, about two degrees north of the equator, the peak comes from May to September. In the region of southern Florida and throughout the West Indies the species is reported to nest from April to August; from late October into February on Heron Island, lying about on the Tropic of Capricorn near the eastern coast of Australia.

Nocturnal laying is the universal rule, the majority of females making their nests between the hours of ten and two. The site chosen is usually above the reach of high tide, but many nests were destroyed on Heron Island in 1930 when the high-water mark for January was more than a foot above that of the preceding November. Even if the eggs escape the action of the waves, the salt water quickly coagulates their yolk or drowns the embryos. On this island the layers came on the

beach " at any state of the tide," but in the Seychelles Hornell noticed that the females preferred to land on a high tide, the greater number appearing on nights when high tide occurred soon after sunset.

There is considerable disagreement in regard to the actual nesting process, which no one seems to have described in detail from beginning to end. The main facts are fairly clear, however.

In ascending the beach the female pulls herself along with the front flippers (at the same time pushing with the hind ones?), leaving a conspicuous track two to three feet wide made up of parallel depressions separated by a ridge. Her progress is in stages of six or seven steps followed by pauses for rest. When a site has been chosen, she proceeds to sink herself into a large hollow which is made with all four flippers, the front pair throwing the sand out by swimming movements and then resting while the hind pair do their work. After depressions have been made fore and aft, the digger revolves enough to change the centre of action and thus finally works herself into the resulting bowl-shaped excavation.

Next she digs the egg pit, a far more delicate procedure. This secondary excavation is a cylindrical undercut hole some eighteen inches deep and twelve or more across, the exact dimensions depending upon the size of the turtle. We have Beebe to thank for the most detailed account of this supreme accomplishment of the hind flippers without aid of reason or sight. The sand is removed by strokes of the edge of the flippers used alternately, difficulty rapidly increasing with depth. Finally the flipper must be curled inward, gently lowered, uncurled, and forced into the sand by skilful pushes until a load has been dislodged. Then the tip is again curled to completely enfold the sand and bring it out, often with loss of scarcely a grain. A final flick sends the sand flying directly backward and well clear of the hole.

Now the other flipper, which has been held flat against its side of the pit, preventing caving in of the walls, is snapped to throw forward any loose sand that may have fallen on it, curled, and lowered into the hole. (One account describes the waiting flipper as idly outstretched.)

The " exquisite accuracy " of the flipper movements is emphasized by Beebe, who goes on to describe the spraying of the sides and bottom of the hole with a liquid, presumably to reduce the chances of caving in. This undoubtedly is cloacal bladder water, not urine.

When the turtle is ready to lay, the hind flippers are brought together, hiding the tail and covering the mouth of the pit. Accounts of actual deposition are very sketchy, owing no doubt to the difficulty of seeing what goes on after the flippers have been brought together. Usually two eggs are ejected at a time. The end of the laying process on Heron Island is described by Moorhouse:

" As soon as the laying is completed the nest is filled in, the hind flippers patting and kneading the sand into the nest. Then follows a flinging of sand over the body by the fore flippers, the hind ones piling it evenly as it falls. The animal, still throwing sand, moves forward and soon the original spot is obliterated. Then she returns to the water. From the time of the turtle's coming out of the water till her return two to two and a half hours have elapsed, though some animals have taken but one hour, while others have taken as long as seven hours in the process."

Before the investigation on Heron Island it was known that the Green Turtle nests more than once a season, but the maximum number of times was largely a matter of conjecture. Many of the fifty turtles marked there laid seven clutches at intervals of approximately two weeks, and it is possible that some of those that deposited seven times returned to increase the number after the departure of the investigator. Not infre-

quently females came ashore and dug nests only to return to the water without laying, some vainly wandering distances of six hundred yards besides digging one or two holes.

Moorhouse was also able to show that relatively few females visit one island during a single season. Moreover, he tentatively concludes that turtles do not lay every season and frequently change their laying islands.

A staggering lot of statistics on the number of eggs laid at a time by females on islands off the west coast of Borneo have been made available by Banks. The average for 16,690 clutches taken from one island in 1934 was 108 eggs per clutch, and 107 for 10,726 others from another in 1932. The maximum number of eggs in any one clutch among many tens of thousands was 176. Disregarding round numbers, the highest count that I find for all parts of the world is 195. Banks further detected in the Bornean region a slight tendency for the size of clutches to be larger on nesting beaches visited by relatively few turtles, one such place having an average count of 118 eggs per nest based on only 875 layings. Correlation between the number of turtles depositing in a given area and the annual weather conditions was also discernible, the reptiles being less productive during damp, stormy years.

The average incubation period in the Seychelles is stated by Hornell to be forty-seven days, the greatest but a few more than fifty; but on Heron Island the eggs of eleven marked nests required from sixty-five to seventy-two days to hatch, those that took the longer time being near enough to fringing vegetation to receive some shade. A shorter period for the former locality, which lies only five degrees south of the equator, is what one would predict; Heron Island is about on the Tropic of Capricorn. Nevertheless, the difference is unexpectedly great.

BEHAVIOUR OF HATCHLING. This is a vexed subject because of lack of agreement and somewhat contradictory statements.

Hornell believes that the young of one nest "hatch out the same day and usually within a couple of hours after the first appears," but Moorhouse states that they "do not all emerge on the same day or night," and goes on to explain how various factors such as low temperature and packing of sand by rain cause delay. It might be argued that the difference is one between actual hatching and subsequent appearance at the surface, but Hornell is certainly of the opinion that hatching is rapidly followed by emergence. Moorhouse refers chiefly to delayed emergence.

The next difficulty is the time of emergence, Moorhouse obviously believing that the night is the normal time, hatchlings having even been seen by him to reach the surface during the day only to bury themselves again. In spite of this, he explains that the young are strongly attracted by a bright light and on three occasions saw individuals leave the sea to approach a petrol lamp.

Another point of disagreement is in regard to the diving ability of very young Green Turtles. Hornell writes that "they are a long time in acquiring the art of diving and staying under water for a prolonged period," but Moorhouse makes no mention of any such inability, to the contrary speaking of the young diving after food and rising to the surface of the sea to breathe. In spite of this, he reports dissecting some and finding "a large percentage of the yolk within them." Now, it is just this yolk that Deraniyagala claims makes young sea-turtles unable to dive!

FOOD AND FEEDING. Adults of this species are chiefly herbivorous, subsisting largely on marine grasses and algæ. Mangrove shoots are relished by Galapagos populations. Eel-grass of the genus *Zostera*, often called "turtle grass," is commonly eaten, and masses of floating leaves of this plant are considered a sure indication of turtle feeding grounds. In cutting the plants near the roots to procure the most succulent parts, the

turtles set countless numbers of the leaves free to float on the surface.

Small mollusks and crustaceans are also devoured. For example, Beebe found a stomach crammed with hundreds of shell-less flying snails and a small number of munidas or "scarlet lobsterettes." Young oysters are sometimes eaten.

The juveniles are decidedly more omnivorous than the adults.

Deraniyagala determined that stomachs of individuals kept out of water four days still retain masses of undigested algæ, whereas only twelve hours are required to empty the stomachs of those left in their native element. This might be one factor in the alleged quick death of stranded turtles, discussed above in the section on habits.

ENEMIES. As in the case of the Hawksbill, man is without rival as an enemy.

Adult Green Turtles are not infrequently preyed upon by sharks, which either swallow the reptiles whole or nip pieces from the flippers. Beebe estimated the weight of a specimen cut out of a thirteen-foot tiger shark as about fifty pounds, and more than one observer has seen a female hindered in the nesting operation by mutilated flippers. In one case the damage was so great that the turtle could not clamber up the beach, but had to be satisfied with a simple nest at the very edge of the waves. The yolk of eggs laid so near the sea would be quickly coagulated by the salt water. That shark, in addition to injuring one adult, perhaps prevented the hatching of thousands of young.

In the Seychelles the hatchlings suffer from the depredations of raptorial birds and fish just as described in the corresponding section under the Hawksbill, and there is abundant corroboration of the same kind of destruction wrought in other parts of the world. On Heron Island house cats chew

off the heads of newly emerged young, while large nocturnal crabs prepare others for eating by holding them with one nipper and removing the shields of the carapace with the other. On this same island Moorhouse relates that, in an effort to determine their destination, twelve hatchlings were released at low water to be followed, but not one survived, as all were soon devoured by fish lurking in the reef.

On beaches of this same island, when crowded at the height of the season by too many arrivals, one female often digs into the finished nest of another, leaving the eggs thus inadvertently uncovered to be eaten by gulls. In North America raccoons sometimes destroy the nests.

CAPTIVITY. This species is hardy in confinement. It is slow and deliberate in its feeding movements, lacking the aggressiveness of the Hawksbill and the loggerheads.

Although chiefly herbivorous in a state of nature, the Green Turtle in captivity is nearly always fed on animal matter, and, oddly enough, seems to relish such food. Raw fish and meat constitute the usual diet, but one individual ate chiefly fiddler crabs. The usual adult fare of marine grasses and algæ can of course be given.

Moorhouse failed to persuade his hatchlings to eat for seven days, after which they refused many kinds of local sea plants but readily ate meat, clams, and fish, even killing fish that were not too lively. After living on a meat diet for some time, they seemed to relish a little seaweed. In feeding, the juveniles push with the fore flippers the part of any piece of food that is not actually between the jaws, thus tearing it loose from the portion already in the mouth.

ECONOMIC VALUE. The Green Turtle is the source of the famous turtle soup, and the species indeed is eaten as well as drunk by man the world over. It is the basis of extensive industries and tens of thousands of dollars' worth of specimens

are sold annually in the markets of our large cities. Without doubt this species is the most important of all turtles from an economic point of view.

Oil is made from both the turtle and its eggs, but the shell has only a low commercial value, being too thin for most purposes.

HAWKSBILL TURTLE

Eretmochelys imbricata (Linnæus)

IDENTIFICATION. The limbs are paddle-shaped and each has two small claws (rarely one). There are two pairs of large shields, the prefrontals, on top of the head between the eyes. Four costal shields are present on each side and, except in old individuals, the rear margins of the shields of the carapace are strongly overlapping.

SIZE. Three feet seems to be about the maximum carapace length attained by this small sea-turtle; one and a half to two feet is the average length of adults. An exceedingly large specimen may weigh 160 pounds. It is singularly hard to find dimensions and weight of the same individual, but one with a carapace two feet long has been recorded as weighing 50 pounds; another, a female, with a 30.31-inch carapace, 98.5 pounds.

THE SEXES. Sexual differences in sea-turtles are seldom referred to, but Deraniyagala mentions two found in this species: The extended tail of the adult female barely reaches the margin of the carapace, whereas the tail of the male is much longer. In females of more than 6.3 inches in carapace length, the two shields in the centre of the top of the head (frontal and frontoparietal) are usually fused; in males they remain separate.

EGG. The eggs are spherical or nearly so and measure from 38 to 41 millimetres in diameter. The soft white shell is thinly covered with a mucilaginous secretion which absorbs water and retains it for many hours.

LONGEVITY. A specimen received by the Berlin Zoological Garden in 1921 was still alive in 1936, and another is reported by Hornell to have been reared to an age of fifteen years. The often quoted account of the individual marked by a Dutch official and found thirty years later on the southern coast of Ceylon is interesting, but can hardly be taken as a scientific datum.

GROWTH. Hornell states that six Hawksbill Turtles confined under semi-natural conditions on Assumption Island attained carapace lengths of 12.5 to 13.5 inches in about twenty-three months, and Deraniyagala tabulates detailed measurements of the growth of two individuals kept in Ceylon. One reached a carapace length of 14.29 inches and a weight of 10 pounds 14 ounces in sixteen months; the other during the same period fell short of equal attainments by only 8 millimetres and 1 pound 6 ounces. The two came from a lot of hatchlings with carapaces 39 to 42 millimetres (1.5 to 1.6 inches) long. At such rates the adult size of twenty to twenty-four inches would be reached in a few years. In fact, Townsend wrote about two captive Florida specimens that attained weights of 50 and 60 pounds and carapace lengths of 24 and 26 inches within seven or eight years. They weighed about 3 pounds when made captive.

DISTRIBUTION. The presence of this turtle on the Atlantic coast north of Florida was long questioned, but its not infrequent occurrence in the vicinity of Woods Hole, Massachusetts, is now established. It also enters Long Island Sound. Records for the region from the Carolinas to New Jersey are, however, astonishingly few.

HABITAT. Shoals, coral reefs, and lagoons of oceanic islands

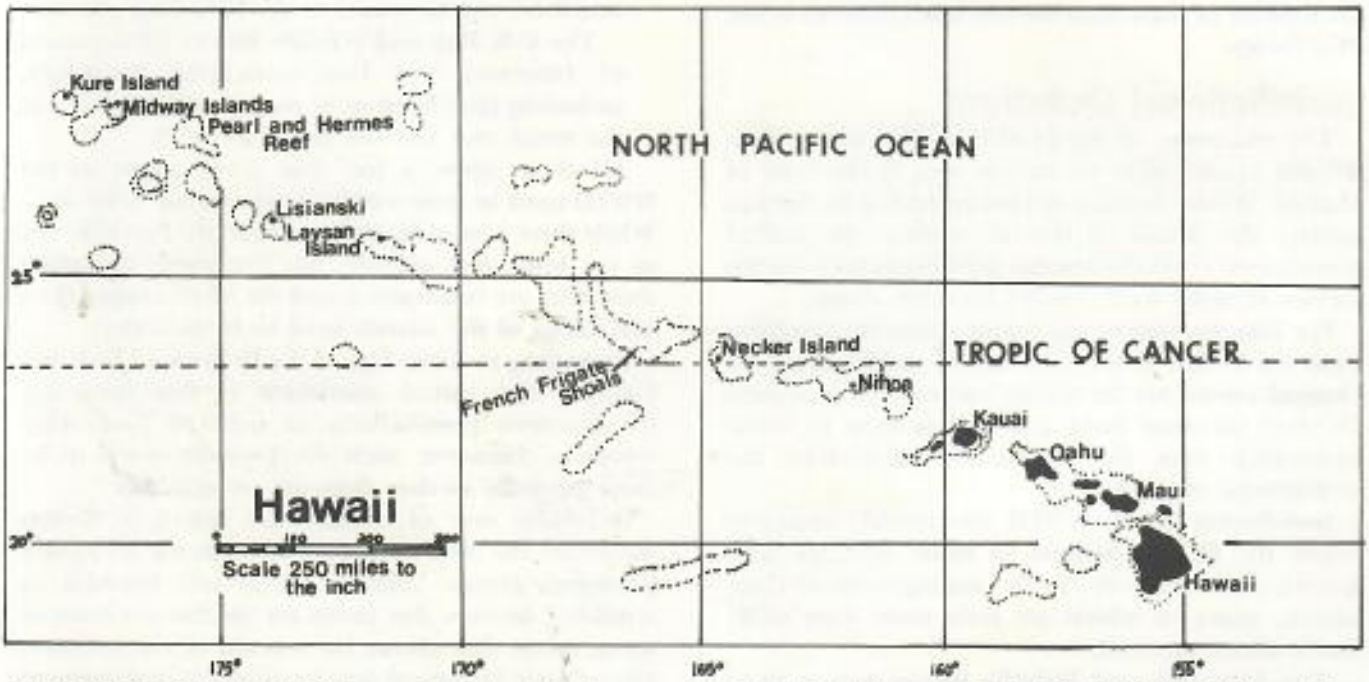
Looks To The Northwest

Conservation and Management Act (FCMA) have underscored the need for state leaders to plan for the **development and management of the marine resources** of the NWHI.

To gather information needed to ensure that the resources of the NWHI be managed and harvested prudently, a broad-scale study coordinated by Richard Grigg has been funded by the University of Hawaii Sea Grant College Program. So that the complex ecosystems of the NWHI can be studied without duplication of costs and effort, the University-based research team will coordinate its efforts with the State Division of Fish and Game, the National Marine Fisheries Service (NMFS), and the U. S. Fish and Wildlife Service.

"An idea whose time has come" is Grigg's assessment of the need for a multi-faceted, multi-disciplinary study of the NWHI resources. "There has been no comprehensive, systematic investigation of the fertility of the NWHI," says Grigg. "Managers of the resources need to know what the basic producitivity is. How much biomass is the system capable of producing?"

The species-specific, Sea Grant-funded projects will seek biological and ecological information on bottom fisheries, sharks, green sea turtles, precious corals, lobsters, shrimp, and pelagic nehu (Hawaiian anchovy). Other studies will compile data on the effects of currents and oceanographic conditions on the population genetics of several commercially



THE HAWAIIAN ISLANDS, drawn by Barbara Hall from a map of the United States published by the National Geographic Society, Washington, D.C. (1968). The dotted lines indicate shallower water.

valuable species. The socio-economic-legal component will assess the impact of the NWHI resources on the current and future economy of Hawaii.

Acropora Found

During a 16-day cruise conducted in November 1978, researchers studying the ecology of the coral reefs of the NWHI made a startling discovery. Although thought to be rare or non-existent in Hawaii, two species of *Acropora* dominated large reefs in the French Frigate Shoals 500 miles northwest of the Island of Oahu.

Scientists had hypothesized that *Acropora*, usually abundant in tropical waters, were absent in Hawaiian waters because of their cooler temperatures. Hence, the dominance of *Acropora* at the French Frigate Shoals constitutes a scientific puzzle.

Grigg, principal investigator of the project on the ecology of the corals, proposed three theories for the presence of *Acropora* in the NWHI:

(1) new colonization initiated by World War II barge traffic between Johnson Islands and French Frigate Shoals,

(2) a relic of the geologic past when the waters surrounding the Hawaiian Islands were warmer.

(3) a natural invasion of the recent past. A study of sediments from the reefs will test this theory. Even if borne out, there is still the question of why the corals are concentrated at the French Frigate Shoals.

The largest coral head discovered by the researchers measured 15 feet 10 inches (about 5 meters), and is estimated to be about 35 years old. According to Grigg, this "match" between the coral head's age and the number of years since the war lends credence to the first theory.

Jurisdictional Questions

The enactment of the FCMA in 1976 added some 300,000 square miles of marine area to the State of Hawaii. While the State of Hawaii retains its right to govern the 3-mile territorial waters, the federal government's jurisdiction has been extended from the former 12 miles to 200 miles from the coasts.

For Hawaii, one of the major questions resulting from the FCMA is the question of **jurisdiction over channel waters.** Are the channels international waters? Or does the state have a case if it were to claim ownership over the waters by promoting the archipelagic regime?

Jurisdiction of the NWHI was already complex, before the FCMA, because so many agencies have historic and legal roles in the management of these islands, many of which are little more than atolls barely above sea level.

— **The U.S. Fish and Wildlife Service** was granted management responsibilities and control of entry to the islands of Hohoa, Necker, Laysan, and Lisianski, when the NWHI were designated as a wildlife refuge.

— **The U.S. Coast Guard** has authority over Tern and Green Islands.

— **The Midway Islands** are part of the U.S. Naval Defense Area (remember World War II) and thus are not part of the Hawaiian Islands.

The inability of the United Nations Law of the Sea Conferences to come to consensus on what the regime ought to be for the ownership of both the discovered and the yet-undiscovered resources of the oceans of the world provides nations the license to continue to hammer out "interim" nationally-oriented laws which will soon, if they have not already done so, have the force of precedence.

The archipelagic regime which would circumscribe a state boundary around the islands of the archipelago has been promoted for the Hawaiian Islands by John Craven, Dean of Marine Programs at the University of Hawaii. This concept would include the NWHI as part of the archipelago.

Tripartite Management

The three agencies, which have been designated certain aspects of a joint study of the resources of the NWHI, will develop plans for the management and control of those resources.

The National Marine Fisheries Service (National Oceanic and Atmospheric Administration, Department of Commerce): the marine resources from the 10-fathom contour outward, including the pelagic resources within the 200-mile zone;

Hawaii's State Division of Fish and Game: the nearshore coastal waters to the 10-fathom contour;

The U.S. Fish and Wildlife Service (Department of Interior): the land-associated resources, including land habitats of marine animals such as the monk seal and the green sea turtle.

All these agencies feel that development of the NWHI must be done within the context of "wise use." While there is need for development, the vast colonies of sea birds and wildlife that live there, including those that are endangered, and the often unique flora and fauna of the islands need to be protected.

According to Kenji Ego of the Division of Fish and Game, "The initial assessment is that there are development possibilities in fisheries and other resources. However, such development needs to be done carefully so that there are no mistakes."

A similar note of caution was voiced by Robert Skillman, the NMFs representative on the tri-agency planning group. "Harvesting is not harmful to wildlife," he says. But limits for the harvest must be set at a rate that allows for renewal of the resource. Hence basic biological data is critical to management and development.

A SCIENTIFIC PUZZLE—Although abundant in tropical waters, Acropora *was thought to be absent in Hawaiian waters because of their cooler than average temperatures. However, last fall reefs at French Frigate Shoals were found to be dominated by corals of the genus* Acropora. *Based on the age of the largest coral head found, scientists theorize that barge traffic in World War II may have introduced* Acropora *to the Northwest Hawaiian Islands.*

Fishery Resources Available

The NMFS is charged with the determination of resources which can be developed and the impact of such development on the resources. Studies indicate a potential for commercial and recreational development of the NWHI. So far identified are substantial populations of

- spiny lobster
- about six species of snappers and groupers, such as opakapaka and ehu
- kawakawa (*Euthynnus yaito*)
- two or three species of jacks

Within the fishery management zone, especially around the Hancock Seamount about 180 miles off Kure Islands, a large fishery of armorheads has been located. These are bottom fish which are unfamiliar to the American public and require a fishing method not commonly used by Hawaiian fishermen.

The possibilities for developing recreational fisheries are also being considered. Such favorites of sports fishermen as jacks and ono are abundant in the NWHI. Negotiations with the U.S. Navy have led to the establishment of a fishing station on Midway Islands.

Although the U.S. Fish and Wildlife Service's work is land-based, the water portion of the refuge is an integral part of the total ecosystem they are studying, because the animals that live on the islands within the wildlife refuge derive food from the ocean.

Henry Hanson of USF&W considers a three-pronged thrust in research to be vital. "What is the extent of the living resources of the NWHI? What is there? What are the ecological groups?" Thus the information to be gleaned is vital to the management studies.

The Fish and Wildlife Service is especially concerned with the spiny lobster fishery because monk seals feed on lobsters. To protect the seals, part of the proposed overall management plans will prohibit taking lobsters within the 10-fathom contour shoreward of those islands which are monk seal habitats.

The Western Pacific Regional Fisheries Management Council is another agency charged with the development of management plans for the living resources of the NWHI. The Council has developed a preliminary management plan for spiny lobsters.

Research data on the basic productivity of the NWHI, provided by the University of Hawaii Sea Grant College Program, will be used to create computer-based ecological models centering on the top predators and working down the foodweb. These models will then be used by the tripartite agencies so they may develop rational management policies for the use and the conservation of the valuable resources which abound northwest of the main Hawaiian islands.

Toxic Chemicals in the Great Lakes

Whitney Gould
University of Wisconsin Sea Grant College Program

Until relatively recently, concern about Great Lakes water quality centered on the problem of ***eutrophication***—the process by which nutrient enrichment causes lakes to age prematurely.

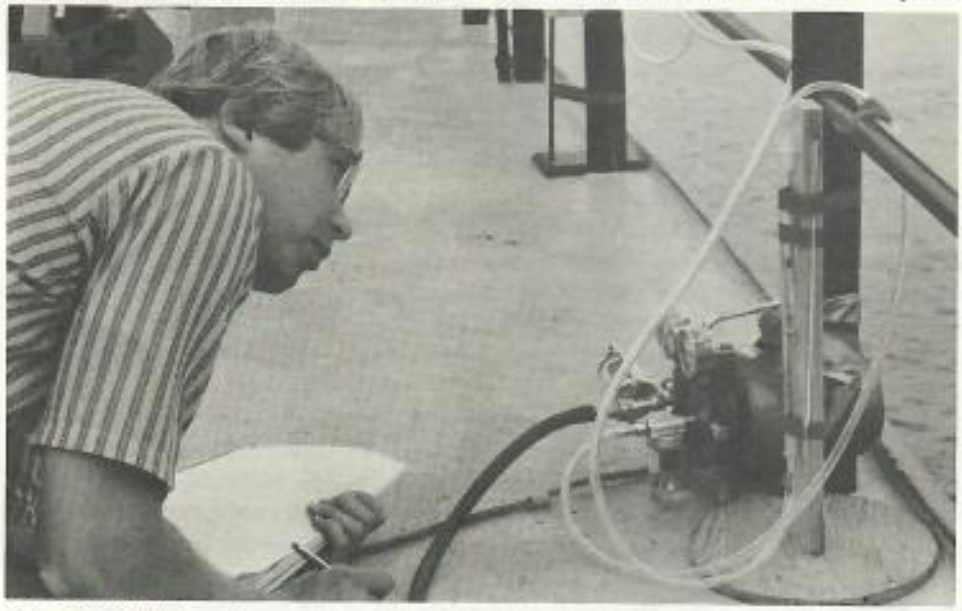
In the past few years, however, the issue of eutrophication has been all but eclipsed by what is now widely regarded as the major threat to Great Lakes water quality—toxic chemicals. Earlier, many of these compounds, which by definition can kill or injure living organisms, went unrecognized. But with improvements in the scientific techniques for detecting them, toxic substances came to light and today loom as a significant environmental problem.

It was the DDT crisis of the 1960s that first brought the threat of toxic chemicals in the Great Lakes to public attention. The persistent pesticide, which was widely used throughout the Great Lakes basin, turned up at high levels in the lakes' fish species, including trout and salmon. Some of these fish, in turn, were declared unfit for human consumption.

Since DDT was banned nationally in 1972, levels of the pesticide in Great Lakes fish have dropped considerably. In Lake Michigan, the decline has been a dramatic 80 percent, and DDT in fish is no longer considered a public health problem.

But more recently, a whole new array of chemical contaminants has aroused the concern of scientists studying the lakes. These range from organic compounds such as PCBs (polychlorinated byphenyls), dioxins and petroleum products, to heavy metals like mercury, arsenic, lead and cadmium.

The chemicals enter the lakes from a variety of places—point sources such as wastewater discharges from cities and industries, leaching from waste disposal sites, illegal dumping, and non-point sources such as atmospheric pollution and runoff from farms and city streets.



CALIBRATING equipment for aerosol sampling on Lake Michigan. Photographs with this article courtesy of the University of Wisconsin Sea Grant College Program.

Contaminants Studied

Since 1969, the University of Wisconsin Sea Grant College Program has concentrated a substantial part of its research effort on the sources, fates and effects of Great Lakes contaminants.

Much of this research has focused on PCBs, industrial chemicals that were used until recently in a variety of industrial products. Though the federal Toxic Substances Control Act included a ban on the manufacture, distribution and use of PCBs as of this year, the PCB compounds already loose in the environment continue to contaminate waterways like Lake Michigan.

PCBs' Behavior

Studies by UW-Madison water chemist **Anders Andren** indicate that perhaps as much as 70 percent of the PCBs entering the lake fall from the atmosphere; that amounts to about 8,600 kilograms a year. Likely sources of PCBs, according to Andren, include landfills and incinerators.

One of Andren's colleagues, **David Armstrong**, has shown how PCBs, once in the water, attach to solid particles and fall to the bottom of the lake. There, the compounds are picked up by bottom-dwelling organisms and passed up through the food chain.

Alewives, for example, eat these organisms and concentrate PCBs. These small, silvery ocean fish are, in turn, the major food source for the top predator fish like lake trout and salmon.

Trout and salmon, as a result, have accumulated PCB levels as high as 25 parts per million in a few areas of Lake

Pig Tale

ALASKA's Agricultural Experiment S improvement of production, processi management. All photos with this art

Pigs and Fish. It would seem the two couldn't be further apart. However, opposites attract and necessity is the mother of invention and therein may lie the reason Alaska has found pigs and fish make a good team.

In all parts of the state economy, Alaska has a traditional problem with the boom-bust syndrome. From the Gold Rush to the pipeline, a series of highs and lows have plagued the economic structure with little moderation between. A general decline since pipeline construction has placed stabilization of the economy foremost among concerns for state officials. Steadying the fishing industry is a road already paved—with intensive aquaculture projects, legislative structures like limited licensing, and a host of management plans. The success of these attempts is partially measured by their ability to deal with new problems to the industry.

Using Fishery Wastes

One of those new problems is what to do with fish processing wastes. Across the country, processors are looking at the same problem, since pending Environmental Protection Agency regulations will stop the dumping of wastes back into the ocean and mandate cleaning of effluent waters. The classic solution to this problem is fishmeal; if wastes can be made into a saleable product, they cease to be waste. Alaskan processors decided some time ago that there was a future in the fishmeal business, and three plants currently operate in the state at Kodiak, Petersburg, and Seward.

One problem Alaska has with encouraging industry of any kind is a lack of necessary infrastructure to support it. The groundwork for fishmeal processing has been laid, however, with those plants in operation. The problem now is getting a big enough market to support them. Not only is the home market for fishmeal small, but Alaska fishmeal sold in a lower 48 has to go at a price that includes high transportation costs. Finfish meal enjoys a fairly large steady market as a high quality protein supplement, especially in livestock feed. Shellfish meal has a poorer quality protein content and finds its biggest market as a fertilizer. The shellfish meal market is much smaller than that of finfish meal and so is the price. Consequently, Alaska processors produce shellfish meal at a loss.

Will Pigs Eat Meal?

It's now that pigs begin to look promising. Since the 1940's, shellfish meal has been considered indigestable and unpalatable. Researchers said the protein content of shellfish meal could not be used, even by livestock. But Fred Husby of the University of Alaska Agricultural Experiment Station takes exception to that commonly held truism.

Husby says those conclusions were drawn from investigations on small numbers of East coast blue and Tanner crab. The chemical composition of Alaskan king and Tanner crab is different from East Coast crabs and should, by its nature, be more digestable. Husby's Sea Grant experiments have centered around raising pigs from 40 pounds to market weight on a diet using shellfish meal as a substitute for part of more expensive protein supplements.

Potential for shellfish meal production in the state is tremendous, given the tonnage of shellfish caught annually. Alaska currently places about one-fifth to one-tenth of its total waste into fishmeal, yet it produces over one-half of the total U.S. shellfish meal output. What is needed desperately is an expansion of the shellfish meal market. Husby's project not only shows a way of getting that increase, but it fits in neatly with state concerns for encouraging stable, renewable industries. It also provides an in-state market, avoiding high shipping costs that make some Alaska products unable to compete in the continental U.S.

There are only two small commercial

UNIVERSITY OF WISCONSIN researchers study chemicals in the waters of the Great Lakes. LEFT: David Armstrong, water chemist, looks over peaks and valleys of chlorinated contaminants as they show up on a read-out from fish sample tests. MIDDLE: Chemist Anders Andren checks the results of a gas chromatograph test for levels of PCBs and other contaminants in an atmospheric sample taken over Lake Michigan. RIGHT: Monkeys fed steady diets containing 2.5 ppm PCBs (left) and 5 ppm PCBs (right) both show toxic effects, in a study by pathologist James Allen.

Michigan. This is greatly in excess of the 5 ppm limit established by the Food and Drug Administration (FDA) for fish destined for human consumption. **The PCB-contaminated fish cannot be sold commercially, and the state of Wisconsin has warned anglers not to eat more than one meal a week of fish from Lake Michigan and other PCB-tainted waterways.**

In short, PCB contamination has dealt a severe blow to Lake Michigan's sport and commerical fisheries, together valued at more than $28 million for the state of Wisconsin alone. The blow could be worse yet if the FDA lowers the permissible limit to 2 ppm, as it has proposed to do. Such an action would adversely affect the whitefish fishery, the major commercial fishery in Wisconsin.

Removing PCBs

How long will PCBs remain a problem in the Great Lakes? David Armstrong and other UW-Madison researchers are developing a computer model designed to predit how long it will take for PCBs to become buried—and effectively sealed—in bottom sediments of Lake Michigan.

Based on the decline of DDT concentrations in coho salmon following the DDT ban, the researchers predict that if all PCB input to the lake were to stop immediately, PCB levels in coho salmon would decline by 60 to 80 percent within about six years. The remaining 20 to 40 percent would decline more slowly.

The rate of PCB removal would depend on such factors as the rate of sedimentation in the lake and the degree to which contaminated muds are stirred up, passing PCBs on into the food chain.

Harvesting Alewives

One possible way to decrease the contamination of food sources for large fish, according to recent Ph.D. recipient **David Weiniger** (now with the Environmental Protection Agency), would be to undertake large-scale harvesting of alewives, which accumulate PCBs at higher levels than other forage fish do. Eliminating alewives, Weininger theorizes, would force trout and salmon to switch to smelt and sculpin—two species with low PCB levels—as a food scource. The result, he suggests, would be that PCB concentrations in adult lake trout and salmon could decline by a factor of about two.

Fish managers with the Wisconsin Department of Natural Resources are intrigued by the idea of alewife harvesting, done on a limited scale already. But they fear that a large-scale effort would be extremely expensive.

On the other hand, as Armstrong points out, the costs of such an effort must be balanced against the costs of PCB contamination of the Lake Michigan fishery.

Do PCBs Hurt Humans?

Whether current levels of PCBs in fish are causing problems in human populations is not yet known.

But the Wisconsin program plans to look into that question, in comparative studies of PCB contamination in the blood and breast milk of two groups of Sheboygan, Wisconsin, women—one group made up of heavy consumers of fish from PCB-tainted waterways, the other with a history of little or no fish consumption.

Infants born to these women will be tested for behavioral and developmental abnormalities.

PCBs and Monkeys

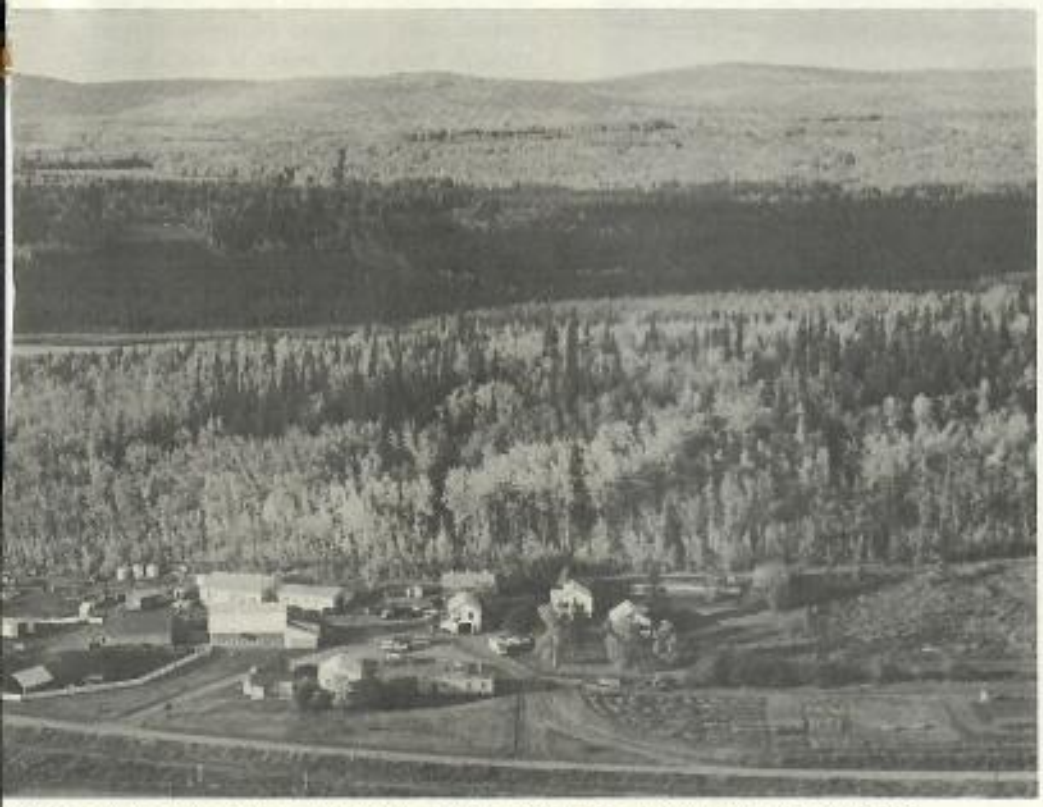
In Sea Grant-supported studies on the effects of PCBs on rhesus monkeys, UW-Madison pathologist **James Allen** has yet to find what he considers a "safe" level of PCBs in food.

Since 1968, Allen has been feeding PCBs to these primates, which resemble humans in their biological responses. Even when fed a steady diet containing PCB levels as low as 2.5 ppm—the amount currently permitted in milk and dairy products—the monkeys experienced reproductive failures, loss of hair, swelling of the eyelids, and other health problems. Infants born to the females suffered similar ailments, in addition to behavioral and learning disabilities.

On the other hand, monkeys being fed PCB-contaminated fish meal—in a situation more closely approximating human exposures—have shown no overt ill effects to date.

These PCB studies are only one facet of the UW Sea Grant program's research on

Continued on page 12



T. Frady
Alaska Sea Grant Progr.

tation carries out studies concerning conservation and development of new land, g and transportation of food and wood products, and development of resources icles by Sabra McCracken, University of Alaska.

pig farms in the state today. Husby says that is partially because of a lack of supporting slaughter houses and processors, so that each operation must raise, slaughter and process its own pork for sale. But the biggest block to a large livestock industry in Alaska is a lack of feed production in the state. Farmers have to import cereal grains and protein supplements, paying not only for the feed, but high shipping costs. Farmers currently pay about $400 per ton for soybean oil meal, used as a protein supplement. King crab meal sells at about $140 per ton from Alaskan producers. If it proves to be an effective substitute, a substantial feed savings can be realized.

Alaska Grown Feed?

One way of solving the feed grain problem may rest in another state project aimed at encouraging renewable industries. About 70 miles southeast of Fairbanks at Delta Junction, the state is sponsoring a 60,000 acre agricultural project raising cereal grains, notably barley. Current marketing plans for the grain call for sales to Japanese and Korean investors. If, however, those plans alter, the grain can be sold in-state to livestock operations. Husby estimates that if the total output of those 60,000 acres were put into pork production, the resulting animals would just meet Alaska's current pork demand.

In his initial experiments, Husby found that pigs had no problem eating shellfish meal. Pigs fed a corn diet had up to 25 percent of the soybean oil meal supplement replaced with shellfish meal, with no adverse effects. The change represented a savings of 3 percent or $3.30 per pig marketed. If they are fed a diet of barley, 50 percent of the soybean oil meal can be replaced at a savings of $2.90 per pig marketed (1979 figures).

Some Drawbacks

There are some drawbacks to the use of shellfish meal. Since the protein is not of the highest quality, Husby does not suggest using the meal as a complete replacement for more expensive protein supplements. He says the shellfish meal is most efficiently used at lower consumption rates. (This is also because pigs tend to waste feed at a high rate.) Pigs have shown no aversion to a diet with some fish meal in it, and indeed a substantial savings in feed costs can be realized, even at lower levels of consumption.

Because of his success in feeding shellfish meal to pigs, Husby has turned his attention to other types of livestock. Preliminary experiments with dairy cattle have been successful. Alaska has one large commercial dairy and a good potential for additional growth with reduced feed costs. Husby says the cattle experiments have yielded good success in spite of one uncooperative cow who wouldn't eat. Levels of intake for most cows were high, and Husby expects successful application of shellfish meal to dairying.

Taste Prejudice

Another problem with putting fishmeal of any kind into livestock feed is a market prejudice about taste. Consumers seem to feel that fish-fed livestock will taste like fish. To alleviate these fears, Husby has kept a careful sampling of his pork for testing by professional tasters. So far, Husby say no one eating the pork has complained of unusual odors or tastes.

One other aspect of the fishmeal problem also under investigation by Sea Grant is the storage of wastes. There are a multitude of small fishing communities in the state that will be put in a real bind by the new EPA regulations on fish waste. These communities are too small to support their own fish meal plants and

FARMERS AND SCIENTISTS alike have held that shellfish meal is unpalatable, but these hogs show little aversion to feed containing a shellfish meal supplement. The animals are placed in control groups. Each group gets a certain percentage of crabmeal in its feed, the percentage varying with the group and reaching a high of 20 percent for some groups.

too far from established plants to get their wastes there cheaply. In order to save enough wastes to make a trip to the processors profitable, they may have to fish for a month or more.

Marine Advisory specialists Curt Kerns and Per Heggelund have been working with an ensilaging process to help with storing wastes. Through manipulation of pH, they have found wastes can be stored for several months with no odor or spoilage. When a community has collected enough to make the cost of shipping per unit low enough, the wastes can be sent away to a fishmeal plant.

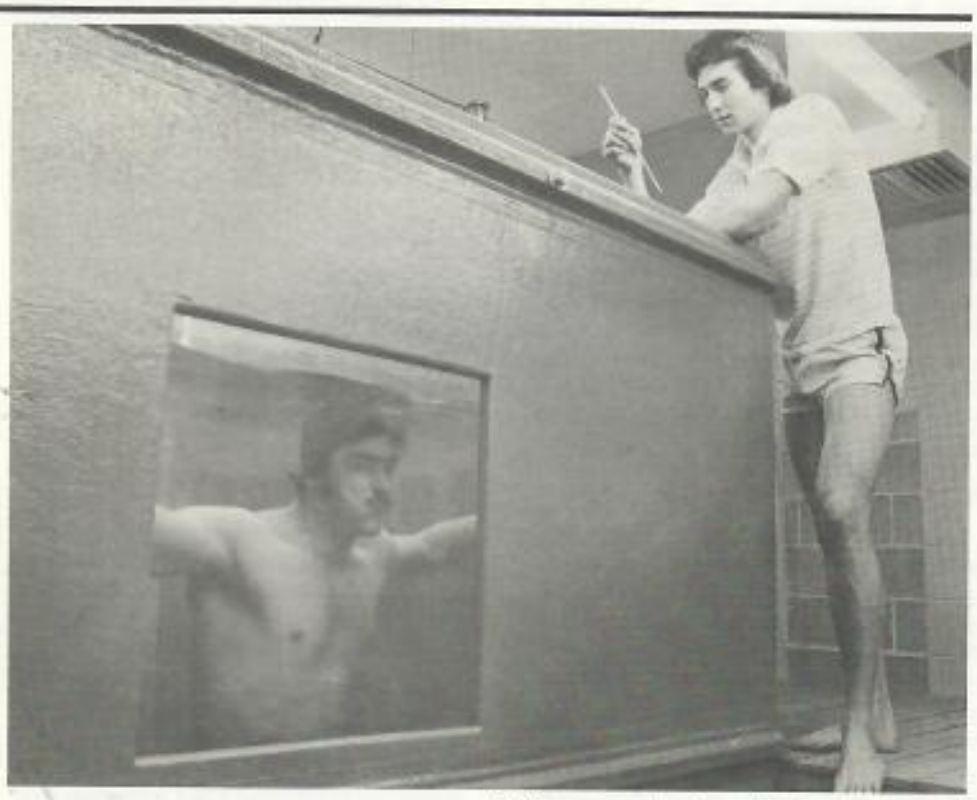
Somewhat of a "chicken-and-egg" syndrome is developing among fish processors and the various state sponsored attempts to stabilize the economy. Although Husby got involved with shellfish meal feeds because the fish processors were looking for new markets, it is equally true that livestock farmers are trying almost as hard to find ways to cut feed costs. Both problems have a possible solution in shellfish meal, but it is difficult to say which came first. An over all guideline of stabilizing Alaska's notoriously fluctuating economy provides a public dimension to the project, helping Alaskans overcome a heavy dependence on short-term revenues like the oil pipeline.

Sailing Lake Champlain

This summer students and alumni of the University of Vermont will be able to learn about **life on a sailing ship** through first-hand experience. Professor Kempton E. Webb, Chairman of the Geography Department of Columbia University, will be guiding the interested through a week-long experience in the **history and geography of Lake Champlain** on board the first windjammer to sail the waters of this lake in fifty years.

Those who enroll will study, live, and sail aboard the Schooner *Richard Robbins*, which is powered only by sail, where food is cooked on a wood stove, and ice cools the food. Participants will explore the lake, learn about sailing craft and navigation, the early explorers and settlers, military campaigns and naval battles and the present threats posed to the lake by development and pollution.

For further information, write Summer Session, University of Vermont, Burlington, VT 05405; or Box 195 Vergennes, VT 05491; phone 802-759-2411.



UMD news service photo by **Kenneth J. Moran.**

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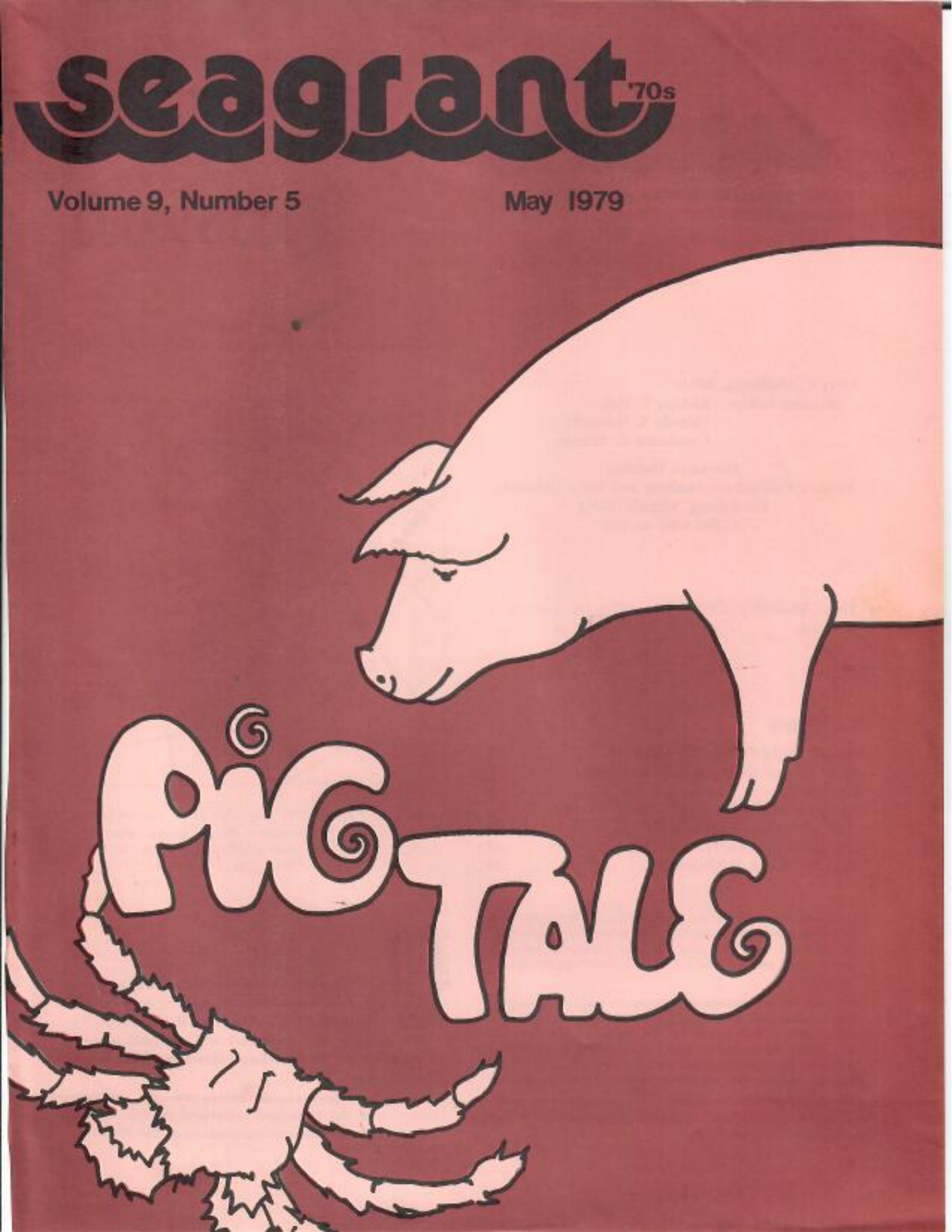

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Virginia Polytechnic Institute and State University
Volume 9, No. 5 May 1979

Hawaii

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This Month's Cover—Drawing by Victoria S. Howarth

Contents

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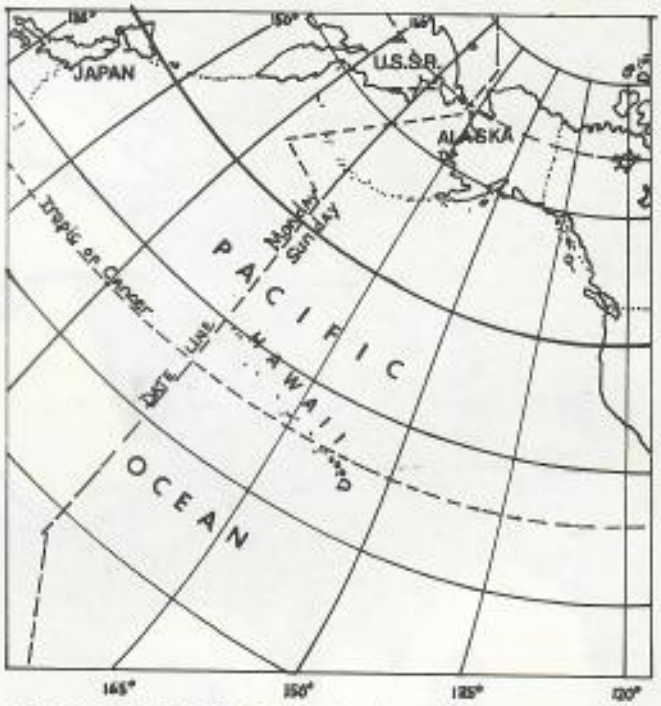

OBLIQUE MERCATOR projection of the western United States and the north-eastern Pacific Ocean, drawn by Barbara Hall from one published by the National Geographic Society, Washington, D.C. (1968).

About three-fourths of the 1600-mile Hawaiian archipelago (see map) was designated a National Wildlife Refuge in 1909 by Theodore Roosevelt, pretty much isolating the coral reef and volcanic islands comprising the **Northwestern Hawaiian Islands** (or NWHI).

Recently, however, pressures on the marine resources of the principal inhabited islands of the archipelago and the implementation of the Fisheries

Anjanette Perry, Department of Oceanography, University of Hawaii

MAGNETITE IN THE GREEN TURTLE

(Major Professor: Dr. Richard E. Young)

Migratory green sea turtles, Chelonia mydas, can accurately navigate in the open ocean over distances of several hundreds to thousands of kilometers. Numerous guidance mechanisms for their feeding to breeding site journeys have been postulated, but few have been examined experimentally. Preliminary data suggest one navigational cue may be the ability of the green turtle to detect the geomagnetic field.

A possible transducer of magnetic field information to the turtle nervous system is the highly magnetic iron-oxide mineral magnetite. Biogenic magnetite has recently been discovered in a variety of marine species, ranging from invertebrates to pelagic fish and marine mammals. In order to determine if Chelonia also synthesize magnetite, hatchling, juvenile and adult specimens were tested for magnetic remanence using the SQUID magnetometers of the Hawaii Institute of Geophysics and the California Institute of Technology. Saturation-induced magnetic remanence one to two orders of magnitude greater than background noise was found in the heads of all turtles examined, and was localized to the dura mater in the adults. Samples were subsequently subjected to alternating field demagnetization to determine magnetic stability.

Dura tissue from six juveniles and one adult was digested with 5% hypochlorite solution (household bleach). The residue was examined microscopically and numerous opaque, needle-shaped magnetic particles were removed. X-ray diffraction and microprobe analysis of the particles showed that they were composed of very pure magnetite crystals. Crystal structure was examined under scanning electron microscopy.

Behavioral studies are planned to conclusively demonstrate whether the green turtle does exhibit magnetic sensitivity.

Michael M. Walker, Department of Zoology, University of Hawaii

THE LIKELY SITE OF THE MAGNETIC SENSE ORGAN IN YELLOWFIN TUNA (THUNNUS ALBACARES) AND BLUE MARLIN (MAKAIRA NIGRICANS)

(Major Professor: Dr. Ernst S. Reese)

The problems we face in understanding animal navigation are epitomized by the migrations of pelagic marine fishes. It is very unlikely that fish could use the sun compass or other known orienting mechanisms to guide pelagic migrations. There is a growing body of indirect evidence that magnetic sensitivity is a very important orienting mechanism for migratory animals. This paper reports successful conditioning of yellowfin tuna (Thunnus albacares) to magnetic fields and an investigation of the possibility that the physical basis for a magnetic sense in both the yellowfin and the blue marlin (Makaira nigricans) is biogenic magnetite deposited within the ethmoid bones of the skull of both species.

Yellowfin tuna were trained using a discrete trials-fixed interval testing paradigm to discriminate between the normal Hawaiian magnetic field and an altered field generated by a coil encircling their tank. Fish were trained to produce or

withhold a conditioned response (swimming through a gate lowered into the water for 30 second trial periods) in anticipation of positive or negative reinforcement. Studies using the cryogenic magnetometers at Hawaii Institute of Geophysics and California Institute of Technology set out to identify concentrations of magnetic material within the bodies of yellowfin tuna and blue marlin. Where concentrations of magnetic material were found the tissues were demagnetized in an alternating field to determine the coercivity of the magnetic material.

All yellowfin tested for magentic sensitivity learned to discriminate between the two magnetic fields after two 30 trial sessions. Control trials were performed with one fish by interrupting the circuit between the dc power supply and the coil around the experimental tank. All other procedures continued as before but discrimination between the positively and negatively reinforced trials ceased. Discrimination by the fish was re-established when the circuit was recompleted providing good evidence for the existence of a magnetic sense in these fish.

Concentrations of magentic material were predictably found within the ethmoid bones of the skull of both the yellowfin tuna and the blue marlin. Examination of the coercivity and other properties of the magnetic material showed that it was single domain magnetite in both cases. Theoretical analyses imply that the amount of magnetite present is sufficient to provide these fish with a very sensitive magnetoreceptor if the magnetite is linked to the nervous system. This finding of magnetite in the same structure in species from different families of pelagic fish strongly suggests that magnetite deposited within the ethmoid bones is the basis of the magnetic sense organ.

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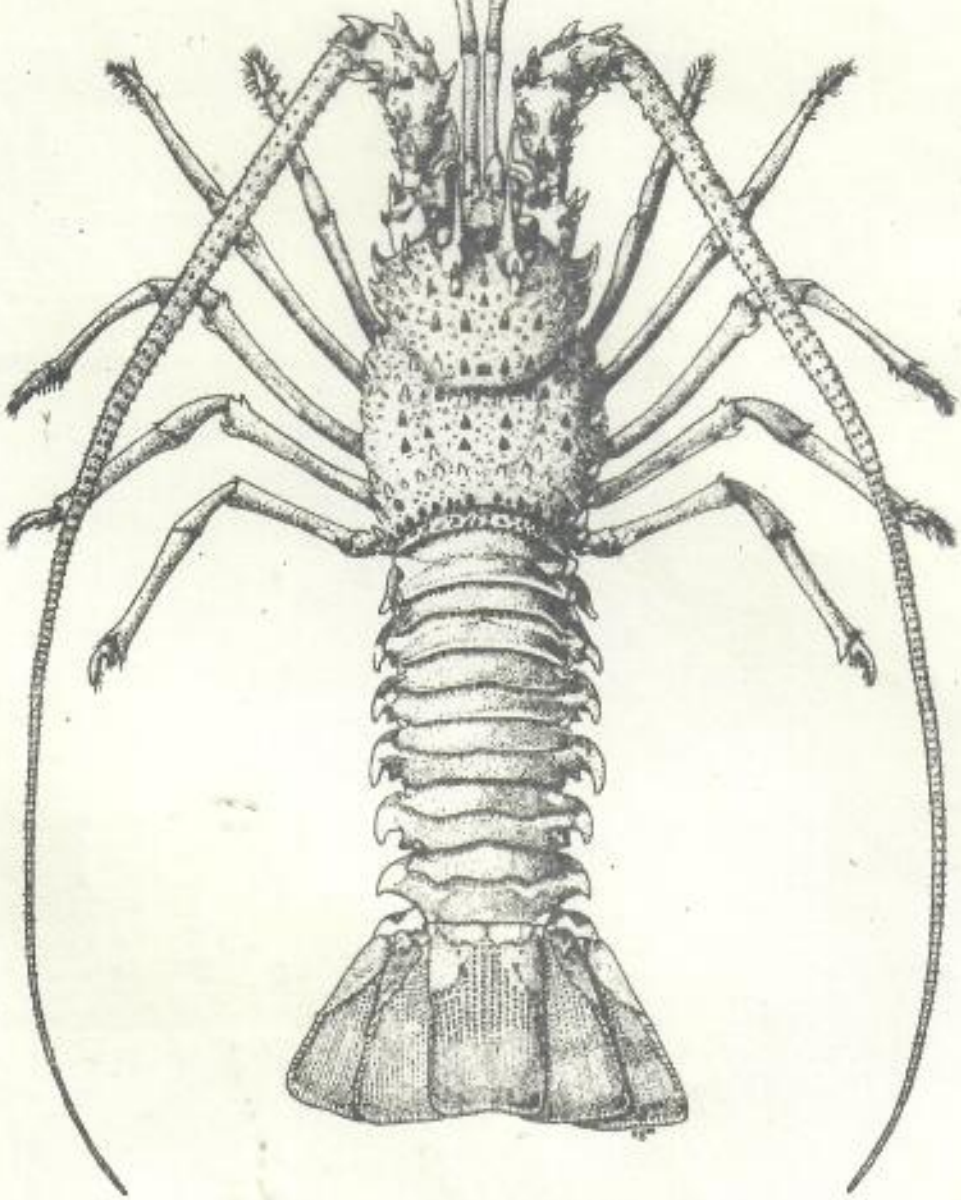


University of Hawaii

FINAL REPORT FOR NOAA CONTRACT 41 USC 252 (c) (15): ANATOMICAL DETERMINATION OF PRESENCE/LOCATION OF MAGNETITE IN YOUNG TURTLES AND BEHAVIORAL STUDY OF MAGNETIC SENSORY CAPABILITY OF SEA TURTLES

Anjanette Perry
Oceanography Department
University of Hawaii
Honolulu, Hawaii

On April 1, 1981, a study was undertaken to determine if the Hawaiian green turtle, Chelonia mydas, possessed a sensory receptor capable of detecting the geomagnetic field. It was postulated that the presence of the ferrimagnetic mineral magnetite (Fe_3O_4) in the head might indicate such a sensory capability, and behavioral studies could confirm that the turtle utilizes the mineral to detect changes in magnetic field intensity and/or inclination.

Employing the SQUID magnetometer of the Hawaii Institute of Geophysics, five hatchling and juvenile turtles, of age 2 weeks to 20 weeks, and one adult head, were examined. Results are presented in Table 1. Magnetic remanence above background noise was found in the head regions of all animals examined. In the adult, the highest readings were obtained from samples of facial muscle and from the dura. Sections of bone and brain adjacent to the dura did not give high magnetic readings, indicating that the magnetic material was concentrated within the dura or in structures closely associated with it. Light microscopy revealed the presence of opaque structures in the areas which had high remanence. No specific cellular components could be elucidated, however, as the samples had been frozen before examination and cellular membranes had broken down.

The mineral magnetite occurs ubiquitously, and its presence alone does not indicate a magnetic field sensibility. One method of determining if a sample contains a conglomeration of many crystal types or of like crystals is to plot a coercivity curve. A magnetic substance's coercivity is an indication of how well its component crystals maintain their orientation, or moment, in the presence of an alternating magnetic field. By subjecting a sample to an alternating field of increasing strength, a curve is obtained indicating the rate at which the sample loses its remanence. Figure 1 illustrates the coercivity curves for the dura and facial muscle of the adult turtle. The muscle sample loses much of its remanence at a low field strength, while the dura sample presents a much more gently sloping curve. The smoother curve is indicative of greater magnetic stability, probably of importance in a sensory mechanism.

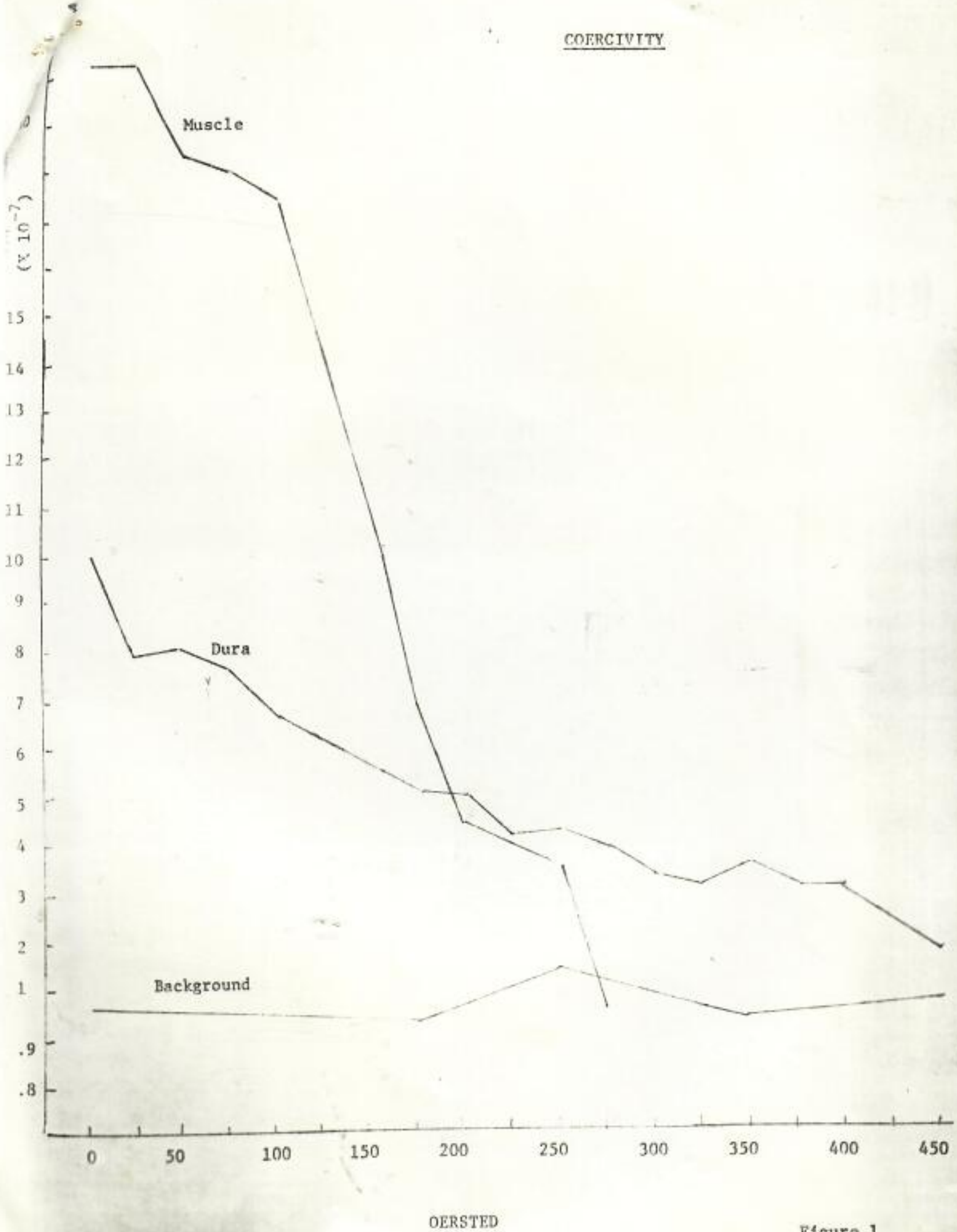
Similar concentrations of magnetite have been found in yellowfin tuna, homing pigeons and dolphins, concentrated in the dura or anterior dorsal region of the head. It is assumed, therefore, that in the turtle the magnetite associated with the dura is responsible for magnetic field detection, and that located in facial tissue is either contamination or serves another purpose in the turtle's metabolic processes.

Two behavioral experiments were set up to test if the turtles would respond to magnetic field conditions that were different from that of the normal geomagnetic field. Helmholtz coils were wrapped around two tanks, one 18 feet in diameter, one 4 feet, and each set was connected to a power source. A one amp current added a vertical field of approximately 0.35 Oersted.

The large tank held 58 turtles. These turtles were being trained to a classical conditioning paradigm. The turtles were observed via a video monitor for a period of two to ten minutes before the field was activated. One minute after the field was turned on food was delivered down a PVC tube. The observer, food entry end of the tube and electrical apparatus were located in a tower and were not visible to the turtles. Noises made by the observer or machinery were masked by the sound of water flow into the tank.

The small tank held one turtle. Near the side of this tank tubing with a plastic disc attached to its end was connected to a microswitch, and the apparatus hooked up to an LVE relay board and to a syringe pump. A syringe on the pump delivered a food paste via the tubing to the turtle when he pressed the disc with his head. The planned experimental setup was to train the turtle to press the disc for food only when a light behind the disc was on. Gradually this light signal was to be replaced by activation of the altered magnetic field. The turtle trained rapidly to the light. However, funding under the NOAA contract was terminated before the turtle could be trained to the magnetic field.

Preliminary results of the large tank experiment indicated a sensibility to the magnetic field, but insufficient data were taken to perform statistical analyses. It is hoped that additional funding can be obtained in order to complete these experiments, so that meaningful conclusions on the turtles' sensibility to magnetic fields can be drawn.


COERCIVITY
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400
450
OERSTED

Figure 1

This is a chapter from:

"Turtles of the United States & Canada"

by

Clifford H. Pope

Published

August 14, 1937

2nd. -- February 1946

3rd. -- September 1949

4th. -- December 1961

5th. -- January 1967

C1: Each bridge with three enlarged poreless inframarginal shields; limbs two-clawed. (See Pl. 91.)
ATLANTIC LOGGERHEAD TURTLE

C2: Each bridge with four enlarged inframarginals (see Pl. 93) with or without pores.

D1: Each inframarginal with a pore; more than five pairs of costals; limbs two- or one-clawed.
PACIFIC LOGGERHEAD TURTLE

D2: Inframarginal poreless; five pairs of costals; limbs three-clawed. KEMP'S TURTLE

A2: Shell covered with smooth skin; carapace with seven prominent longitudinal ridges. LEATHERBACK TURTLE

GREEN TURTLE

Chelonia mydas (Linnæus)

IDENTIFICATION. The limbs are paddle-shaped and each has one small claw (rarely two). There is a single pair of large shields, the prefrontals, on top of the head between the eyes. Four costal shields are present on each side, and the shields of the carapace are not overlapping (slight overlap evident in the very young).

SIZE. A cast made from a 700-pound Green Turtle caught in the Key West region is exhibited in the New York Aquarium; this turtle is said to be the largest ever taken by the Key West dealers. Babcock, however, gives 850 pounds as the West Indian record. Seventy-five to 150 pounds is the usual weight range of specimens caught at present in American waters. Where this turtle is little molested by man, breeding females have carapaces thirty-eight to forty-six inches long and weigh 300 to 500 pounds.

THE SEXES. In the adult the tail of the female barely reaches

beyond the margin of the carapace, whereas that of the male reaches even beyond the tips of the extended flippers.

EGG. The eggs are sometimes spherical, but more often one diameter is from 1 to 3 millimetres greater than the other. For example, the lesser diameters of six typical eggs from Brazil ranged from 40 to 42, the greater from 41 to 44 millimetres. The soft shell is white.

LONGEVITY. A specimen from the Pacific Ocean lived in the New York Aquarium for fifteen years.

GROWTH. Although the growth rate of the Green Turtle has never been fully determined, there is some reliable information on the subject. Moorhouse found that a carapace length of eight inches is reached in one year off the eastern coast of Australia, and Schmidt secured substantiating data in the West Indies. Judging by the findings of these men, this turtle during very early life adds every month about half a pound to its weight and half an inch to its carapace. Moorhouse tentatively states that a female first matures when its carapace is thirty-five inches long and that a length of forty-four inches probably indicates an age of at least ten years.

According to Flower, three specimens in the Aquarium of the Zoological Society of London increased from a weight of less than one to more than fifty pounds in about nine years and four months. Hornell reports a captive individual that reached a carapace length of one and a half feet in twenty-eight months.

DISTRIBUTION. The Green Turtle occurs throughout the Gulf of Mexico and northward along the Atlantic coast to the North Carolina sounds, in which it was abundant before being decimated by turtle-hunters during the nineteenth century. It has been taken as far north as Cohasset, Massachusetts, and is occasionally seen off New Jersey and Long Island coasts. It is now the commonest sea-turtle of Bermuda. In the Pacific it occasionally reaches the bays of San Diego County in extreme

southern California and is abundant as far north as southern Lower California.

This valuable turtle has a world-wide distribution in tropical and subtropical seas, usually remaining within 35° of the equator.

Pleistocene fossil remains from Florida prove that it has occurred in the Florida region for perhaps tens of thousands of years.

HABITAT. Shoals and lagoons of oceanic islands and continental shelves. Bays and sounds are often entered, especially in the vicinity of sand beaches. Coral reefs are avoided.

The browsing method of feeding is a strong determining factor in the habitat preference of the Green Turtle, which is prone to frequent fields of sea plants.

HABITS. Just where this turtle sleeps is the most interesting question about its habits. That it does sleep is a well-established fact, for many observers have seen relaxed individuals floating on the surface of the sea. In 1925 Wetmore presented indisputable evidence that great numbers sleep on remote Hawaiian rock ledges and sandy beaches, a fact contradictory to the general belief that sea-turtles die if stranded on their bellies, owing to the lack of sufficient support afforded to internal organs by the lower part of the shell. Breathing is said to be seriously impaired and specimens going to market are always turned on their backs.

Recent observations on the Galapagos Islands confirm Wetmore's evidence, so the beach- and ledge-sleeping habit cannot be considered a peculiarity of the Hawaiian turtles, and remarks on the belief that stranded individuals die unless lying on their backs are in order. Wetmore himself has suggested that the vibration of a ship's deck might have bad effects, but I think that the oxygen requirement of a sleeping turtle may be enough less than that of one struggling from fear and discomfort to account for survival in one case and ultimate death in

the other. In this connection it must not be forgotten that laying females of all sea-turtles often remain on a beach for many hours. During much of this time, however, most of the weight rests only on the edge of the carapace.

Deraniyagala states that loggerheads live on land longer than Green Turtles because the plastron and sides of the shell are more completely ossified and better resist the pressure of the upper parts.

Still another point calls for elucidation. Why has no one of the many persons interested in commercial fisheries ever seen Green Turtles asleep on a beach? Again Wetmore's experience is helpful; he noticed that the frequent appearance of human beings on the remote beaches where turtles rested soon caused the reptiles to take their siestas in still more remote places. The habit of sleeping on the strand probably has long since been abandoned wherever turtles have been even slightly molested by man. They must quickly learn that sleep on the bosom of the deep is far safer; certainly it sounds more comfortable and inviting! Fishermen long ago told Bumpus that Green Turtles occasionally sleep off Rhode Island shores with the head resting on lobster-buoys. Are these reptiles astonishingly resourceful or Rhode Island fishermen surprisingly imaginative?

The Hawaiian siestas may also be considered a form of sun bathing, as indeed similar excursions ashore have been called by Deraniyagala in reporting the midday landing of sea-turtles on an uninhabited island in the Maldives.

Although adults drag themselves along on land by laborious strokes of the front limbs moved together and aided (or not?) by alternate pushes of the hind flippers, the gait of the young is relatively nimble for they "walk like most four-footed beasts."

MIGRATION AND INDIVIDUAL RANGE. In spite of a general belief that Green Turtles regularly go back and forth from feed-

ing areas to breeding grounds, sometimes travelling hundreds of miles in doing so, there is no scientific evidence that such mass movements take place. Hornell has brought together the available information supporting the migration hypothesis, but it is not convincing. In fact, the only scientific investigation ever made, the marking experiments of young turtles by Schmidt in the West Indies, gave absolutely no evidence of extensive migrations. Among nine individuals marked and retaken, only one was found any great distance from its starting-point. That one was discovered fifty miles away after ten months. Others were captured much nearer to or at the common point of release. Although this evidence is limited and largely of a negative character, it is some indication that young Green Turtles are rather stationary.

The problem is a complex one, however, and cannot be so readily dismissed. Working on Heron Island, off the east coast of Australia, Moorhouse found that, although a canning factory had killed all the turtles seen on the island during the 1928–9 laying season, a new crop, including many large individuals, visited the same beaches the following year. Here is strong evidence that females either do not lay every year or else change nesting sites. Such a change would be in the nature of a migration.

A female that landed two consecutive nights on Heron Island was turned each night and actually taken to the factory the second one, before being released. Ten days later she was found laying on an island sixteen miles distant. This change in site was evidently the result of fright, which, however, did not prevent her from making subsequent nests on Heron Island.

Only prolonged investigation on a large scale can solve the many problems of sea-turtle wanderings and individual range.

MATING. The following facts about mating have been well established although actual courtship and copulation really remain to be described: Mating takes place off the nesting

beaches during the laying season; many males attempt to copulate at the same time with one female; the mated pairs are oblivious of danger and float on the surface, the male on top with his forelimbs stretched forward and pressing against the carapace of his mate; spent females returning to the sea at least sometimes accept the attention of waiting males and at once copulate.

Judging by Hornell's account, mating takes place not only during but for some time before the laying season, actually beginning with the gathering of the turtles off the nesting beaches. He also states that an ardent male occasionally follows a female a short distance ashore before realizing the futility of his effort and clumsily returns to the water.

Although only diurnal copulation is mentioned, the frequent references to males awaiting females returning from laying is indication of nocturnal mating. Probably the act, usually begun at night, often lasts well into the day.

NESTING. In the Seychelles, east of Africa and some five degrees south of the equator, the Green Turtle lays throughout the year, with a *very* decided peak during March, April, and May; off the west coast of Borneo, about two degrees north of the equator, the peak comes from May to September. In the region of southern Florida and throughout the West Indies the species is reported to nest from April to August; from late October into February on Heron Island, lying about on the Tropic of Capricorn near the eastern coast of Australia.

Nocturnal laying is the universal rule, the majority of females making their nests between the hours of ten and two. The site chosen is usually above the reach of high tide, but many nests were destroyed on Heron Island in 1930 when the high-water mark for January was more than a foot above that of the preceding November. Even if the eggs escape the action of the waves, the salt water quickly coagulates their yolk or drowns the embryos. On this island the layers came on the

beach " at any state of the tide," but in the Seychelles Hornell noticed that the females preferred to land on a high tide, the greater number appearing on nights when high tide occurred soon after sunset.

There is considerable disagreement in regard to the actual nesting process, which no one seems to have described in detail from beginning to end. The main facts are fairly clear, however.

In ascending the beach the female pulls herself along with the front flippers (at the same time pushing with the hind ones?), leaving a conspicuous track two to three feet wide made up of parallel depressions separated by a ridge. Her progress is in stages of six or seven steps followed by pauses for rest. When a site has been chosen, she proceeds to sink herself into a large hollow which is made with all four flippers, the front pair throwing the sand out by swimming movements and then resting while the hind pair do their work. After depressions have been made fore and aft, the digger revolves enough to change the centre of action and thus finally works herself into the resulting bowl-shaped excavation.

Next she digs the egg pit, a far more delicate procedure. This secondary excavation is a cylindrical undercut hole some eighteen inches deep and twelve or more across, the exact dimensions depending upon the size of the turtle. We have Beebe to thank for the most detailed account of this supreme accomplishment of the hind flippers without aid of reason or sight. The sand is removed by strokes of the edge of the flippers used alternately, difficulty rapidly increasing with depth. Finally the flipper must be curled inward, gently lowered, uncurled, and forced into the sand by skilful pushes until a load has been dislodged. Then the tip is again curled to completely enfold the sand and bring it out, often with loss of scarcely a grain. A final flick sends the sand flying directly backward and well clear of the hole.

Now the other flipper, which has been held flat against its side of the pit, preventing caving in of the walls, is snapped to throw forward any loose sand that may have fallen on it, curled, and lowered into the hole. (One account describes the waiting flipper as idly outstretched.)

The " exquisite accuracy " of the flipper movements is emphasized by Beebe, who goes on to describe the spraying of the sides and bottom of the hole with a liquid, presumably to reduce the chances of caving in. This undoubtedly is cloacal bladder water, not urine.

When the turtle is ready to lay, the hind flippers are brought together, hiding the tail and covering the mouth of the pit. Accounts of actual deposition are very sketchy, owing no doubt to the difficulty of seeing what goes on after the flippers have been brought together. Usually two eggs are ejected at a time. The end of the laying process on Heron Island is described by Moorhouse:

" As soon as the laying is completed the nest is filled in, the hind flippers patting and kneading the sand into the nest. Then follows a flinging of sand over the body by the fore flippers, the hind ones piling it evenly as it falls. The animal, still throwing sand, moves forward and soon the original spot is obliterated. Then she returns to the water. From the time of the turtle's coming out of the water till her return two to two and a half hours have elapsed, though some animals have taken but one hour, while others have taken as long as seven hours in the process."

Before the investigation on Heron Island it was known that the Green Turtle nests more than once a season, but the maximum number of times was largely a matter of conjecture. Many of the fifty turtles marked there laid seven clutches at intervals of approximately two weeks, and it is possible that some of those that deposited seven times returned to increase the number after the departure of the investigator. Not infre-

quently females came ashore and dug nests only to return to the water without laying, some vainly wandering distances of six hundred yards besides digging one or two holes.

Moorhouse was also able to show that relatively few females visit one island during a single season. Moreover, he tentatively concludes that turtles do not lay every season and frequently change their laying islands.

A staggering lot of statistics on the number of eggs laid at a time by females on islands off the west coast of Borneo have been made available by Banks. The average for 16,690 clutches taken from one island in 1934 was 108 eggs per clutch, and 107 for 10,726 others from another in 1932. The maximum number of eggs in any one clutch among many tens of thousands was 176. Disregarding round numbers, the highest count that I find for all parts of the world is 195. Banks further detected in the Bornean region a slight tendency for the size of clutches to be larger on nesting beaches visited by relatively few turtles, one such place having an average count of 118 eggs per nest based on only 875 layings. Correlation between the number of turtles depositing in a given area and the annual weather conditions was also discernible, the reptiles being less productive during damp, stormy years.

The average incubation period in the Seychelles is stated by Hornell to be forty-seven days, the greatest but a few more than fifty; but on Heron Island the eggs of eleven marked nests required from sixty-five to seventy-two days to hatch, those that took the longer time being near enough to fringing vegetation to receive some shade. A shorter period for the former locality, which lies only five degrees south of the equator, is what one would predict; Heron Island is about on the Tropic of Capricorn. Nevertheless, the difference is unexpectedly great.

BEHAVIOUR OF HATCHLING. This is a vexed subject because of lack of agreement and somewhat contradictory statements.

Hornell believes that the young of one nest "hatch out the same day and usually within a couple of hours after the first appears," but Moorhouse states that they "do not all emerge on the same day or night," and goes on to explain how various factors such as low temperature and packing of sand by rain cause delay. It might be argued that the difference is one between actual hatching and subsequent appearance at the surface, but Hornell is certainly of the opinion that hatching is rapidly followed by emergence. Moorhouse refers chiefly to delayed emergence.

The next difficulty is the time of emergence, Moorhouse obviously believing that the night is the normal time, hatchlings having even been seen by him to reach the surface during the day only to bury themselves again. In spite of this, he explains that the young are strongly attracted by a bright light and on three occasions saw individuals leave the sea to approach a petrol lamp.

Another point of disagreement is in regard to the diving ability of very young Green Turtles. Hornell writes that "they are a long time in acquiring the art of diving and staying under water for a prolonged period," but Moorhouse makes no mention of any such inability, to the contrary speaking of the young diving after food and rising to the surface of the sea to breathe. In spite of this, he reports dissecting some and finding "a large percentage of the yolk within them." Now, it is just this yolk that Deraniyagala claims makes young sea-turtles unable to dive!

FOOD AND FEEDING. Adults of this species are chiefly herbivorous, subsisting largely on marine grasses and algæ. Mangrove shoots are relished by Galapagos populations. Eel-grass of the genus *Zostera*, often called "turtle grass," is commonly eaten, and masses of floating leaves of this plant are considered a sure indication of turtle feeding grounds. In cutting the plants near the roots to procure the most succulent parts, the

turtles set countless numbers of the leaves free to float on the surface.

Small mollusks and crustaceans are also devoured. For example, Beebe found a stomach crammed with hundreds of shell-less flying snails and a small number of munidas or "scarlet lobsterettes." Young oysters are sometimes eaten.

The juveniles are decidedly more omnivorous than the adults.

Deraniyagala determined that stomachs of individuals kept out of water four days still retain masses of undigested algæ, whereas only twelve hours are required to empty the stomachs of those left in their native element. This might be one factor in the alleged quick death of stranded turtles, discussed above in the section on habits.

ENEMIES. As in the case of the Hawksbill, man is without rival as an enemy.

Adult Green Turtles are not infrequently preyed upon by sharks, which either swallow the reptiles whole or nip pieces from the flippers. Beebe estimated the weight of a specimen cut out of a thirteen-foot tiger shark as about fifty pounds, and more than one observer has seen a female hindered in the nesting operation by mutilated flippers. In one case the damage was so great that the turtle could not clamber up the beach, but had to be satisfied with a simple nest at the very edge of the waves. The yolk of eggs laid so near the sea would be quickly coagulated by the salt water. That shark, in addition to injuring one adult, perhaps prevented the hatching of thousands of young.

In the Seychelles the hatchlings suffer from the depredations of raptorial birds and fish just as described in the corresponding section under the Hawksbill, and there is abundant corroboration of the same kind of destruction wrought in other parts of the world. On Heron Island house cats chew

off the heads of newly emerged young, while large nocturnal crabs prepare others for eating by holding them with one nipper and removing the shields of the carapace with the other. On this same island Moorhouse relates that, in an effort to determine their destination, twelve hatchlings were released at low water to be followed, but not one survived, as all were soon devoured by fish lurking in the reef.

On beaches of this same island, when crowded at the height of the season by too many arrivals, one female often digs into the finished nest of another, leaving the eggs thus inadvertently uncovered to be eaten by gulls. In North America raccoons sometimes destroy the nests.

CAPTIVITY. This species is hardy in confinement. It is slow and deliberate in its feeding movements, lacking the aggressiveness of the Hawksbill and the loggerheads.

Although chiefly herbivorous in a state of nature, the Green Turtle in captivity is nearly always fed on animal matter, and, oddly enough, seems to relish such food. Raw fish and meat constitute the usual diet, but one individual ate chiefly fiddler crabs. The usual adult fare of marine grasses and algæ can of course be given.

Moorhouse failed to persuade his hatchlings to eat for seven days, after which they refused many kinds of local sea plants but readily ate meat, clams, and fish, even killing fish that were not too lively. After living on a meat diet for some time, they seemed to relish a little seaweed. In feeding, the juveniles push with the fore flippers the part of any piece of food that is not actually between the jaws, thus tearing it loose from the portion already in the mouth.

ECONOMIC VALUE. The Green Turtle is the source of the famous turtle soup, and the species indeed is eaten as well as drunk by man the world over. It is the basis of extensive industries and tens of thousands of dollars' worth of specimens

are sold annually in the markets of our large cities. Without doubt this species is the most important of all turtles from an economic point of view.

Oil is made from both the turtle and its eggs, but the shell has only a low commercial value, being too thin for most purposes.

HAWKSBILL TURTLE

Eretmochelys imbricata (Linnæus)

IDENTIFICATION. The limbs are paddle-shaped and each has two small claws (rarely one). There are two pairs of large shields, the prefrontals, on top of the head between the eyes. Four costal shields are present on each side and, except in old individuals, the rear margins of the shields of the carapace are strongly overlapping.

SIZE. Three feet seems to be about the maximum carapace length attained by this small sea-turtle; one and a half to two feet is the average length of adults. An exceedingly large specimen may weigh 160 pounds. It is singularly hard to find dimensions and weight of the same individual, but one with a carapace two feet long has been recorded as weighing 50 pounds; another, a female, with a 30.31-inch carapace, 98.5 pounds.

THE SEXES. Sexual differences in sea-turtles are seldom referred to, but Deraniyagala mentions two found in this species: The extended tail of the adult female barely reaches the margin of the carapace, whereas the tail of the male is much longer. In females of more than 6.3 inches in carapace length, the two shields in the centre of the top of the head (frontal and frontoparietal) are usually fused; in males they remain separate.

EGG. The eggs are spherical or nearly so and measure from 38 to 41 millimetres in diameter. The soft white shell is thinly covered with a mucilaginous secretion which absorbs water and retains it for many hours.

LONGEVITY. A specimen received by the Berlin Zoological Garden in 1921 was still alive in 1936, and another is reported by Hornell to have been reared to an age of fifteen years. The often quoted account of the individual marked by a Dutch official and found thirty years later on the southern coast of Ceylon is interesting, but can hardly be taken as a scientific datum.

GROWTH. Hornell states that six Hawksbill Turtles confined under semi-natural conditions on Assumption Island attained carapace lengths of 12.5 to 13.5 inches in about twenty-three months, and Deraniyagala tabulates detailed measurements of the growth of two individuals kept in Ceylon. One reached a carapace length of 14.29 inches and a weight of 10 pounds 14 ounces in sixteen months; the other during the same period fell short of equal attainments by only 8 millimetres and 1 pound 6 ounces. The two came from a lot of hatchlings with carapaces 39 to 42 millimetres (1.5 to 1.6 inches) long. At such rates the adult size of twenty to twenty-four inches would be reached in a few years. In fact, Townsend wrote about two captive Florida specimens that attained weights of 50 and 60 pounds and carapace lengths of 24 and 26 inches within seven or eight years. They weighed about 3 pounds when made captive.

DISTRIBUTION. The presence of this turtle on the Atlantic coast north of Florida was long questioned, but its not infrequent occurrence in the vicinity of Woods Hole, Massachusetts, is now established. It also enters Long Island Sound. Records for the region from the Carolinas to New Jersey are, however, astonishingly few.

HABITAT. Shoals, coral reefs, and lagoons of oceanic islands

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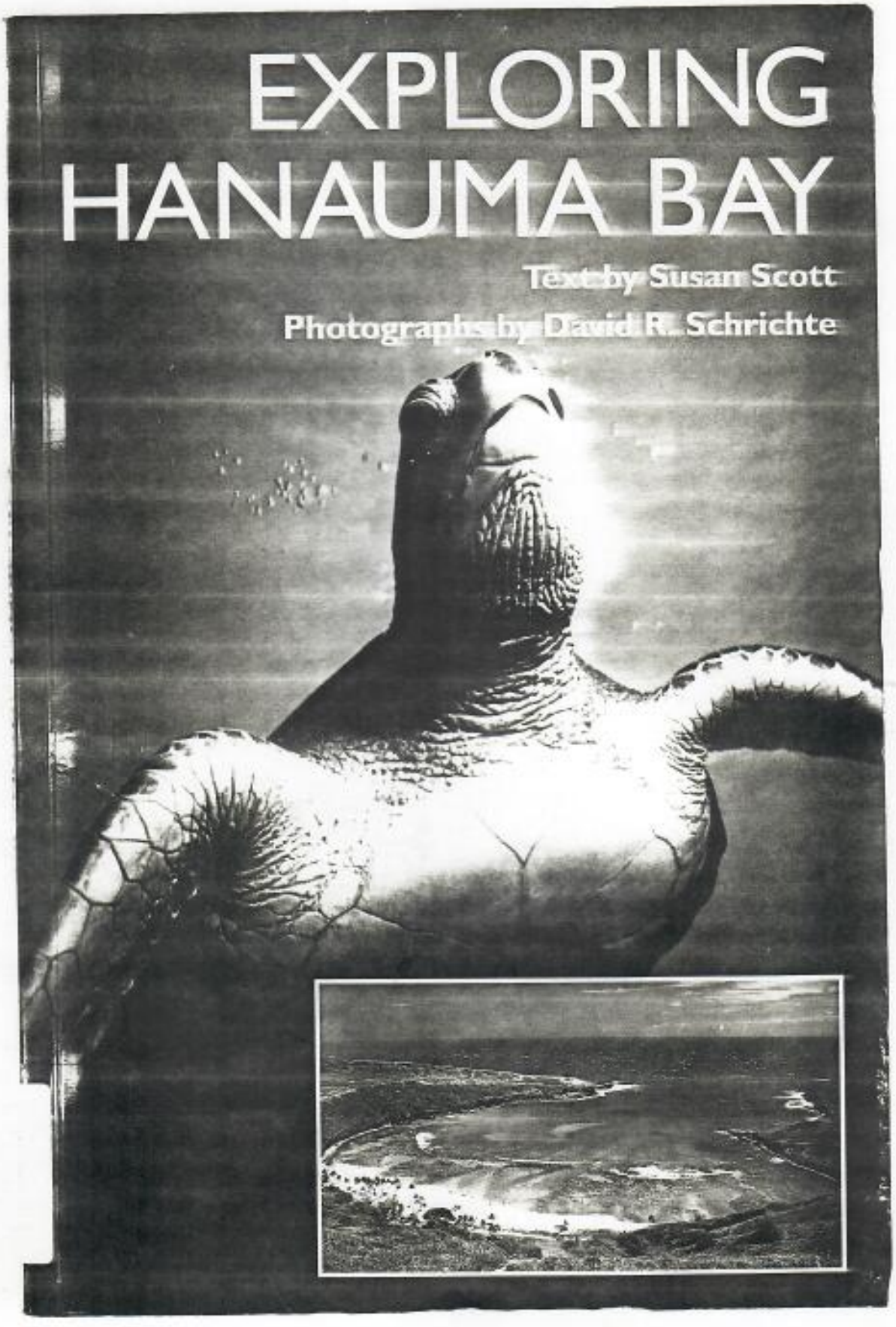
EXPLORING HANAUMA BAY

Text by Susan Scott

Photographs by David R. Schrichte



EXPLORING HANAUMA BAY

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A KOLOWALU BOOK
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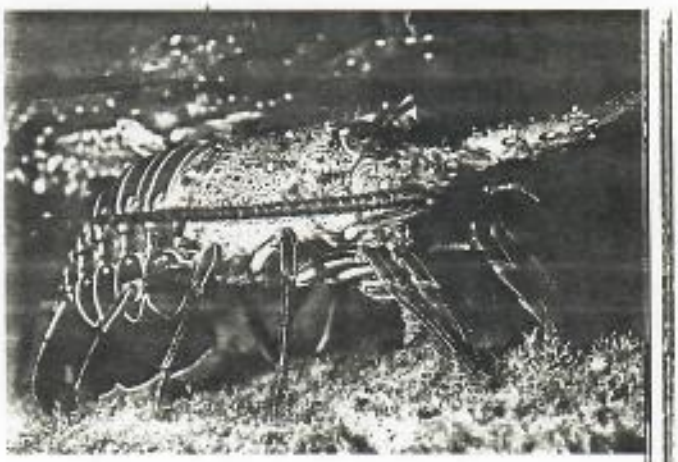
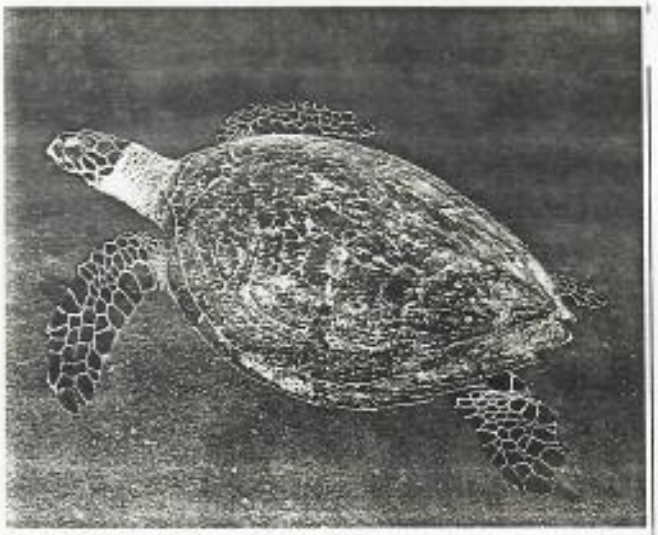
HONOLULU

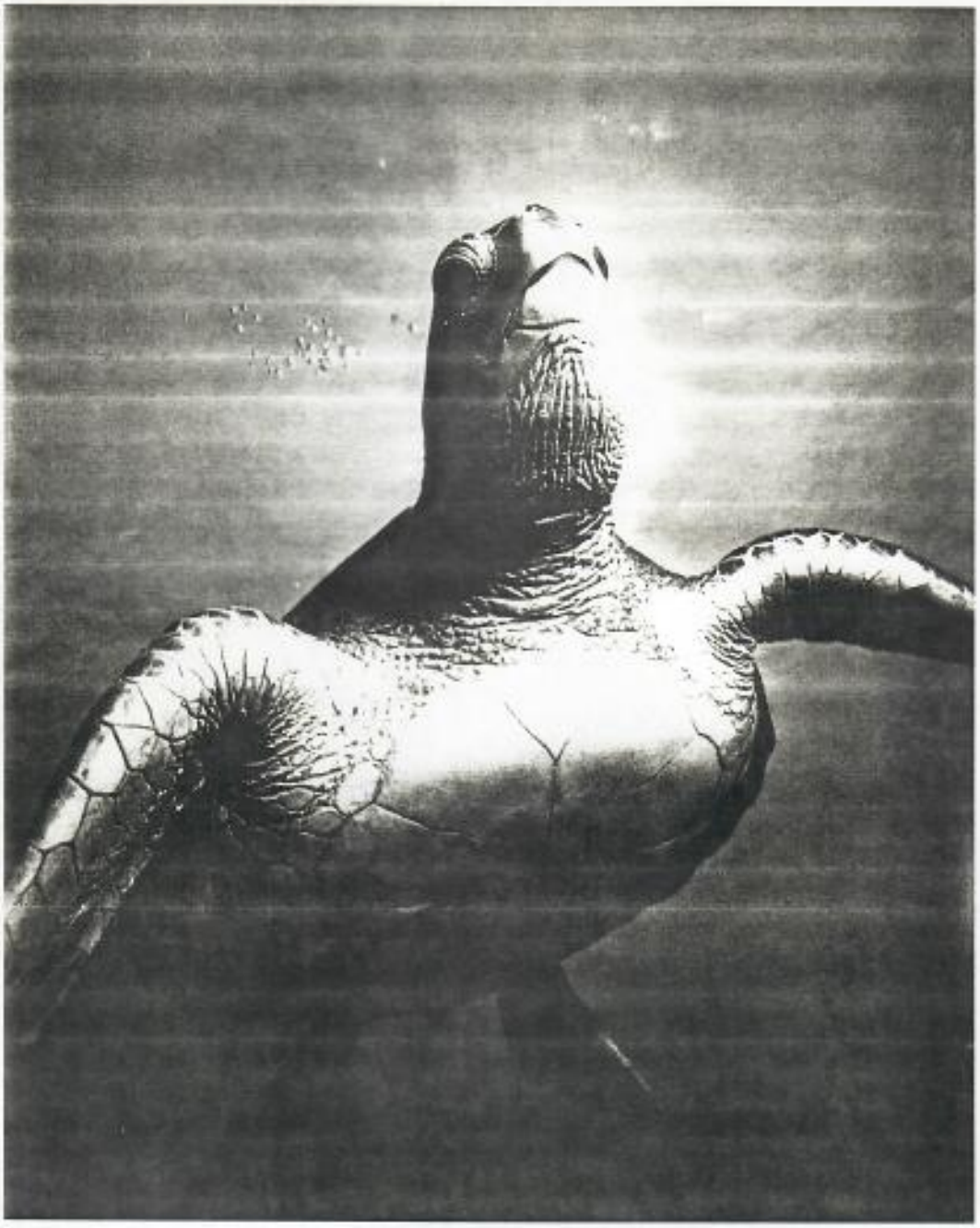
Spiny Lobster *(ula). Panulirus marginatus.* These dark lobsters are social animals that gather under rocks and ledges, where they pass the day together. At night, these predators venture out, searching the reef for snails, clams, crabs, and shrimps. Spiny lobsters have long, stout antennae that often poke out from the edge of their daytime hiding places. These black, waving antennae are sometimes all you will see of these lobsters, which can grow to 18 inches long.



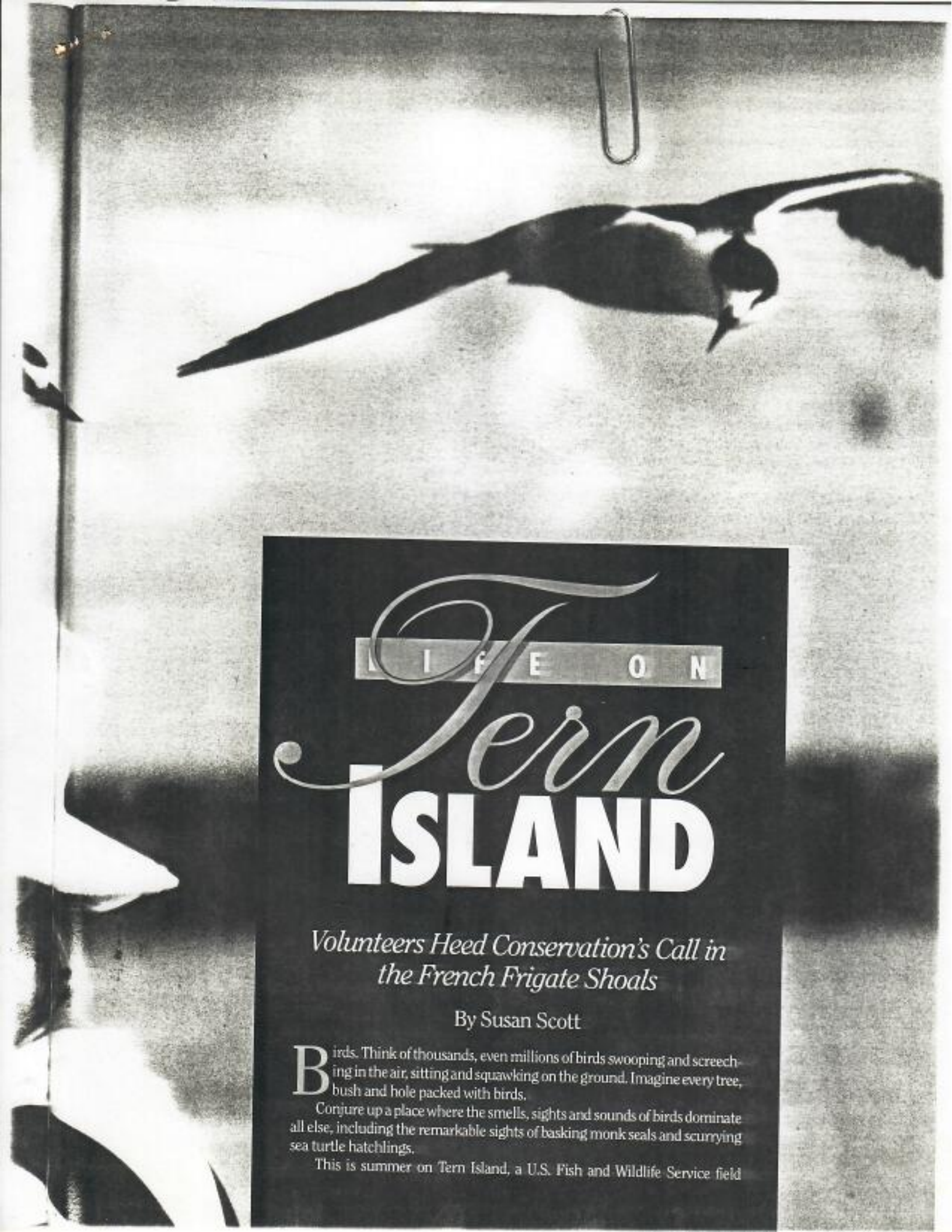
Regal Slipper Lobster *(ula papapa). Arctides regalis.* Slipper lobsters have wide, flat bodies with mottled colors that blend with their background. Of the eight types of slipper lobsters found in Hawai'i, the 6-inch-long regal is the most colorful. Like the spiny lobsters, all slipper lobsters are nocturnal, venturing from their daytime resting places to hunt snails, clams, shrimps, and crabs. Neither spiny nor slipper lobsters have enlarged pincers, as do their New England cousins, the American lobsters.



Hawksbill Sea Turtle *('ea). Eretmochelys imbricata.* Compared with green sea turtles, hawksbills are rare in Hanauma and in Hawai'i. The few hawksbills that do live here are found close to coral reefs, where they poke their narrow beaks into crevices for sponges and other invertebrates. Hawksbill sea turtles are smaller and have more elongated beaks than green sea turtles. Over the years, people have slaughtered hawksbill turtles to near extinction for their lovely shells. If you are lucky enough to see one, remember that this turtle is rare and needs our protection. Don't chase; just watch. Adult hawksbill shells, "tortoise shell" in color, grow to about 3 feet long.



Green Sea Turtle *(honu), Chelonia mydas.* Of the several types of sea turtles found in Hawaiian waters, only the green sea turtle is common in the bay. These turtles are named for their green body fat once used in soup. Their shells are gold, brown, and black. Look for green sea turtles floating on the water's surface, resting underwater, or grazing on submerged seaweed. Because animals have been protected in the bay since 1967, and turtles are protected throughout the state, some turtles now commonly approach swimmers. Enjoy the beauty and charm of these creatures without touching, chasing, or riding them. This is not only illegal but could harm the animal. Green sea turtles grow 3 to 4 feet long and can weigh up to 400 pounds.



LIFE ON Tern ISLAND

Volunteers Heed Conservation's Call in the French Frigate Shoals

By Susan Scott

Birds. Think of thousands, even millions of birds swooping and screeching in the air, sitting and squawking on the ground. Imagine every tree, bush and hole packed with birds.

Conjure up a place where the smells, sights and sounds of birds dominate all else, including the remarkable sights of basking monk seals and scurrying sea turtle hatchlings.

This is summer on Tern Island, a U.S. Fish and Wildlife Service field

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Hawaii™ MAGAZINE

Aloha Nui Loa — Welcome to the Islands

ALLAN SEIDEN

Hilton Hawaiian Village, p.22

PETER FRENCH

Christmas in Hawaii, p.50

PETER FRENCH

On the Cover:

The sunken USS *Arizona* is still intact on the bottom of Pearl Harbor. Our stories about the attack and the events commemorating its 50th anniversary begin on page 30. Cover photo by Peter French.

Departments

station in the atoll French Frigate Shoals.

French Frigate Shoals is part of the Hawaiian Islands National Wildlife Refuge, a chain of eight islands, reefs and atolls extending about 800 miles northwest from the main Hawaiian Islands. Tern Island is the largest of a number of small islets in French Frigate Shoals and is the only island in the refuge that has year-round human inhabitants.

Usually, two full-time assistant managers live and work on Tern Island but in the summer, volunteers, researchers and students bring the population up to a crowded eight or nine. This place, and all islands of the refuge, are part of the City and County of Honolulu though any resemblance to the busy city is in name only.

"You give up a lot to work here," says Ken Niethammer, who has lived on Tern Island as assistant refuge manager for the last two years. A fairy tern named Spike shares the railing he leans on and the full moon is rising slowly over the bird-chattering island. "But then, you get a lot too," he adds.

Niethammer is one of two permanent, full-time Fish and Wildlife Service employees on the Island and it is his responsibility to see that things keep working—a challenging task on a 56-acre island isolated from civilization by hundreds of miles.

The systems work well and the tiny Tern Island community has a surprising number of comforts including a spacious "house" left by the U.S. Coast Guard when the atoll was a LORAN station. The large, one-story residence has two long corridors with adjacent rooms that serve as offices and bedrooms and a central kitchen, dining room and entertainment center shared by everyone who stays there.

PHOTOS: SUSAN SCOTT

A supply plane only arrives once every six weeks (bottom), making "plane day" a holiday on the island. Above, Alyce Reuter measures and weighs young birds before banding and releasing them.

Solar panels stand guard on the roof to help power water pumps, lights, refrigerators and radios. Stoves and refrigerators run on propane. The sun heats water and residents can enjoy hot, if brief, showers.

The old tennis court at the side of the building is now a platform for catching rain that is stored nearby in huge water tanks. The tanks were nearly overflowing last summer because of an unusual amount of rainfall, so there is a luxurious amount of fresh water to squander.

But this isn't all good. The dark, rain-bearing clouds hide the sun enough that Niethammer must run a generator in the evenings to charge the house batteries that keep things going. And, during rainy spells, the showers are cold.

Storms slow activity here because most of it is outdoors. But even in bad weather, birds still need banding, the seal census goes on and lost hatchling turtles need to be collected and taken to the beach.

Wildlife biology is the bottom line here and all human activity is tailored to suit the best interests of the animals. Niethammer, a wildlife biologist, is careful that everyone on the Island knows the rules about approaching these wild creatures. Most have evolved with few predators which makes them easy to walk up to but which isn't always good for their delicate reproduction rituals.

Hawaiian monk seals, especially females, are the royalty of the refuge. Of all the animals that live here, this group is in the most serious danger of extinction. Also, like most other seal species, these animals are extremely sensitive to human activity. They are solitary creatures and prefer to be alone, hence the name monk seal. Sometimes, just the presences of a human walking on a beach will cause a resting mother monk seal to abandon her pup.

So the beaches here belong to the seals, which make good use of them. During the day, the white sand is littered with gray snorting bodies, sleeping like logs in the hot sun. During the night, the seals prefer to lie in the brush areas above the beach which gives the turtle people a chance to walk the beaches to look for signs of nesting female sea turtles.

If a seal is sleeping under a bush that has a bird study going on in it, forget it. The bird study stays on hold until the seal moves.

Mitch Craig, a National Marine Fisheries Service (NMFS) employee who works on Tern Island from March through August to research seals, tiptoes and whispers as he counts and identifies individual seals. Some have tag numbers which he tries to read from a distance with binoculars but he identifies most from body scars.

Craig carries packets of photos and cards detailing individual seals and their scars and must try to match one of these with each seal he finds. If the animal is lying on its mark, Craig waits for it to turn, sometimes for 30 minutes or more. "They always seem to turn the minute I walk away and then, just when I get back to them, they roll back over the scar," he jokes.

The job can be frustrating and tedious but Craig likes it and stays on the monk seal project back in Honolulu. He came to know the project while working with seals for the Smithsonian Institution at the National Zoo in Washington, D.C.

With the exception of Niethammer and assistant refuge manager Jennifer Megyesi, Craig and all other people who shared the quarters at Tern Island last summer were temporary residents.

During the turtle nesting season (the end of April through September), two employees of the Fish and Wildlife Service work specifically on turtles. Because a larger number of sea turtles bask and nest on East Island, an 11-acre islet about six miles from Tern, these two take turns living and working in a tiny tent camp there.

"I'm not ready to go back to Tern yet," said Glynnis Nakai, a Sea Life Park employee who took a leave of absence from her job in the education department to work on the turtle project. She talks about Tern Island like it's a crowded metropolis. "I love being out here alone with the animals," she says. "I like the peace and solitude."

Nakai and Michael Moser, the other turtle worker, trade off between Tern and East Islands every four days. They work long nights recording which turtles come ashore to lay eggs, how many times they do it and the nest locations. They stay awake nights and sleep during the day even while on Tern to keep their night-working rhythm for the tasks on East Island.

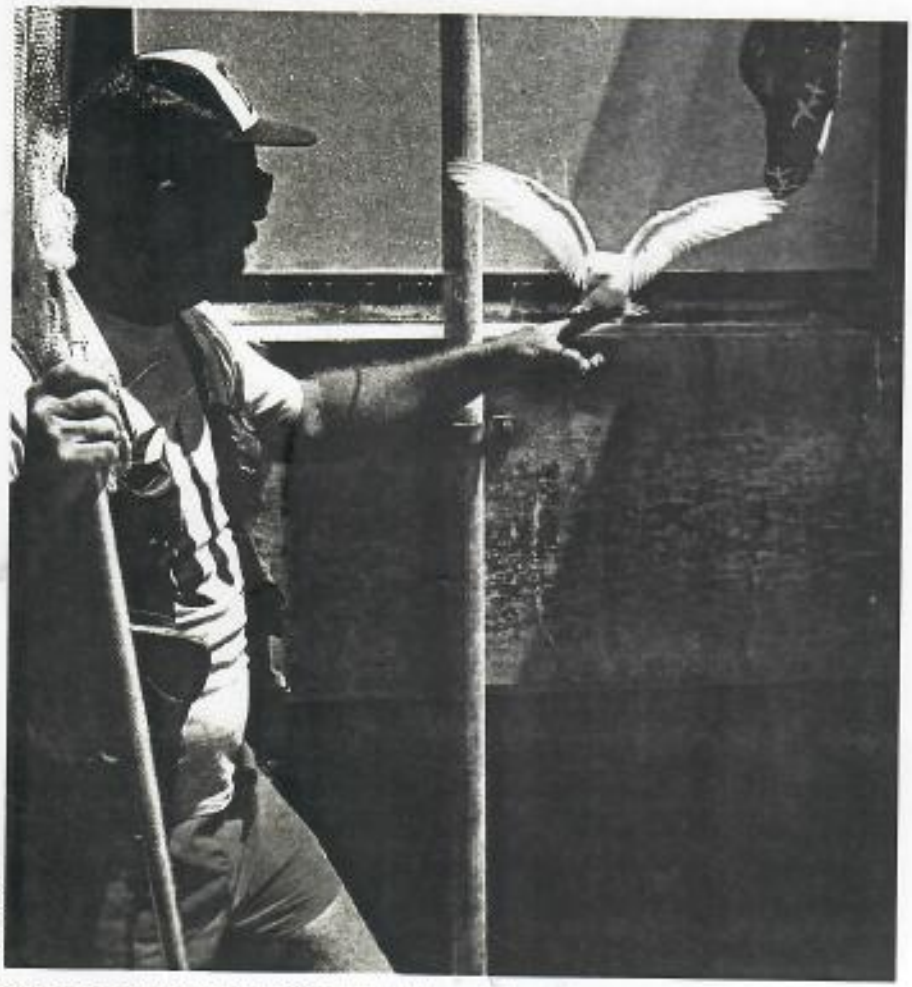
Moser has worked for Fish and Wildlife since 1990, when he was a graduate student at the University of Hawaii. He likes the work but misses his wife too much to consider staying longer than this season. He will consider the current job opening of second assistant refuge manager only if his wife will come as a volunteer.

The waters surrounding French Frigate Shoals are packed with marine animals, many economically important to the fishing industry. Bottom fish, lobsters, shrimp and Kona crabs are abundant near the atoll and tuna swim around it.

No fishing is allowed inside refuge boundaries and, so far, this hasn't been a problem. "The fishermen respect our limits," said Niethammer. "And we do what we can for them when they need help."

Tern Island managers arrange for medical air evacuations when someone on a fishing boat is seriously ill or injured.

Occasionally fishermen call and request permission to enter the protected waters of the atoll to rest or fix broken parts when sea conditions are rough. The isolated staff at Tern welcomes contact with these lobster and fishing boats and the same seems to be true of the fishermen who are sometimes out for months. More than once, Niethammer has gone to the refuge boundaries in one of the Boston Whalers to exchange greetings and trade lobsters and fish for cookies.



CRAIG THOMAS

A fairy tern stands on Ken Neithammer's finger during his daily census. These seabirds aren't afraid of people because they have no natural predators.

Managing the French Frigate Shoals wildlife refuge is a delicate balancing act for the U.S. Fish and Wildlife Service. Refuge managers must juggle issues like resource use and public access while working with modest, unpredictable budgets.

The Fish and Wildlife Service addresses these questions of protection versus exploitation in a refuge master plan, which was completed in 1986 and written with the purpose of providing long-range

WHERE THE HECK IS FRENCH FRIGATE SHOALS?

Mention French Frigate Shoals and the most common response is: "Where is that?" Few people know about this Hawaiian atoll that is rich in wildlife as well as history.

French Frigate Shoals was so named because it was nearly the end of a couple of French frigates en route from Monterey to Macao.

On November 6, 1786, at 1:30 a.m., men on both ships sighted breakers directly ahead. La Perouse, the French explorer and captain of the ships, immediately turned both around and avoided crashing on the reef with only a tenth of a mile to spare.

Because La Perouse nearly lost his vessels at this place, he named it the Shoal of the French Frigates. This name was officially changed in 1954 to French Frigate Shoals.

Given his near disaster, La Perouse wasn't too interested in seeing more of this place and quit when he saw a large lava rock, named La Perouse Pinnacle many years later. The pinnacle is now the major landmark in the center of the atoll. At 122 feet, it is the highest point around, towering above the flat, sand islands.

It wasn't until 1859 when Lt. John M. Brooke visited the area on the U.S. schooner *Fenimore Cooper* that the atoll was explored thoroughly. Brooke made the first complete map of the Islands and took formal possession for the United States.

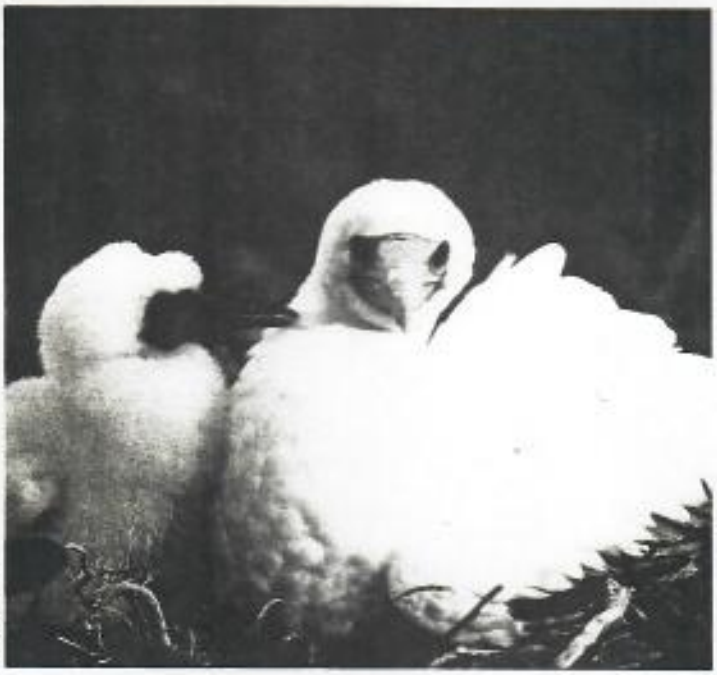
Brooke's report of *guano* (bird droppings valued as fertilizer) in the area caused some excitement in Honolulu among guano investors but subsequent voyages to the shoals proved that the tiny Islands were not as rich as they had hoped. Rain and waves continually wash the droppings into the ocean, often turning the water a pleasant milky blue.

It's hard to imagine anyone thinking guano here is in short supply: 18 species of seabirds and four species of endangered birds, totalling up to 14 million animals, visit the refuge each year, leaving their white bird logos on everything, including people.

Early sailors also noted an abundance of Hawaiian monk seals, sea turtles and fish, and it wasn't long before people began killing these animals for various uses.

Sealers slaughtered monk seals to near extinction. The Japanese began killing thousands of birds for a booming hat trade and hauling off huge numbers of sea turtles. These events led President Theodore Roosevelt to set aside all the Northwestern Hawaiian Islands, except Midway, as an animal preserve in 1909.

But the military was as interested in French Frigate Shoals as the biologists. In 1928, the officer in charge of a U.S. Coast and Geodetic Survey wrote to the commander of the U.S. Naval station at Pearl Harbor: "...French Frigate Shoals might be a very important point in case of a war between this nation and some power to the westward..."



SUSAN SCOTT

CRAIG THOMAS

A red-footed booby parent with chick (above) enjoying the sunshine. Bottom, Tern Island after a rainstorm. Ground-nesting wedge-tailed shearwaters have dug burrows throughout the green foreground.

By 1935, the U.S. Navy was using the area routinely as a training base for coordinated plane-ship exercises. The Navy was secretive about its seaplane squadrons there but East Island, an 11-acre islet near the middle of the atoll, became a tent city to house naval aviators.

Not long afterward, the place became a turning point in World War II with that "power to the westward."

On March 3, 1942, the Japanese used French Frigate's lagoon as a point for two submarines to refuel and load with weapons for another raid on Pearl Harbor. The U.S. Navy got wind of this, mined the lagoon, stationed marines on East Island and had navy vessels patrol the area.

This forced the Japanese to attack Midway without knowing what was going on in Pearl Harbor—namely that the U.S. Fleet was already headed for Midway.

The stunning United States victory at the battle of Midway is now history. If the Japanese had won that fight they planned to use French Frigate Shoals as a staging area for raids on the main Hawaiian Islands.

After this crucial battle, the Navy decided it needed an air base at French Frigate Shoals. The Seabees joined the Hawaiian Dredging Company and by 1943, tiny Tern Island had been transformed into a new island by dredging coral around the island and dumping it in the shape of a giant aircraft carrier.

Everyone seems to have forgotten that this area was a wildlife refuge. After the war, the Navy turned the atoll over to commercial fishing companies; then it was converted to a Coast Guard LORAN Station.

With improved electronic navigation systems, the atoll was finally given to the U.S. Fish and Wildlife Service in 1979 and it was reestablished its refuge status. Since then, the wild animals that have always lived here once again have priority over human activities.

—*S.S.*

guidance for managing the area.

Public access is a particularly challenging issue. A national wildlife refuge belongs to the public and continues to exist through public support. But how many people can visit such an ecologically delicate place without destroying the qualities that make it a good refuge?

While public access is restricted, a permit system gives a few individuals a chance to visit the area. Refuge managers issue permits for research and educational programs that will benefit refuge animals or increase the public's knowledge of the refuge and its resources.

The number of visitors here per year is low for several reasons, the most obvious being that human activity can hurt the animals that live and breed here.

Most of these creatures evolved without predators so they nest on the ground or in low bushes and bask on beaches. When people are around, monk seals often scoot from the beach into the water, female sea turtles sometimes won't lay their eggs and birds fly off their nests leaving them unprotected.

How many people are too many? That is a constant worry among researchers. Although managers need to learn the biology of these animals to know how to help them, human traffic broadens the chance of someone accidentally introducing harmful organisms that could wipe out entire native populations.

Ants are already a problem on Tern Island, where they swarm over the downy bodies of baby birds. And weeds are a constant battle in a place where people must be extremely careful about herbicides.

A number of concerned individuals and groups believe that public access (including their own) to French Frigate Shoals should be strictly limited if that will help preserve the area. These people believe that our quality of life is enhanced by simply knowing these animals are there and protected, regardless of anyone seeing them firsthand.

Others believe a refuge is of little value if no one uses it. One partial solution, and a priority of the Fish and Wildlife Service, is to show this unique place to the public through the impressions and cameras of wildlife journalists, photographers and film makers.

The master plan also includes supervised visits for educators and wildlife enthusiasts.

SUSAN SCOTT

Team Turtles. To identify individuals for research purposes, biologists paint white numbers on the backs of green sea turtles.

Tern Island is now just a ghost of the past bustling military presence that created it (see sidebar). It still holds its shape of an aircraft carrier, albeit an ancient one. Roofs and fittings of the old buildings leak and rust. Metal sheets used for seawalls are deteriorating as the wind and salt water relentlessly work at claiming them.

These seawalls, which now line three sides of the rectangular island, have been rebuilt twice and repaired once since the creation of the runway. Not only are they rusting away again, they are a bad design for animals which get caught between the wall and the land. Workers must check the walls daily for trapped sea turtles and monk seals.

The seawall situation can't be ignored and left to go away by itself. If the breakwaters aren't there, the island will crumble. The ocean would take back the coral rock that is the foundation of this artificial island.

Also, managers fear the rusty structures will form a huge trap for seals and turtles long before the island and seawall are totally reclaimed by the sea. These animals can swim in through gaps they accidentally find, but they don't know how to get out.

The Army Corps of Engineers has a program for cleaning up World War II debris and has proposed a plan for rebuilding the island with ramps instead of walls. This would cost an estimated $5 to $10 million. However, the impact of such renovation on these sensitive breeding grounds is an issue that must be considered if this plan is implemented.

Right now, the island runway is still intact and is used to transport people and supplies to this wildlife field station. Niethammer, grades the runway with a small tractor just before a plane is due. Aircraft, along with an occasional supply ship, help the field station stay in touch with the outside world.

But the fate of the station lies in question because the refuge budget in Hawaii has not increased despite the added costs of new refuges in Hawaii, such as Kauai's Kilauea Point and the Big Island's Hakalau Forest.

Regional managers recently had decided to close the Tern Island field station because money was so short. But at the last moment, U.S. Senators Daniel Inouye and Daniel Akaka added funds to a bill to keep the Tern Island station going. And so, in the curious way of politics, the field station was saved.

But for how long is anyone's guess. Senator Akaka made a visit to Tern early last summer and workers here are hopeful that he will help keep money coming to the area.

According to refuge manager Ken McDermond, closing the Tern Island field station would have a number of negative consequences. No one would be there to enforce wildlife laws so Hawaii's easily approached green sea turtles, monk seals and sea birds would be vulnerable to poachers.

McDermond also worries that vandalism would be a problem on the Island and there would soon be no turning back to make it usable again. Even without vandals, the salt, wind and waves would soon finish off the structures.

So what is the future of this Tern Island field station that is such a vital part of refuge management?

"Uncertain," says McDermond, "and dependent upon future funding."

Right now, the money comes from Congress only one year at a time. This makes planning difficult. Refuge managers hope that the Fish and Wildlife Service will get long-term refuge funds through the executive budget in 1991 so Congress doesn't have to decide on this issue each and every year.

Susan Scott writes "On The Reef" for HAWAII Magazine. She also writes a weekly column, "Oceanwatch," for the Honolulu Star-Bulletin *and is the author of Oceanwatcher: An Above-Water guide to Hawaii's Marine Animals.*

Hawaii's marine life

By SUSAN SCOTT

Part of the fun of boating in Hawaii is observing the behavior of the ocean's animals. While most marine life forms stay hidden from view behind their watery barrier, some are air breathers, using both the land and the sea for survival. It is these air breathing reptiles, mammals and birds that we most often see from our boats.

Photo by Susan Scott

The most familiar marine reptile found in Hawaii is the sea turtle. Three species are seen here: the Pacific green, the hawksbill and the leatherback.

The Pacific green (Honu) is our most common turtle and is named for the color of its fat rather than its shell. The hawksbill turtle ('Ea) is less common and smaller. Both have been hunted to near extinction, the first for food and the second for its lovely tortoise shell color.

The leatherneck is only an occasional visitor to Hawaii and, as its name implies, is distinguished by a smooth leathery skin rather than a shell.

The Honu is primarily a vegetarian, grazing in shallow water on marine grasses. The 'Ea and leatherback eat jellyfish, sea urchins, shell back eat jellyfish, sea urchins, shellfish and squid along with seaweed.

All sea turtles lay their eggs on beaches in sand holes dug by the females. Since most beaches on the major islands have been taken over by humans, nesting now takes place primarily in the Leeward Islands. This group of reefs, atolls and shoals that extends 1200 miles northwest of Kauai has been the Hawaiian Islands National Wildlife Refuge since 1909.

All sea turtles are listed as endangered by the U.S. Department of the Interior and must not be taken or harassed in Hawaiian waters for ANY purpose.

Marine birds are a common sight on Hawaiian waters. Twenty two different species nest here. Most all of these range widely over the Pacific.

As with the sea turtles, the greatest nesting concentrations are in the Leeward Islands where there are no human instrusions. Breeding seasons among different species are staggered to maximize limited space. Marine birds return to the same nesting site every year with the same mate.

Each pair of birds raises only one chick a year with both sexes sharing the nest duties. Most marine birds commonly live 20 to 25 years and so, even though reproduction rate is low, population size remains balanced.

The largest marine bird in Hawaii is the Albatross with a wingspan of 76-84 inches. The black-footed albatross can be seen from coasts of the main islands but frequently stays offshore in the open ocean.

These large birds glide gracefully in the wind near the ocean surface looking for squid and fish. They are not so graceful on land however, and earned the nickname "gooney birds" from crashing into bushes and trees when landing or taking off. They do their best takeoffs from a cliff's edge where they can jump off into uplifting wind currents.

Like all marine birds, the albatross drinks salt water and excretes the excess salt through a unique salt gland in the beak. It is this special gland that enables the marine birds to stay at sea for so long. Sea turtles have a similar gland.

The Monachus schauinslandi, or Hawaiian monk seal, will not be seen around the major islands like the sea turtle or albatross. The most recent count of this rare animal was 616 individuals. That's about half the number counted in 1958. Almost all live in the Northwest Chain.

Monk seals are extremely sensitive to human activity. They will live and breed only on isolated beaches that have some protection from waves and surge. A female will pup every one to two years, a low rate of reproduction compared to other species of seals and sea lions.

Most of these animals remain on the island of their birth but some interisland travel has been noted. A green fur apparent on many seals is actually algae that has grown during long periods at sea.

Octopuses, lobsters, eels, bottom and reef fish are all included in the diet of the monk seals. Unfortunately, reef fish are sometimes the source of ciguatera poisoning. At least 90 monk seals died from the naturally occurring toxin in 1978.

Other factors besides human intrusion and ciguatoxin are significant in the decline of the monk seal population. Most all individuals bear scars of shark attacks, a major cause of death. Adult males sometimes attack females and juveniles in attempts to mate, injuring them beyond recovery. Entaglement in discarded fishing nets and lines has also been observed.

As of May 30, 1986, NOAA has designated most of the beach areas, lagoon waters and ocean waters out to 10 fathom depths of the Northwest Hawaiian Islands as critical habitat for the Hawaiian monk seal. It is hoped that this added protection will aid in these unique creatures' struggle for survival. ⚓

Left: A Kure Island monk seal glares at the camera.
Below: Baby gooney bird on Kure Island.

Photos by Carol Hogan

Gigi Rounds Horn, Is Bound For New Zealand

Ty Techera, the Detroit, Michigan, native who began a solo circumnavigation with the support of several U.S. Government agencies (see "Shoreline," February 1985), has passed his first milestone by rounding Cape Horn.

The scientific research aspect of the voyage, however, has been terminated. Due to a series of communications problems between Techera and the Smithsonian Institute (the government's liaison for the project), all U.S. Government-issued equipment was removed from the boat during a layover in the Falkland Islands.

In a recent letter postmarked from earthquake-ravaged Vina del Mar, Chile, Techera described his voyage to date:

"*Gigi* (a Contessa 32) arrived here February 21 after a very rough rounding of the Horn. This year was much rougher than last due to strong (35 to 45 knots) westerlies and northwesterlies and seas of mostly 15 to 20 feet. The boat was knocked down and lost all masthead instruments and the dodger and spray panel were destroyed.

"Because we stopped in the Falklands for electrical repairs I had to go much farther south than I would have liked. Last year Gigi rounded the Horn doublehanded in 11 days, this year 14½. Next port New Zealand. Should take about 70 days."

Turtle Tidbits

Almost all of us who have cruised in tropical waters have at least once mistaken the greenish discs floating in the water for debris — that is until the "debris" lifts its head, looks indignantly about and then disappears. These floating Frisbees, the animals-in-a-box, are the sea turtles, one of the few intact survivors of the Dinosaur Age.

There are seven different species of sea turtles in the world, all restricted to living in the tropics due to their inability to regulate their own body temperature. Tropical seas provide a constant, warm environment for the animals who then have no need to hibernate.

To gain extra heat, turtles often float about on top of the water, soaking up the sun's warm rays. It is during this basking that they can be spotted from a boat — but not for long. Even though sea turtles breathe air with lungs similar to our own, these cautious, shy creatures will dive when frightened and can stay down for extended periods of time. Don't wait for one to emerge. Large turtles have been known to stay underwater for over two hours on one breath of air.

The stories about lusty, amorous male turtles are true. They are often indiscriminate about their choice of mates and will attempt to mate with crude decoys, other males, divers and even rowboats. Unreceptive females will bite at the males and then go off to a "safe zone." These zones, poorly understood by humans, are simply areas to which the females can go to escape aroused males. The males respect these areas.

Gravid females await a nocturnal high tide to crawl ashore and dig a hole for their eggs. This is no easy task for this marine animal. She must often dig several nests because the walls of those dug in dry sand collapse. After laying up to 250 eggs, she returns to the sea. She will come ashore again in two to four years.

After about two months' incubation and some organized digging, the baby turtles emerge from their hole all together. All scurry toward the water in unison, making tasty targets for birds and other predators.

All species of turtles are considered in danger of extinction due to the hunting of adults and interference with the nesting process. While sharks are the turtle's greatest predator, humans are its deadliest enemy.

A baby Hawaiian Monk seal and a green sea turtle grab 40 winks together at Frigate Shoals, Hawaii.

It is illegal to take a sea turtle for any reason; it is a crime against our Earth to disturb or annoy a female in the nesting process. The latest data suggests that green turtles may take 40 or even 50 years to reach breeding age, a fact that makes survival impossible in the face of egg stealing and killing for profit.

Try to imagine navigating your way to the Cayman Islands in heavy fog by following the sounds of migrating turtle herds. It happened in the 16th century. If we take care of our turtle friends, it can happen again.

Susan Scott
Honolulu, Hawaii

Check These Expiration Dates

Sailors are reminded that visual distress signals obtained in 1981 or earlier have expired and must be replaced for this year's yachting season. The federal law that requires all pleasure boats 16 feet and longer that use coastal waters or the Great Lakes to carry approved pyrotechnic signals, also provides that those signals must be replaced 42 months from the date of manufacture.

Following are the types of signals approved for use by the U.S. Coast Guard:

DAY ONLY — Orange 50-second smoke signals (three required); 3-foot × 3-foot flag, specially marked.

DAY AND NIGHT — Red six-second meteor flare with 10,000 candlepower (three required); hand-held two-minute red flare with 500 candlepower (three required); red parachute flares (three required).

NIGHT ONLY — Automatic electric SOS light.

RNOC Celebrates Anniversary

The Royal Naval Officers Club (RNOC), a little-known organ-

ization mainly of retired officers of the Royal Navy who became expatriates after World War II and are now residents in the United States, recently celebrated the 35th anniversary of its founding in 1949 at the New York Yacht Club. Direct membership inquiries to David Pacy, President, RNOC, Ferranti Electric, 87 Modular Ave., Commack, NY 11725.

Gathering Of The Clan

Tartan Marine announces the second annual Gathering Of

1978

Tutu's Kitchen

Margaret Stone

Seaweed—a Food With Other Uses

Limu is a general Hawaiian name for all plants living under water, fresh or salt. The English word is seaweed, the Japanese word, *ogo*, and the Korean word, *miyuk*.

Before the kapu system was lifted in Hawaii in 1819, women were not allowed to eat certain foods, including pork, bananas, coconuts and many fish, so it was necessary and desirable to know where to find non-kapu foods such as invertebrates and algae. It has been estimated that about three ounces of a certain type, provides more than the necessary daily requirements of Vitamin A, riboflavin and Vitamin B12.

There were other uses for *limu* besides food in old Hawaii. When family dissensions arose a *Ho'oponopono* was traditionally held. This was a time when the family got together to "set things right." Wrongs and grievances were aired and discussed, forgiveness was asked and prayer was offered. Following this ceremony, family members ate a certain type of *limu* which had been cleaned and blanched. It was called *limu kala* which means to forgive.

Priests also employed *limu kala* in some of their rituals, one of which was to purify those who had watched over and mourned a dead relative. Iolani Luahine, the famous hula dancer, wore neck and head leis made from *limu kala* during one of her performances.

Medicinally, *limu* is used to heal coral cuts. After being chewed well, *limu* makes an excellent poultice.

A familiar sight 40 years ago, along the shores at low tide, from Waikiki to Kahala and around Hilo Bay, was women, wearing broad-brimmed hats with their dresses tucked up between their legs, picking *limu* and also *opihi* (shell fish). It is important to know what *limu* is edible and what is not, as some, such as *limu-make-o-Hana*, are poisonous.

Tales about *limu* also abound. One quaint story told about an old Hawaiian woman who was known for her

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good works. Her *aumakua* (family god) was the turtle. Very early one morning she went down to the seashore to pick *limu* for her friends and herself. She seated herself on what she thought was a large flat rock and began to search with her hands for the seaweed. To her dismay, she found very little. Suddenly she felt herself moving, and she realized she had been seated on the back of an enormous turtle who was slowly but carefully moving her across the water. He stopped by a part of the shore that was abundant with *limu-kohu*, the most delicious and sought after *limu*. After her basket was filled to the brim, the turtle slowly returned her to the shore. She later told everyone her *aumakua* had rewarded her this way so she was able to share with her friends.

One authority claims that at least 70 edible algae exist in the waters, but only 40 varieties are commonly used. In Hawaii, three popular ones follow:

Limu-kohu – soft, succulent and red. Best liked of all edible seaweed; sold in Honolulu markets in balls; quite expensive.

Limu-pae – called a landed seaweed. Term also applicable to a newcomer or, in a bad sense, a drifter, vagabond or outcast.

Limu-ka-kanaka – a slimy blue-green algae, bright green when fresh. Grown on the shores of Hanalei, Kauai, and famous in song. Called a man-striking moss because a person can slip and fall on it.

Most Hawaiians prefer to eat *limu* raw or lightly salted. A favorite Hawaiian method is simply to mix the cleaned *limu* with roasted, salted kukui nuts, chili peppers and seafood, such as opihi (shellfish).

Before *limu* can be prepared for consumption, it must be cleaned. Soaking the *limu* in water before cleaning helps to remove some of the debris, but bits of coral and sand must be picked out carefully by hand.

Most of the recipes below call for the crunchy red *limu* found in supermarkets. Other varieties, if available, can be substituted.

OGO TEMPURA (Fried seaweed)

1 lb. ogo
1 cup flour
½ tsp. sugar
½ tsp. salt
1 tsp. shoyu
1 egg
¼ cup milk
Ajinomoto

Wash ogo, pour hot water over it and drain after 5 minutes. Pour cold water over it and squeeze out all the water. Mix flour, sugar, salt, shoyu, egg, Ajinomoto and milk. Put ogo in, a little at a time and fry in deep fat. Drain and serve hot.

LIMU TSUKUDANI (Seasoned seaweed)

½ cup mirin (rice wine vinegar)
1½ cups shoyu
1¼ cups brown sugar
dash of Ajinomoto
1 colander of limu (drained)

Clean limu. Bring sugar, shoyu and mirin to a full boil and add limu. Stir occasionally to prevent burning. Reduce heat to low and cover and cook about 15 minutes or until soft. A heavy aluminum type pot is recommended to keep from scorching. Add the Ajinomoto during the last stages of cooking. Goma (sesame seeds) and chili pepper may be added according to taste.

TERIYAKI MEAT WITH NORI

1 lb. beef or chicken, sliced 2" by 1/5"
1 sheet nori (roasted black seaweed, found in Japanese stores)
Marinade:
½ cup shoyu
1 tsp. grated ginger
1 clove garlic, grated
1 T. sake (rice wine) or mirin
3 T. sugar

Mix all ingredients well. Slice meat thin and allow to stand at least three hours or overnight in marinade.

Cut across the width of the seaweed to make strips ½ inch in width. Taking four or five strips of meat in one hand, fasten seaweed around the center of the meat strips. Deep fry until cooked and drain on absorbent paper.

"Supernatural Hawaii Paperback"
Book that also contains turtle story

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ATOLL RESEARCH BULLETIN

No. 51

Observations on French Frigate Shoals, February 1956

by

Arthur Svihla.

Issued by

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September 15, 1957

Observations on French Frigate Shoals, February 1956

by

Arthur Svihla

A visit was made to French Frigate Shoals from February 11 to February 21, 1956, in order to study the life habits, distribution and abundance of the Hawaiian Seal (Monachus schauinslandi). Incidental to the primary purpose of the trip, observations and collections of other animals and plants were made.

I am indebted to the U. S. Coast Guard for transportation to French Frigate Shoals as well as for assistance and cooperation while there.

All collections were made on Tern Island due to inability to visit the other islands in this group. Specimens of plants and terrestrial arthropods which were collected have been deposited in the Bernice P. Bishop Museum, Honolulu, Hawaii.

Tern Island consists largely of the barren landing strip but there is a small area of approximately three acres in extent which still retains some of the original flora. This consists of various grasses (some of which are undoubtedly introduced), the beach morning-glory (Ipomoea pes-caprae) and Scaevola. Around the buildings of the Loran Station three coconut trees and several clumps of Casuarinas have been planted. The trunks of the three coconut trees are about one foot high and seem to be established. The Casuarinas, planted in front of the mess hall are about 15 feet high. They too appear to be growing well.

Under blocks of coral above the beach line as well as under discarded boards were found sow-bugs, crickets, cockroaches, earwigs and spiders. Since soil from Honolulu had been brought to Tern Island, these arthopods might have been introduced in this way. A few house flies were present in the buildings.

The only nesting bird on Tern Island was the Laysan Albatross. Each nest had a single chick about a month old. A few Black-footed Albatross were also present but were not nesting although they were going through the characteristic dancing antics. About 15 Turnstones frequented the vicinity of the mess hall where scraps were thrown to them. Only 1 Sanderling was seen. On several occasions Man-of-War birds were observed flying over the island. Six Fairy Terns flew over the island one day. The most numerous birds were the Sooty Terns which appeared every evening just before or after sunset over the shallow lagoon where they were apparently feeding. Their loud calls could be

heard as soon as they appeared and continued until they disappeared about 3:00 o'clock each morning. I have been informed by one of the men who was stationed there that later in the year these birds nest in enormous numbers on the island, hence the name Tern Island.

The mammals on the island consisted of a fluctuating population of Coast Guard personnel, two house cats (said to be of the same sex) which fed to a certain extent on the birds; two dogs, pets of the men, and the Hawaiian Seal. Four of these mammals were seen on Tern Island. On the return flight to Honolulu a count of seals was made. A total of 32 seals were seen on February 21, 1956, from the following islands of the group:

Shark (didn't fly over)		
Tern	0	(4 day before)
small island in front of Trig	4	
Trig	4	
Skate	10	2 turtles
Whale	7	1 turtle
Round	2	
Mullet	3	
East	1	
on reef in lagoon	1	
	32	

The plane did not fly over Gin, Little Gin or Disappearing Islands.

The previous count of Hawaiian Seals occurring on French Frigate Shoals was 16. This mammal is apparently on the increase here. On some of the islands the seals were seen in pairs, the males could be distinguished by their larger size, heavier forequarters and dark brown color from the smaller, more slender light brown color females. Pairing was apparently occurring here at this time of the year.

Several large sea turtles were also seen from the air.

Turtle Tidbits

by
Susan Scott

Photo by George Balazs

Fins & Feathers

Almost all of us who have spent some time on Hawaiian waters have at least once mistaken the greenish discs floating on the surface of the water for debris—that is until the "debris" lifts it's head, looks indignantly about and then disappears. These floating frisbees, the animals-in-a-box, are the sea turtles, one of the intact survivors of the Age of Reptiles, a period in the evolutionary history of the earth that occurred some 90 million years ago. Turtles are living fossils of that peiod, the only change being that they are now smaller. Their methods of living and reproducing have been quite successful even if sometimes viewed as a bit awkward by spying humans. Regardless of their evolutionary history or lack of grace, the sea turtles are unique and fascinating creatures.

Sea turtles, like whales and dolphins, breathe air with lungs similar to our own. However, unlike mammals, their reptilian heart is divided into only three chambers which creates a comparitively inefficient system of oxygenating blood. This characteristic is one which causes the "slow as a turtle" reputation although they can and do exibit bursts of speed when necessary. Since newly oxygenated blood is continually mixing with oxygen-depleted blood, the animal is unable to cope with extended aerobic workouts. Turtles can literally claim a "bad heart" as an excuse for being slow.

There are seven different species of sea turtles in the world, all are restricted to living in the tropics and subtropics due to their inability to regulate their own body temperature. Tropical seas provide a constant environment for the animals who then have no need to hibernate. To gain extra heat, turtles often float about on top of the water. It is during these baskings that they can be spotted—but not for long. These cautious, shy creatures will usually dive when frightened and can stay under water for extended periods of time. Don't wait for one to emerge—large turtles can stay down for over two hours on one breath of air.

Sea turtles differ from their terrestrial cousins, the tortoises, in characteristics that are distinctly adapted to the marine environment. The ocean going branch of the family has a streamlined shell for swimming. Broad flat flippers have replaced stubby, round legs in another adaptation. These paddles are efficient only in the water however. They are the cause of the clumsy, laborious lumbering about that these animals do when on land.

Given the sea turtles proficiency in the water, they spend little time ashore. However, the females are nature bound to go ashore for the purpose of nesting. During the breeding season, (summer) males and females migrate long distances to find appropriate nesting beaches. They mate in the water; the male uses a sort of hook on his front flipper to hang onto the shell of the female. The stories about amorous, lusty male turtles are true. They are often indiscrimi-

cont'd on pg. 20

MULTIHULL MADNESS OR THE GOOD, THE BAD, AND THE UGLY

The Good

They've done in again, those funny boats. The 300 mile transit tag race from Quebec to St. Malo, France is over. The winner, the 80 foot cat **Royale** in 8 days 19 hours at an average speed of 14.1 knots. Now, are you ready for this? The fastest day was 524 miles in a 24 hour period. Simply incredible. That days average was 21.8 knots. These are boats no longer. They are gran prix racing machines.

The Bad

In the same Race **Double Bullitt** was lost (the 67 foot cat that last year set a new Cal. to Hawaii record of 7 D 7 Hr) when it hit a log and was abandoned. No injuries. On a sadder local note, Dean and Wanda lost their 31 Brown, **Brightwing** on or about 30 Sept. off the Calif. coast (42 degrees N.) They had been laying a hull in 55K winds and 24 to 28 foot seas (varied by C.G.) when the tiller which had been tied off, broke. When they went forward to set the parachute sea anchor, they discovered major structual damage to one float connection. They set off the Epirb and prepared to abandon ship. Within 3 hours a plane dropped a raft and within 12 hours a ship picked them up. 48 hours later **Brightwing** was reported 140 miles south capsized with one float missing. The C.G. asked and received permission to blow up the boat. A sad end for a boat which had traveled many 10's of thousands of miles with us thru the South Pacific.

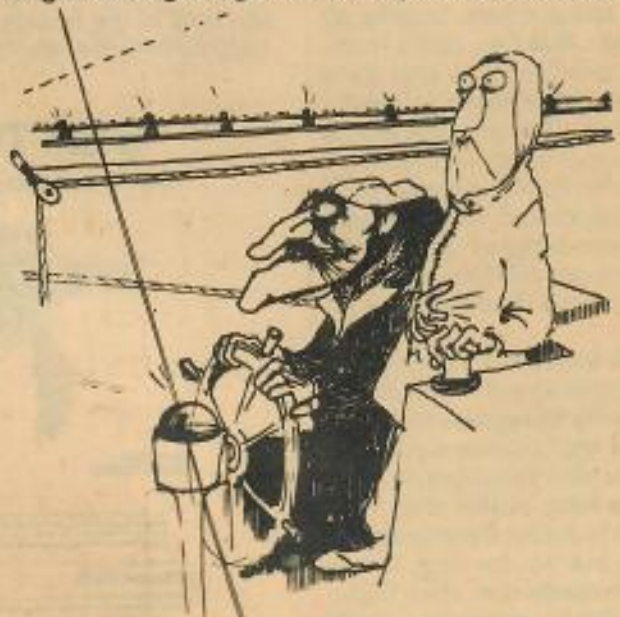
The Ugly

When the phone rang and Pete first invited me for the Seattle to Hono. crossing, I was thrilled. It was a chance to sail a State-Of-The Cruising-Art Multihull on an easy off the win passage. Endless surfing for 12 days, Li'Dat. A week of motoring and ghosting across a windless high ended hopes for a fast passage but it still gave me time to evaluate and compare **Tevake** to my antique.

Speed. The reason most people turn to Multihulls. At 8K **Antigone** is pushing water and transverse wave action is causing what leaners call hull speed. At 10K to 12K blocks and lines creak and groan and I simply wait to see what is next to get all Bus-Up. Nine knots on **Tevake** is effortless, even to weather. It does get a bit wet close reaching above 12K because of the open wing decks, however. In cruising, what really counts is days in passage. If you don't think so, just ask yourself, what is the first thing anyone asks you when you arrive? "How long did it take?" Well, How about Australia to the Solomans, 1200 MI/5 days or Japan to Hawaii, 5000 MI/32 days or Hawaii to Sidka, Alaska, 160 days. One speed racer, dis one.

Contemporary Multihulls speak for themselves. They no longer resemble Keehis 3 sotry Godzillas (gag me with a spoon, fer sure). Me? I've never had a particular affinity towards ocean bashing so as far as I'm concerned, less time out, more fun ashore. Our longest passage was 18 days, Galapagoes to the Marquesas, 3000 miles without a cold beer. Barbaric! I leave long passages to wetsnails with 3 bladed sea anchors and to those who profess that it matters not how long it takes "cus I'm in no hurry". Well, there's a bottle of cold hinano waiting for me in Papaete so leave your anchor light burning at night. When we go by we'll sing you a song. You may not know it but you'll never forget it.

Arnold Carruthers



cont'd from pg. 17

Female turtles of all species can store sperm—the eggs they lay could be fertile from a mating that took place years ago. A gravid female will await a nocturnal high tide to crawl ashore and dig a hole for her eggs. This is no easy task. She must often dig several nests as the walls of those dug in drying sand often collapse. After laying and burying up to 250 eggs, she returns to the sea to begin the ancient cycle over again. She will come ashore again in 2 to 4 years.

The baby turtles emerge from their hole all at once after about two months incubation time and some organized digging. All scurry in unison toward the water making a good target for predators. These little turtles are easy pickings and make good snacks for crabs, birds and other predators. The mortality rate for the hatchlings is often, unfortunately, quite high.

Three of the seven species of sea turtles can be found in Hawaii, the most common being the Pacific Green Sea Turtle or Honu. It was named not for it's shell color but rather for it's green color of fat once coveted for soup. It is a gentle, shy creature that can grow up to a whopping 800 pounds. Nesting is primarily done in the French Frigate Shoals, a National Wildlife Refuge, since most of our beaches suitable for nesting have been taken over by humans. The adult Honu only eats algae and marine vegetation.

The Pacific Hawksbill and Leatherback Sea Turtles can be seen in Hawaiian waters but are not as common as the Honu. The Hawksbill is relatively small (100 pounds) and was the source of tortoiseshell for jewelry. Leatherbacks are the largest of all the sea turtles weighing up to 1500 pounds. This species eats jellyfish almost exclusively.

nate—they will attempt to mate with crude decoys, other males, divers and even (if you can believe this) rowboats. Unreceptive females may bite pursuing males, leave the water or retreat to the "safe zone". The reserve is an area where females can go to escape aroused males. It is known how this territory is established among the turtle community, but females go there and males honor it.

All species of sea turtles are protected in Hawaiian waters because of their endangered status. While sharks are the turtles' greatest marine predator, humans are its deadliest enemy.

It is illegal to take any sea turtle in Hawaii for any reason. It is an inexcusable crime against Earth to take, annoy or disturb a nesting female or her eggs. No species of sea turtle is considered safe at this time. The Honu takes 15 years to reach sexual maturity—at four year breeding cycles, the mathematics of recovery are quite simple. It will be slow.

Try to imagine: navigating one's way to the Cayman Islands in the fog by following the noise of migrating turtle herds. It happened in the 16 century. If we pay attention to these magnificent ocean animals, we can have them back again.

ON THE HOOK

by Nanette

SUNDAY SAILING

Sunday is the universal day to go out on the water to play. We can always tell when it's Sunday. There's as many wakes going under our boats as there are air planes going over.

We enjoy sitting on deck with our morning cup of coffee. To just kick back and take a deep breath and snuggle in the beauty all around us, we're in Paradise!

We notice a little smog but we can still see the greens, reds and browns on the mountains. And we can still see the tall buildings downtown.

The trades are usually blowing just a little too much but then, if it stays like a lily pond all day, it's liable to rain. When the trades blow too strong, rowing home is a bitch, but it's easy to get to shore. Strong winds keep the mosquitos and flys away and tests our anchors.

The Sunday Sailors are fun to watch in mild breeze and full trades. As the wind fills their sails, the boats pick up speed and go gliding across the top fo the water, across our view, as if parading just for us.

Not all of them make it with full grace. Some Sunday Sailors forget the one-two-threes and our stage becomes a comedy. The hero or the heroine comes to the rescue and the boat sails on, taking their stories along.

Once in a while a Sunday Sailor gets tangled in our anchor lines and we become on-stage. Then it's always a comedy. But the scene never lasts long and soon we're back to watching the parade: Big boats, little boats, fast boats and slow boats. Motor boats, sail boats, row boats and barges. Tug boats, speed boats, yachts and dinghys. Scooners, ketches, yawls and sloops. Monohulls, catamarans, trimarans and flat bottoms. Steel, cement, fiberglass and wood. Cruisers, sailers, fishermen and skiers. We watch them all go by on Sunday in Paradise.

December 1984

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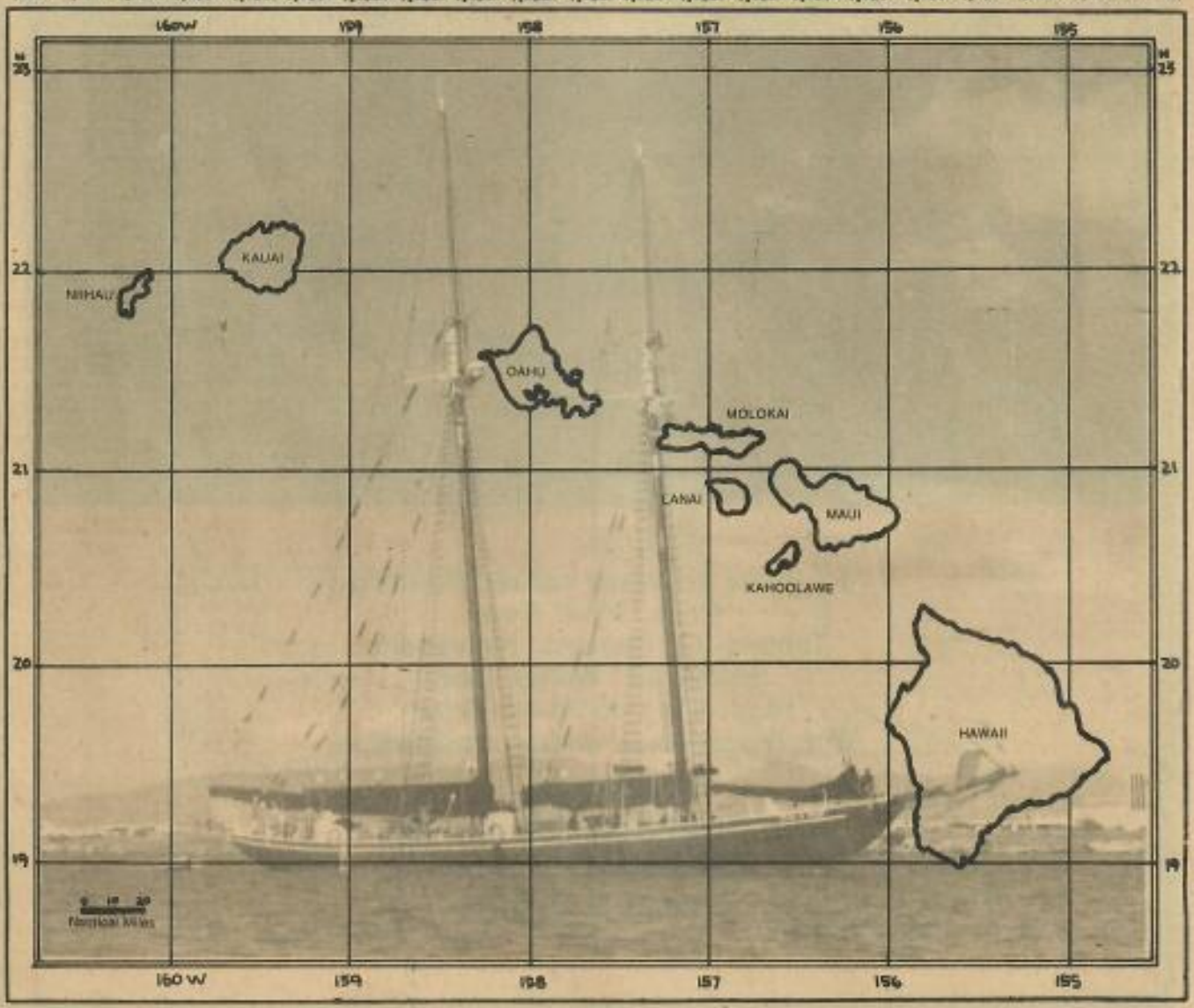

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THE EDITOR'S COLUMN

Aloha once again here we are in the final phase of 1984. It has been an exciting year with many changes, mostly good. I hope it has been a good year for all you guys too. I want to express my appreciation to the hospitality I received on the big Island recently. The island is every bit as beautiful as I have heard and so are the people. 21° North will be distributed there on a regular basis. The stories I heard about the fish being caught there are truly amazing. The Marlins are in the thousand pound range. It's really a fishermans paradise in those crystal blue waters. And for the sailing folks it's absolutely perfect conditions. I also would like to thank the people that gave me the support I needed to help me get this edition out. Have a safe holiday on the water no matter what your in and enjoy yourselves. Watch for those Kona storms.

MELE KALIKI MAKA
HOULI MAKHIKI HOU

HOW TO TELL A BUSINESSMAN FROM A BUSINESSWOMAN

An anonymous but acute and mischievous observer of the office scene compiled this telling commentary:

A businessman is agressive; a businesswoman is pushy.

He is careful about details; she's picky.

He loses his temper because he's so involved in his job; she's bitchy.

He's depressed (or hung over), so everyone tiptoes past his office; she's moody, so it must be her time of the month.

He follows through; she doesn't know when to quit.

He's firm; she's stubborn.

He makes wise judgements; she reveals her prejudices.

He is a man of the world; she's been around.

He isn't afraid to say what he thinks; she's opinionated.

He exercises authority; she's tyrannical.

He's discreet; she's secretive.

He's a stern taskmaster; she's difficult to work for.

The above was loosely adapted from "The Executive Woman," a newsletter for women in business.

turning turtle

Two years ago, North Shore local Pancho Sullivan ran over a Hawaiian Green Turtle while surfing Rocky Point and ripped the fins out of his surfboard. Damage to the turtle remains unknown. Early this season at Backdoor, Pancho had another run-in with *CHELONIA mydas*, but this shell-back was quicker and did what came naturally to avoid any damage to house or foam. Photo: Vince Cavataio.

[coming] next issue

on sale Jan.28

Longboarding today

Huge East Coast swell

Early-season Hawaii

& 1991: The year in review

WILLIAM FINNEGAN, 38
NEW YORK, NEW YORK

His natty dress, uptown office at *The New Yorker* and award-winning journalism may fool America's literati, and yield him still greater honors—a Pullitzer, perhaps? But none of those things fool those who know William Finnegan as "Billy Jr.," a surfer from the San Fernando Valley whose dad produced *Hawaii Five O.*

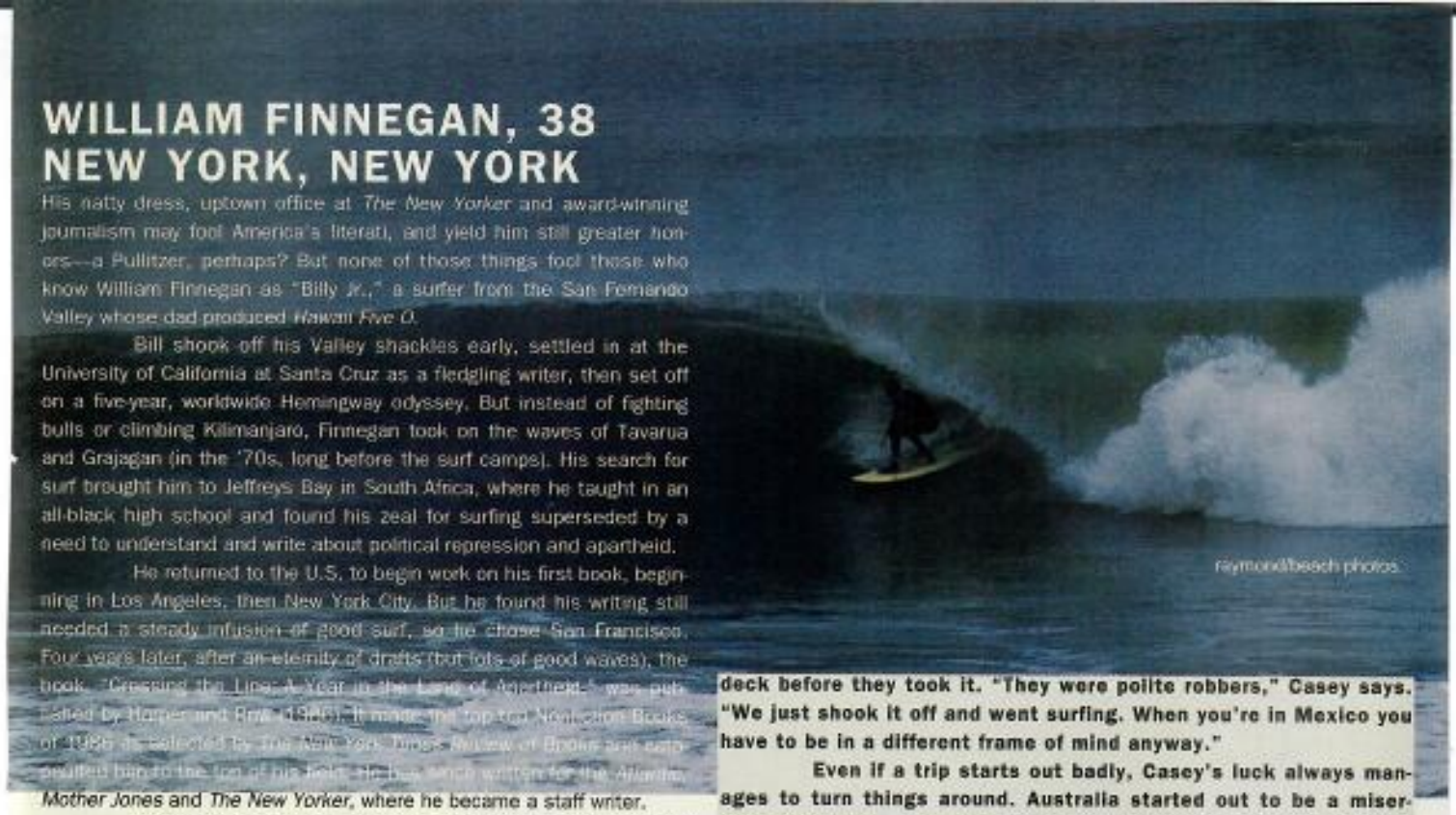
Bill shook off his Valley shackles early, settled in at the University of California at Santa Cruz as a fledgling writer, then set off on a five-year, worldwide Hemingway odyssey. But instead of fighting bulls or climbing Kilimanjaro, Finnegan took on the waves of Tavarua and Grajagan (in the '70s, long before the surf camps). His search for surf brought him to Jeffreys Bay in South Africa, where he taught in an all-black high school and found his zeal for surfing superseded by a need to understand and write about political repression and apartheid.

He returned to the U.S. to begin work on his first book, beginning in Los Angeles, then New York City. But he found his writing still needed a steady infusion of good surf, so he chose San Francisco. Four years later, after an eternity of drafts (but lots of good waves), the book, "Crossing the Line: A Year in the Land of Apartheid," was published by Harper and Row (1986). It made the "top ten" Notable Books of 1986 as selected by the *New York Times Review of Books* and established him as one of his field. He went on to write for the *Atlantic Monthly*, *Mother Jones* and *The New Yorker*, where he became a staff writer.

Ever the surfer, Finnegan managed to sell the editor of *The New Yorker* on the idea of writing about surfing in San Francisco. Bill has yet to finish that important task, having been side-tracked into writing essays and books on such mundane matters as Mozambique's revolution and America's drug problems.

Meanwhile, between lecturing stints at Yale and Harvard, Bill can be found in the shorebreak at Fire Island, Montauk Point or his secret spot on Block Island.

—Mark Renneker



raymond/beech photos

CASEY STAHR, 16
ST. AUGUSTINE, FL

Some guys get all the breaks. At 16, Casey Stahr has already been to California, the Dominican Republic, Costa Rica, Mexico, Australia, Tahiti, Indonesia, New Zealand and Bali. In addition to surfing the world's greatest waves, Stahr's consistent good luck has allowed him to hobnob with other famous surf travelers. In Indonesia, he spent a day surfing with Wendy Botha, Titus Kinimaka and Richard Cram. At Pasquales in Mexico, he surfed with his favorite pro, Brad Gerlach. In North Narrabeen, Australia, he spotted Tom Carroll and Damien Hardman, surfing at home.

Casey's luck has a lot to do with the people who brought him into the world. Dan and Kerri Stahr, who love to surf and bodyboard, are living proof that you don't need to own a Lear Jet to travel the world. Dan Stahr is a teacher, so every Easter, summer and Christmas vacation it's time to pack the cameras, tents and surfing equipment and head for the nearest airport.

"When we travel, we don't fully style out," Casey says. "As long as you're there, that's what matters."

He admits, however, that low-budget traveling sometimes has its disadvantages. While asleep in their tent at a secret spot in Southern Mexico, the Stahr's had all their cameras, electronics and money stolen from the family car. But the robbers left the traveler cheque receipts so they could get their money back, and they ejected the tape from the tape deck before they took it. "They were polite robbers," Casey says. "We just shook it off and went surfing. When you're in Mexico you have to be in a different frame of mind anyway."

Even if a trip starts out badly, Casey's luck always manages to turn things around. Australia started out to be a miserable adventure, with rain, 50-degree weather and a disgruntled father who had been talked into the expensive trip by his wife and son. "At first everywhere we went it was gigantic and closed out and cold, but when we got a little farther up the coast it was the best trip of our entire lives, so Dad owed us one." Of all the places he has visited, Stahr ended up liking Burleigh Head the most. "I like the speed. It's such a long wave. It's like a beach break, but it's a point, so you can get really long tubes."

Casey's travels have made him the focus of considerable envy. "Between his contest results, his Rusty and Oakley sponsorships and his traveling, Casey's the most hated kid at the shop," says sponsor Nancy Macri, co-owner of St. Augustine's Blue Sky Surf Shop, where Casey works. "But he's as low-key and quiet about these things as you can be." Casey does admit his traveling experiences and familiarity with bigger waves give him an advantage at local National Scholastic Surfing Association contests. He won the last two NSSA contests held in waves over 3 feet.

Like many hot grommets, Casey dreams of someday hooking up with the ASP Tour. "When I get out of high school, my Dad and I are going on a year-long, 'round-the-world trip. I want to follow the ASP and see how I do. They get better waves than any other tour."

What can the tour life offer Casey that he doesn't have, or hasn't done, already? "I haven't been to Europe, yet." he says.

Breaks your heart.

—Amy Vansant

david macri.

3/92 SURFER

WAIKIKI AQUARIUM

Kilo i'a*

a publication of the Friends of the Waikiki Aquarium

Turtle Ungirt

Chris Yamashita, Greg Enos, and Dave Clugston bid aloha to former tenant. (photo by George Balazs)

The scene on the beach in front of the Aquarium early one morning recently reminded one spectator of an old George Raft move: "You know, the one where he's wearing a new but ill-fitting suit and the prison warden gives him $20 and shakes his hand." To me, it was more reminescent of "Born Free" or at least "Lassie Come Home". The scene? The return of two green sea turtles from captivity back to their native ocean.

The onlooker's analogy about the old prison movie was far from correct although to some people the captivity of any wild animal is tantamount to imprisonment. Institutions that display living organisms have a serious and dual responsibility: the first obligation is to the animal, to assure that the environment, food, and behavioral setting are as suitable as possible. The second obligation is to the viewing public, to insure that the animals are displayed in a setting that encourages people to learn about the natural history of the animal as a unique species (and certainly not as a human caricature).

Really, in the final analysis, the only justification for placing animals in captivity is to assure the well-being of wild populations through increased human knowledge and understanding. Like it or not, we humans hold the survival of all life-forms in our collective grip. If we are ignorant or insensitive to our fellow species, we may inadvertently or impulsively commit irreparable damage. But with increased understanding through first-hand contact, we can guard against such damage. As an example, I think the widespread concern about the fate of the world's great whales has roots in the display of the smaller toothed whales in oceanariums.

Because our green sea turtles, hawksbills, and loggerheads had to share space with three large seals to the disadvantage of all the animals we felt that we were unable to meet the dual responsibility of exhibit standards and therefore had to consider several alternatives. One obvious solution was to improve the

* Kilo i'a means "watcher of sea life". For more information on Kilo i'a, see next page.

present facility and provide a new sea turtle pool with a nesting and basking beach. The 1976 State Legislature appropriated $100,000 for this purpose and Acting Governor Ariyoshi (then campaigning for Governor) participated in a ground breaking ceremony for the pool. Alas, the funds were never released and the pool is still a dream.

The remaining alternatives were simpler (and cheaper): find homes at other institutions, or, release the animals. For two species, release was ill-advised. The hawksbill is an endangered species and its unlikely we would be able to obtain specimens again; the Atlantic loggerheads could probably not survive in the strange waters of the Pacific. These animals are now on display as guests at our colleague-institution, Sea Life Park.

With the cooperation of Hawaii's distinguished turtle researcher George Balazs of the Hawaii Institute of Marine Biology, eight adult green sea turtles have been released to the wild. The animals have all been tagged and several have been observed more than six months later at areas far distant from release points. One adult female was seen by George Balazs one year and two months after release at East Island, French Frigate Shoals. This is the major nesting ground for Hawaiian green sea turtles. It is notable that the former female resident of the Waikiki Aquarium was observed to nest and produce live hatchlings.

So as we bid aloha to two more turtles recently we had confidence that (barring human interference) they have a good chance of resuming a natural life in their native ocean.

Leighton Taylor

Nautilus III

Micronesian Mariculture Center Director, Dr. William Hamner (far right) led a tour of the lab for Palau visitors including (l to r) Linda Taylor (WA), Ed Dols (NY Aquarium), Nixon Griffis, Carrie Denney (NYA), Maria & Rob Taylor (WA), Bill Flynn (NYA), and Mike deGruy, Bruce Carlson (WA).

From Jan 12 to February 8, Leighton Taylor, Mike deGruy, and Bruce Carlson participated in an expedition to the Palau Archipelago to collect live chambered Nautilus. The trip was sponsored by the New York Zoological Society with the support of Trustee Nixon Griffis, in order to obtain specimens for display at the New York Aquarium. Also participating in the collecting activities were Mr. William Flynn, Associate Director of the N. Y. Aquarium, and his assistant Mr. Ed Dols.

Seventy-four Nautilus were collected, including several rarely taken juveniles. Most of the adult Nautilus were tagged and released because facilities were not available for keeping so many animals. A special catch were three specimens that had been tagged and released in May and July, 1977. These were measured for growth changes and again released.

One Nautilus was also tagged with an ultrasonic transmitter provided by Dr. Don Nelson and James McKibben of California State University at Long Beach; its movements were monitored from the surface using a unidirectional hydrophone. During the early part of the evening the animal stayed at depths between 300' - 500', but near midnight it moved deeper (below 600') before the signal was finally lost.

Once again we had 100% survival on all Nautilus brought back to Hawaii. Four of these will remain with us (in addition to three animals remaining from last summer's trip to Palau); twelve more Nautilus are already on their way to the New York Aquarium. Other animals collected on this trip include colorful and bizarre fishes, corals, giant clams and other invertebrates.

A very special animal from Palau soon to be on display is a juvenile salt water crocodile obtained and donated by Mike deGruy. The baby croc is presently at the reptile house of the Honolulu Zoo and will join us soon.

Special thanks for the success of this trip are due to the Micronesian Mariculture Demonstration Center, Air Micronesia, and the University of Guam Marine Lab.

Bruce Carlson

About Kilo i'a

Issue Number 3	March 1978
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Kilo i'a is produced bimonthly by the Friends of the Waikiki Aquarium and is dedicated to increasing the community's knowledge of the Waikiki Aquarium and Hawaii's marine life.

Kilo i'a means "watcher of sea life", or "watcher for fish" and refers not only to the ancient Hawaiian fishing specialists who aided others in finding fish but, herein, to all who find sustenance and pleasure in merely "watching sea life".

The editors welcome your comments, suggestions, and contributions for future issues.

Aquarium Adventures in Learning

HAWAIIAN SEA BIRDS!

The Aquarium is offering a brand new, once-in-a-lifetime class in seabird ecology, biology and identification. Hawaii's internationally respected expert on Hawaiian birdlife, Dr. Andy Berger, professor of zoology at UH and author of Hawaiian Birdlife will be the instructor. The class will meet at the Aquarium for lectures on April 19 and 26 at 7:30 p.m., and will go on two Sat. field trips. The first, April 22, will visit the seabird colonies on Rabbit (Manana) Island offshore from Sea Life Park. The second field trip will be on April 29 to the Red Footed Booby breeding colony at Kaneohe Marine Base. This class is a must for naturalists, photographers and others who enjoy learning in the out-of-doors. The $20 fee helps support the Aquarium's education programs, and covers boat fees to Rabbit Island.

ADVANCED UNDERWATER PHOTOGRAPHY!

A class in Advanced Underwater Photography will be offered May 9-25, (Tues. & Thurs.), 7-9:00 p.m. The Instructor is photo-journalist Doug Wallin. Students need to provide their own equipment. Fee $35

MAINLAND ADVENTURE!

The Friends of the Waikiki Aquarium and the National Marine Education Association are sponsoring a special tour which will combine participation in the National Marine Education Conference and a special "behind the scenes" visit to marine education centers and aquariums on the West Coast.

Included in the trip will be guided tours of the Seattle, Vancouver and Scripps Aquariums, the Marine Science Center in Poulsbo, Wash., Pacific Science Center in Seattle, Sea World in San Diego, the Hubbs-Sea World Research Institute, and the Orange County Floating Lab and On-Shore Lab in Dana Point. As an added bonus the tour will also visit the King Tut exhibit in Seattle. Ann Fielding and Pat Raines will act as tour leaders on the two-week trip.
Dates: Aug. 8 - 22
Enrollment is limited to 30
Cost: $850.00 (includes all transportation, rooms, entrance fees, and selected meals and parties)
Deadline for payment: May 5
Hawaii residents have first priority until April 7, after that the tour will be opened to educators on the Mainland. (DOE B credit will be available for teachers.)
Detailed brochures available on request. Phone 923-4725.

Spring Specials

We would like to call your attention to the following special lectures to be held in the Aquarium foyer at 7:30 p.m. All Friends are invited.

Wednesday, March 29: Dr. Ed Shallenberger, Sea Life Park, will speak on "Hawaiian Cetaceans" and show the recently produced Nat'l. Geographic film on the Great Whales. (Co-sponsored by Sea Grant and the Hawaiian Academy of Science.

Saturday, April 1: Mr. Quentin Keynes (great grandson of Charles Darwin) will lecture and show a film about his famous ancestor and his voyage aboard the Beagle. (Co-sponsored by Hawaii Geographic Society.

Friday, April 7: Bruce Carlson, Aquarium staff member, will report on "Nautilus III," the recent collecting expedition to Micronesia sponsored by the New York Zoological Society.

Wednesday, April 12: Dr. Jan Newhouse, Dept. of General Science, UH, will lecture on his research involving "Man and the Atoll Ecosystem." (Co-sponsored with Sea Grant & HAS)

Wednesday, April 26: George Balazs, Hawaii Institute of Marine Biology, will lecture on "Wildlife and Geology of the Hawaiian Leeward Islands." (Co-sponsored with Sea Grant and HAS)

Wednesday, May 10: Dr. Robert Johannes, HIMB, will talk on his research in Palau and "Micronesian Marine Lore: A Scientific Bonanza." (Co-sponsored by Sea Grant & HAS)

Taylor "Goes Fishing" on Television

Bruce Carter and Leighton Taylor discuss two rare fishes, the bigscale pomfret and the razorback scabbardfish. (Stan Wright Photo)

Watching "Let's Go Fishing", the popular local television show hosted by Bruce Carter and Hari Kojima (pride of Tamashiro Market and a "Friend" of the Aquarium), is a Sunday afternoon tradition for most local sportsmen. Leighton Taylor, Director of the Waikiki Aquarium, has been a guest on several recent shows discussing some very notable catches by local fishing boats.

Recently, viewers had the opportunity to see a "Bigscale Pomfret" and a "Razorback Scabbardfish", two very rare fish in Hawaii. Each is known from only one other specimen, both in the fish collection of the Bishop Museum. The fish were caught by the modern Hawaiian fishing vessel Mokihana, on standard tuna longline gear. The scabbardfish is over 2-1/2 m long (7'5") but only about 13 cm (5") high. Both specimens will be curated by Dr. Taylor for deposit in the study collection of the Bishop Museum. He expressed his gratitude to Bruce Carter and local fishermen for bringing these rare specimens to public attention.

Meet the Staff: Greg Enos

Expediter. Resource person. Guide. Teacher. Counselor. At any one time Gregory K. Enos might be serving in several of these capacities while still performing his regular duties as Aquarist Foreman.

Greg is an eight year veteran of the Aquarium having joined the staff in March of 1970, and in the years that he's been employed he has taken on more tasks and responsibilities than would be expected of him normally, always maintaining an unruffled but quietly efficient mien.

Raised on Kauai, he graduated from Oahu's Kam School in 1965 and from the Church College of Hawaii four years later. He worked for Hawaiian Telephone Co. for a year before settling in at the Aquarium. The Enos Family - Greg, wife Sharon Ann, Gavin, age 9, and Gaylin, age 8 - are long-time residents of Kapahulu.

When he is not in green apron attending his tanks, Greg can be seen directing Explorer Scouts or Community Quest students as they perform various Aquarium jobs, or serving as their mentor when they learn about the ocean. Or he might be organizing a task force to pick up such varied items as food for the animals, chairs for evening lectures, tools, chemicals or office desks. He has lectured to various groups on aquarium keeping, counseled hobbyists in the care of their animals, served as Science Fair judge, hosted visiting school groups, scientists and aquarium people. He has served as fiscal officer, cashier, mechanic, custodian and SCUBA diver.

Greg is continuing his education at the University - working for his teaching certificate. He has been a serious stamp collector for many years. Greg is the co-captain of the Aquarium's off and on volleyball team, an avid rod and reel shore caster, and a faithful follower of Monday-night football.

He is also a person possessed of an unusually long middle name; the "K" stands for Kailipolohilani, and if anybody can catch him during an unbusy moment (he might explain what it means. (Greg's smiling face appears on the first page of this newsletter.)

Charles DeLuca

Bubbles from the Director's Snorkel

Good News! Long-time (and long-suffering) volunteer Pat Raines is now a paid staff member. As an employee of the University of Hawaii Foundation, she will handle all Friends business and continue to help in our education and docent programs. The position of Education Coordinator, formerly and ably filled by Sara Peck (who is presently freezing in Montana), is now the job of Mr. Les Matsuura. Welcome aboard, Les! We're glad you're in the same boat!

The Natural Selection Shop continues to be a success with visitors and staff alike. Please drop in and see the variety of items for sale, including autographed prints of Richard Ellis' humpback whales and original watercolors of Hawaiian fish by staff artist K. C. Miller. The shop will be open before and after the special spring evening lectures (listed elsewhere) and will feature price reductions for selected products for those nights only.

Thanks are due to the New York Zoological Society and Trustee Nixon Griffis for their sponsorship of the Aquarium's recent collecting and research trip to Micronesia. More Nautilus have joined our staff along with a perky little saltwater crocodile whose mother was probably 12 feet long! Bruce Carlson will report on the trip on April 7.

Recipients of the Friends' sponsored Employee-of-the-Month bonus selected by staff voting are: Oct. Ralph Alexander, Nov. Aileen Wun, Dec. Greg Enos, Jan. Harry Cordeiro and Feb. Paul Nakamura. Congratulations!

Be prepared for a special event in June to mark the first anniversary of the Friends of the Waikiki Aquarium.

Aloha from the Aquarium staff!
Leighton Taylor

WAIKIKI AQUARIUM
University of Hawaii
2777 Kalakaua Avenue
Honolulu, Hawaii 96815

September, 1981

Outrigger Neighbors

By Leighton Taylor

Outrigger Club beachgoers and terrace sitters are accustomed to seeing heads bob up among the waves between the beach and the windsock. Sometimes these heads have hair on them and are fitted with goggles; some are merely fitted with goggles; almost all of them belong to human beings. Occasionally, however, a head will pop up with no hair and no goggles and will then disappear for a long period of time, indicating that the owner of the head has considerable breath-holding ability. If you're sailing along very quietly in a Hobie Cat or paddling quietly in a canoe or maybe just swimming quietly, you may be lucky enough to sneak up on the headbobber, which is one of our shy but friendly neighbors. If you are so lucky, you will notice the large, rounded shell of the green sea turtle.

Fortunately, green sea turtles are becoming more abundant off the Club. These animals are a protected species. Heavy fishing and spearing over the past several decades have diminished their numbers to a dangerously low level. They are now protected by State and Federal law, and it is illegal to take these docile plant-eating creatures.

Green sea turtles are great long-distance swimmers and migrate throughout the Hawaiian chain. Like other turtle species, the green sea turtle female crawls ashore, digs a deep hole in the sand, deposits her eggs (about the size of ping-pong balls), covers up the hundred or so eggs with sand and crawls back into the sea.

There has been no evidence in recent years of green sea turtles nesting among the high islands. The major nesting area is French Frigate Shoals, about 600 miles northwest of Honolulu. George Balazs, a Hawaiian marine biologist and internationally known turtle researcher, has applied metal tags to green sea turtles at French Frigate Shoals and found that the turtles swim back to the main islands after nesting. He has also applied tags to turtles taken in waters from around Hawaii, Maui and Oahu (including some captive specimens from the Waikiki Aquarium, which were subsequently released), tagged them, and found them again at French Frigate Shoals, indicating that the individual turtles make the long round trip. When the green sea turtles are in the high island waters, they are mainly concerned with feeding on the lush limu growing around Hawaii's reefs, particularly in areas off the Club.

If you're lucky enough to sneak up on a *honu*, as the Hawaiians call the green sea turtle, and if its shell is larger than a garbage-can lid, look at its tail. If it's very long, exceeding the rear flippers in length, it's a male. If it has a short tail, it's probably a female.

Honu were important to ancient Hawaiians, who used the rich, tasty meat for food and used the shells to make jewelry and such tools as net spacers. Green sea turtles were often looked upon by some Hawaiian families as *'amakua*, or personal guardian gods. It is likely that Hawaiians harvested the turtle eggs.

Green sea turtles may not appear to be green, but are named instead for the greenish cast to the fat, which is visible only after they have been butchered, and, of course, it's not only unneighborly but also illegal to butcher our green sea turtle friends.

Although the Hawaiian specimens belong to the same species as those found in Mexico and the Caribbean Sea, they represent a different subspecies in population. Turtle biologists feel that the Hawaiian population is unique in demonstrating "basking" behavior. Green sea turtles in other parts of the world only crawl out of the water to nest. Hawaiian turtles, however, like their human neighbors at the Outrigger Club, apparently enjoy crawling out on the beach or reef tops to bask for long periods in the sun.

So, the next time *you* are basking for a long period in the sun at the Outrigger Club, keep an eye open for the little bobbing heads of our green sea turtle neighbors. While your fellow members are munching Health Spa salads on the terrace, turtles are munching their own limu salad just a few yards away.

GB –
I should have had
you review
this but I was
late! sorry.
Now tell me
how many
mistakes ☺
made

Aloha
Leighton

BALD JOKE

6

IN JOKE

Mr. Balazs

A LIST OF
THE AMPHIBIANS, REPTILES, AND MAMMALS
OF THE HAWAIIAN ISLANDS

(Exclusive of the Whales)

By
Spencer Wilkie Tinker

Honolulu, Hawaii
1980

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Notice to libraries: To increase the life of this pamphlet, it should be enclosed in a strong, protective cover.

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INTRODUCTION

This pamphlet is a checklist of the amphibians, reptiles, and mammals (exclusive of the whales) which occur as "wild animals" within the State of Hawaii. It includes many domesticated animals which were living in a wild state at some time in the past on one or more of the various islands and which no longer have wild populations.

The exact number of species of animals living wild in Hawaii is uncertain. In some cases, the exact number of species is uncertain because scholars do not agree on their identity. For example, some forms of marine turtles are regarded by some authorities as full species, while other scholars regard them as subspecies. In some cases, animals, including some frogs and toads, which were formerly known to be established in some areas, have become scarce and may have died out in the intervening period. Some groups are also difficult to identify and to inventory because of the uncontrolled commercial traffic in them, particularly through pet stores; this is especially true of the terrapins and tortoises.

The amphibians found in the Hawaiian Islands are few in number and were all introduced into Hawaii by man in recent times, probably in the years subsequent to about 1875. A few species in Hawaii were brought from both Asia and the Americas in about equal numbers, but none were brought from Europe, Asia Minor, or Africa. Only the tailless amphibians (*Anura*), the frogs and toads, occur in Hawaii today. The tailed amphibians (*Urodela*), which include the salamanders and related forms, were probably never introduced into Hawaii and, if they were, did not survive, for none occur there today. The legless amphibians (*Apoda*), a small group which includes the caecilians, likewise do not occur in Hawaii.

The reptiles include three well-known groups: the turtles, the lizards, and the snakes. In Hawaii, the turtles are represented by a few native marine species which are of wide distribution in tropical seas. In addition, a few introduced fresh water and terrestrial forms occur. Two groups of lizards, the geckos and the skinks, have been in Hawaii for many years and are believed to have been transported from the South Seas by the Hawaiian navigators in ancient times. Additional species of geckos, iguanids, and chamaeleonids have appeared in the years since about 1950. The snakes in Hawaii at present include but two species. One is a widely-distributed,

tropical, poisonous, marine snake and the other is a small, burrowing, land snake from tropical south-eastern Asia and its adjoining islands.

The mammals known from the various islands of the Hawaiian Chain are nearly all introduced species. Only two species are endemic and occupied these islands prior to the arrival of man. They are the native Hawaiian Bat and the native Hawaiian Monk Seal; both occur nowhere else on earth. The Polynesians doubtless brought three additional mammals with them in their canoes; they were the Polynesian Rat, the Domestic Dog, and the Domestic Pig; of these, the last two were food animals. The remaining mammals have all been introduced through commercial channels from various places during the period which followed the arrival of Captain James Cook, R.N., on his third and last voyage in 1778. At that time, Captain Cook landed a pair of European pigs and three goats (a buck and two does) upon the island of Niihau on February 1, 1778.

All of the mammals in this list have been liberated at some time and at some place in Hawaii and have there assumed a wild or feral status. Some of these wild populations have since died out, been exterminated, or were captured in their wild habitat and so no longer exist in Hawaii as "wild animals".

It is the pattern of this checklist to include a large and wide framework of animal classification, so that persons who use this list may know the names of the larger animal groups which are represented in Hawaii and, in addition, know the names of other closely related groups which do not occur in Hawaii. This will give the student a greater perspective of the animal kingdon and its divisions and will help the student to better understand the framework into which the Hawaiian species are placed.

Spencer W. Tinker
1121 Hunakai Street
Honolulu, Hawaii 96816
United States of America

A TABLE OF THE AMPHIBIANS, REPTILES, AND MAMMALS LIVING WILD IN HAWAII

(Exclusive of the Whales)

ANIMAL GROUP	ENDEMIC (Native to Hawaii Only)	INDIGENOUS (Native to Hawaii and Elsewhere)	EXOTIC or FOREIGN (Introduced and Established)		TOTAL SPECIES
			Introduced by early Hawaiians	Introduced by recent Commerce	
Amphibians					
True Frogs	0	0	0	4+	4+
Other Frogs	0	0	0	1	1
True Toads	0	0	0	3+	3+
Total Amphibians	0	0	0	8+	8+
Reptiles					
Turtles					
Marine	0	5	0	0	5
Fresh Water	0	0	0	1	1
Terrestrial	0	0	0	?	?
Lizards					
Geckos	0	0	4	1	5
Iguanids	0	0	0	2	2
Chamaeleonids	0	0	0	1	1
Skinks	0	0	4	0	4
Snakes					
Terrestrial	0	0	0	1	1
Marine	0	1	0	0	1
Total Reptiles	0	6	8	6	20
Mammals	2 (bat, seal)	0	3 (rat, dog, pig)	21	26

THE ANIMALS OF HAWAII

Including Only The Amphibians, Reptiles, And Mammals

(Exclusive of the Whales)

Kingdom Animalia — The Animal Kingdom

Phylum Chordata — The Chordates Or Vertebrate-like Animals And Related Groups

*Subphylum Acrania** — The Vertebrate-like Animals Without A Cranium

Class Tunicata (Urochordata) — The Tunicates, Ascidians, Salps, And Related Forms . . . . . Omitted

Class Cephalochordata — The Lancelets . . . . . Omitted

Subphylum Craniata — The Vertebrate Animals With A Cranium

Superclass Agnatha — Vertebrate Animals Without Jaws

Class Ostracodermi — Ancient, Extinct, Armored Fishes. . . . . Extinct

Class Cyclostomata — The Cyclostomes Including The Lampreys And The Hagfishes . . . . . .None in Hawaii

Superclass Gnathostomata — The Vertebrate Animals With Jaws

Class Placodermi — The Ancient, Extinct, Armored Fishes . . . . . Extinct

Class Chrondrichthyes (Selachii) — The Cartilaginous Fishes. . . . . Omitted

Class Ostichthys (Pisces) — The Bony Fishes. . . . . Omitted

Class Amphibia (Batrachia) — The Amphibians

Subclass Labyrinthodontia — The Ancient, Primitive, Extinct Amphibians. . . . . Extinct

Subclass Lepospondyli — The Ancient, Primitive, Amphibians With Spool-like Vertebrae. . . . . .None in Hawaii

Subclass Lissamphibia — The Smooth Amphibians

Order Urodela (Caudata) — The Tailed Amphibians Including The Salamanders, Newts, And Related Forms . . . . . .None in Hawaii

* The Hemichordata, including the tongue worms (Balanoglossus), the pterobranchs (Cephalodiscus), and related forms which are often included within this group, are here regarded as a separate phylum and placed below the Chordata.

Order Apoda (Gymnophiona) — The Legless, Tailed Amphibians Including The Caecilians And Related Forms . . . . . .None in Hawaii

Order Proanura — The Ancient, Extinct Frogs . . . . . .Extinct

Order Anura — The Tailless Amphibians Including The Frogs And Toads

Family Ranidae — The True Frog Family

→ *Rana catesbeiana* Shaw, 1802. — The American Bull-frog . . . . . [ ]

→ *Rana clamitans* Latreille, 1802. — The Green Frog . . . . . [ ]

→ *Rana nigromaculata nigromaculata* Hallowell, 1860. — The Japanese Black-spotted Frog . . . . . [ ]

→ *Rana rugosa* Schlegel, 1838. — The Japanese Wrinkled Frog. . . . . [ ]

Family Dendrobatidae — The Arrow-poison Frog Family

→ *Dendrobates auratus* (Girard), 1855. — The Gold And Black Poison Frog . . . . . [ ]

Family Bufonidae — The Toad Family

→ *Bufo boreas halophilus* Baird and Girard, 1853. — The California Toad . . . . . [ ]

→ *Bufo bufo gargarizans* Cantor, 1842. — The Asiatic Toad. . . . . [ ]

→ *Bufo marinus* Linnaeus, 1758. — The Giant Tropical American Toad . . . . . [ ]

Class Reptilia — The Reptiles Including The Turtles, Lizards, Snakes, And Ancient, Extinct Reptiles.

Subclass Anapsida — The Reptiles With A Solid Roof On The Skull And No Openings Behind The Eyes.

Order Cotylosauria — The Stem Reptiles Or Ancient, Extinct, Squat, Ancestral Reptiles Including The Pareiasaurs And Relatives . . . . . .Extinct

Order Testudinata (Chelonia) — The Turtles And Their Relatives

Suborder Amphichelydia — The Ancient, Extinct Turtles. .Extinct

Suborder Proganochelydia — The Ancient, Extinct Turtles. Extinct

Suborder Pleurodira — The Turtles With Side-folding Necks . . . . . .None in Hawaii

Suborder Cryptodira — The Turtles With Vertically-folding Necks

Family Testudinidae — The Pond And Land Turtle And Tortoise Family

Subfamily Emydinae — The Common Aquatic And Terrestrial Turtles And Terrapins ..... Omitted

Subfamily Testudinae — The True Land Tortoises .. Omitted

Family Cheloniidae — The Sea Turtle Family

Chelonia mydas agassizi Bocourt, 1868. — The Eastern Pacific Green Turtle ..... [ ]

Chelonia mydas japonica (Thunberg), 1787. — The Western Pacific Green Turtle ..... [ ]

Caretta species. — The Loggerhead Turtle ..... [ ]

Eretmochelys imbricata bissa (Ruppell), 1835. — The Pacific Hawksbill Or Tortoise-shell Turtle ..... [ ]

Family Dermochelyidae — The Leather-back Turtle Family

Dermochelys coriacea schlegelii (Garman), 1884. — The Pacific Leather-back Or Trunk Turtle ..... [ ]

Family Trionychidae — The Soft-shelled Turtle Family

Trionyx sinensis sinensis Wiegmann, 1834. — The Chinese Soft-shelled Turtle ..... [ ]

Subclass Synapsida — The Ancient, Extinct, Land Reptiles .... Extinct

Order Pelycosauria — The Ancient, Extinct, Primitive Pelycosaurs Including The Sail-fin Lizards ..... Extinct

Order Therapsida — The Ancient, Extinct, Mammal-like Reptiles ..... Extinct

Subclass Euryapsida — The Ancient, Extinct, Land And Marine Reptiles ..... Extinct

Order Araeoscelidia — The Small, Slender, Early, Ancient, Primitive, Extinct, Lizard-like Reptiles ..... Extinct

Order Sauropterygia — The Ancient, Extinct, Marine Plesiosaurs, Nothosaurs, And Related Reptiles .... Extinct

Order Placodontia — The Ancient, Extinct, Armored Placodonts And Related Reptiles ..... Extinct

Subclass Ichthyopterygia — The Ancient, Extinct, Aquatic Reptiles ..... Extinct

Order Ichthyosauria — The Ancient, Extinct Fish-lizards .... Extinct

Subclass Lepidosauria — The Scaled Reptiles

Order Eosuchia — The Ancient, Extinct, Small, Lizard-like Reptiles ..... Extinct

Order Rhynchocephalia — The New Zealand "Tuatara" And Ancient, Extinct Relatives ..... None in Hawaii

Order Squamata — The Lizards And Snakes

Suborder Lacertilia (Sauria) — The Lizards

Family Gekkonidae — The Gecko Lizard Family

Lepidodactylus lugubris (Dumeril and Bibron), 1836. — The Mourning Gecko ..... [ ]

Hemiphyllodactylus typus typus Bleeker, 1860. — The Tree Gecko ..... [ ]

Gehyra mutilata (Wiegmann), 1835. — The Stump-toed Gecko ..... [ ]

Hemidactylus garnoti Dumeril and Bibron, 1836. — The Indo-Pacific Or Fox Gecko ..... [ ]

Hemidactylus frenatus Schlegel in Dumeril and Bibron, 1836. — The House Gecko ..... [ ]

Family Iguanidae — The New World Or Iguanid Lizard Family

Anolis carolinensis porcatus Gray, 1840. — The Green Anole Lizard ..... [ ]

Iguana iguana Linnaeus, 1758. — The Green Iguana ..... [ ]

Family Chamaeleonidae — The Chamaeleon Lizard Family

Chamaeleo jacksoni Boulenger, 1896. — Jackson's Chamaeleon ..... [ ]

Family Scincidae — The Skink Lizard Family

Ablepharus boutoni poecilopleurus (Wiegmann), 1835. — The Snake-eyed Skink ..... [ ]

Emoia cyanura (Lesson), 1830. — The Azure-tailed Skink ..... [ ]

Leiolopisma metallicum (O'Shaughnessy), 1874. — The Metallic Skink ..... [ ]

Leiolopisma noctua noctua (Lesson), 1830. — The Moth Skink ..... [ ]

Suborder Amphisbaenia — The Ringed Lizards ... None in Hawaii

Suborder Serpentes (Ophidia) — The Snakes

Family Typhlopidae — The Blind, Burrowing Snake Family

→ *Typhlops braminus* (Daudin), 1803. — The Braminy Blind Snake. . . . . [ ]

*Family Hydrophiidae** — The Sea Snake Family

→ *Pelamis platurus* (Linnaeus), 1758. — The Yellow-bellied Sea Snake. . . . . [ ]

Subclass Archosauria — The Ruling Reptiles Including The Dinosaurs And Related Forms. . . . . Extinct

Order Thecodontia — The Ancient, Extinct, Primitive Ancestral Reptiles . . . . . Extinct

Order Crocodilia — The Crocodiles And Their Ancient, Extinct Relatives. . . . . None in Hawaii

Order Pterosauria — The Flying Reptiles And Related Forms . Extinct

Order Saurichia — The Dinosaurs With A Three-branched Pelvis ("lizard hips") . . . . . Extinct

Order Ornithischia — The Dinosaurs With A Four-branched Pelvis ("bird hips"). . . . . Extinct

Class Aves — The Birds . . . . . Omitted

*Class Mammalia*** — The Mammals

Subclass Prototheria — The Egg-laying Mammals . . . . . None in Hawaii

Order Monotremata — The Monotremes Or Egg-laying Mammals (The Platypus and Spiny Ant-eater). . . . . None in Hawaii

Subclass Theria — The Viviparous Mammals

Infraclass Metatheria — The Marsupial Or Pouched Mammals

Order Marsupalia — The Marsupial Or Pouched Mammals

Family Macropodidae — The Kangaroo And Wallaby Family

→ *Petrogale penicillata* (Griffith, Smith, and Pidgeon), 1827 — The Brush-tailed Rock Wallaby . . . . . [ ]

Infraclass Eutheria — The Viviparous Mammals With A Placenta

Order Insectivora — The Insect-eating Mammals (The Hedgehogs, Shrews, Moles, Etc.) . . . . . None in Hawaii

*Often placed as a subfamily within the *Family Elapidae*.

**The orders of extinct mammals are omitted. All orders of living mammals are listed.

Order Dermoptera — The Flying Or Gliding Lemurs . . . . . .None in Hawaii

Order Chiroptera — The Bats

Family Vespertilionidae — The Common Or Simple-nosed Bat Family

→ *Lasiurus cinereus semotus* (H. Allen), 1890 — The Native Hawaiian Bat . . . . . [ ]

Order Primates — The Primates (Monkeys, Apes, Man) . . . Omitted

Order Edentata — The Edentates (Sloths, Armadillos, Ant-eaters) . . . . . .None in Hawaii

Order Philodota — The Pangolins . . . . . .None in Hawaii

Order Tubulidentata — The Aardvark . . . . . .None in Hawaii

Order Lagomorpha — The Rabbits, Hares, And Pikas

Family Leporidae — The Rabbit And Hare Family

→ *Oryctolagus cuniculus cuniculus* (Linnaeus), 1758 — The European Rabbit . . . . . [ ]

Order Rodentia — The Rodents

Family Muricidae — The Rat And Mouse Family

→ *Rattus rattus rattus* (Linnaeus), 1758 — The Roof Rat, Black Rat, Or House Rat. . . . . [ ]

→ *Rattus rattus alexandrinus* (E. Geoffroy-Saint-Hilaire), 1803 — The Grey-bellied Rat Or Alexandrine Rat . . . . . [ ]

→ *Rattus norvegicus norvegicus* (Berkenhout), 1769 — The Norway Rat . . . . . [ ]

→ *Rattus exulans hawaiiensis* Stone, 1917 — The Polynesian Rat . . . . . [ ]

→ *Mus musculus domesticus* Rutty, 1772 — The House Mouse . . . . . [ ]

Family Caviidae — The Guinea Pig Family

→ *Cavia porcellus* (Linnaeus), 1758 — The Guinea Pig . . . . . [ ]

Order Carnivora — The Carnivores Or Flesh-eating Mammals

Family Canidae — The Wolf And Dog Family

→ *Canis familiaris familiaris* Linnaeus, 1758 — The Domestic Dog . . . . . [ ]

Family Viverridae — The Civet, Mongoose, And Genet Family

Herpestes auropunctatus auropunctatus (Hodgson), 1836 — The Small Indian Mongoose . . . . . [ ]

Family Felidae — The Cat Family

Felis catus Linnaeus, 1758 — The Domestic Or House Cat . . . . . [ ]

Order Pinnipedia — The Aquatic Carnivorous Mammals

Family Phocidae — The Hair Seal Family

Monachus schauinslandi Matschie, 1905 — The Hawaiian Monk Seal . . . . . [ ]

Order Odontoceti — The Toothed Whales . . . . . Omitted

Order Mysticeti — The Baleen Or Whale-bone Whales . . . . Omitted

Order Proboscidea — The Elephants . . . . . .None in Hawaii

Order Sirenia — The Manatees And The Dugong . . .None in Hawaii

Order Hyracoidea — The Hyraxes Or Hyracoids . . .None in Hawaii

Order Perissodactyla — The Odd-toed Ungulate Mammals

Family Equidae — The Horse Family

Equus caballus caballus Linnaeus, 1758 — The Domestic Horse . . . . . [ ]

Equus asinus asinus Linnaeus, 1758 — The Donkey . . . . . [ ]

Equus asinus ♂ *x Equus caballus* ♀ — The Mule . . . . . [ ]

Order Artiodactyla — The Even-toed Ungulate Mammals

Family Suidae — The Old World Swine Family

Sus scrofa scrofa Linnaeus, 1758 — The Domestic Pig . . . . [ ]

Family Cervidae — The Deer Or Antlered Ruminant Family

Axis axis (Erxleben), 1777 — The Axis Deer Or Spotted Deer . . . . . [ ]

Odocoileus hemionus columbianus (Richardson), 1829 — The Mule Deer Or Columbian Black-tailed Deer . . . . . [ ]

Family Antilocapridae — The American Pronghorn Family

Antilocapra americana americana (Ord), 1815 — The American Prong-horn . . . . . [ ]

Family Bovidae — The Cattle Or Hollow-horned Ruminants Family

Bubalus bubalis (Linnaeus), 1758 — The Water Buffalo . . . . . [ ]

Bos taurus Linnaeus, 1758 — The Domestic Cattle . . . . . [ ]

*Bison bison** (Linnaeus), 1758 — The North American Bison. . . . . [ ]

Capra hircus hircus Linnaeus, 1758 — The Domestic Goat . . . . . [ ]

Ovis aries Linnaeus, 1758 — The Domestic Sheep . . . . . [ ]

Ovis musimon (Pallas), 1811 — The Mouflon Sheep . . . . . [ ]

*Currently limited to ranch lands on the Island of Hawaii.

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Isolation and Characterization of Midway Virus: A New Tick-Borne Virus Related to Nyamanini

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Midway virus, a new tick-borne virus isolated from two species of Ornithodoros (Alectorobius) ticks of the capensis group (O capensis, O denmarki), is described from Midway, Kure, and Manana islands in the Central Pacific (Hawaiian Archipelago) and from norther Honshu (Japan). Midway virion is enveloped, unusually large, acid and temperature sensitive, and its type of nucleic acid is RNA. Complement-fixation (CF) tests show a close relation of Midway to Nyamanini virus, which has been isolated from ardeid birds and Argas ticks in Africa, the Indian subcontinent, and Southeastern Asia. However, cross-box tests (CF, mouse and tissue culture neutralization, immunofluorescence) show that these two viruses are quite distinct. Midway virus is lethal for newborn Swiss mice inoculated by intracerebral, but not intraperitoneal route. It fails to kill four-week-old mice by either route. Midway virus causes cytopathic effects in BHK-21 cells and titerable plaques in Vero cells. Antibodies to it were prevalent among nestlings of Larus crassirostris (Black-tailed Gull) on Aomatsushima I., but were scarce among those of Nycticorax nycticorax (Black-crowned Night Heron) of the same island.

Key words: tick-borne viruses, Midway virus, Nyamanini serogroup

INTRODUCTION

In 1966, a new tick-borne virus of the Nyamanini serogroup was isolated at the Rocky Mountain Laboratory (RML) from seabird parasites, Ornithodoros (Alectorobius) capensis Neumann, collected in Central Pacific Islands [Clifford et al, unpublished information; Yunker, 1970]. The new agent, called Midway virus, was originally isolated from ticks collected on Midway and Kure islands (Midway group, Hawaiian Archipelago) and later from a related species of tick on Manana I., off Oahu, Hawaii [Yunker, 1975; Clifford, 1979].

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In 1971 and 1972, isolations of a virus serologically related to Nyamanini were made at the National Institute of Health (NIH), Tokyo, from O. capensis ticks collected on Aomatsushima I., off northern Honshu (Iwate Prefecture), Japan [Takahashi et al, 1980]. Tentatively named Hirota virus, the agent was subsequently shown to be serologically indistinguishable from Midway virus.

Although Midway virus has been mentioned briefly in the literature [Yunker, 1970, 1975; Hoogstraal, 1973; Clifford, 1975, 1979] specific details of its discovery and characteristics are lacking. The purpose of this paper is to report details of isolation of Midway (=Hirota) virus and to provide combined results of our serological, biological, and physicochemical characterization of this virus. Results of an antibody survey among nestling birds on Aomatsushma I. are also included. The epidemiological significance of this new virus, which exists in the same marine-bird-tick biocoenose with 13 other arboviruses, including suspected human and avian pathogens, warrants investigation.

MATERIALS AND METHODS

Tick Collection and Processing

All ticks collected were members of a closely related species-group, the Ornithodoros (Alectorobius) capensis group (sensu lato) of Clifford et al [1980], whose members parasitize seabirds in the tropical and temperate latitudes of the world. Two species were involved, O. (A.) capensis [Neumann, 1901] on Midway, Kure, and Aomatsushima islands, and O. (A.) denmarki [Kohls et al, 1965] on Manana I.

Midway (Sand I.) (about 28° 13′N × 177° 23′W) and Kure (Ocean I.) (about 28° 25′N × 178° 25′W) are among the most westerly islands of the Leeward Chain of the Hawaiian Archipelago. Midway I. is approximately 2130 km WNW of Oahu, Hawaii; and Kure I. lies an additional 94 km in the same direction. Both are small, flat coral islands with sizeable populations of breeding and roosting resident and pelagic birds. On Midway I., the Sooty Tern, Sterna fuscata, is reported to be the most numerous species of the avifauna [Bailey, 1956]. Manana (Rabbit I.) (about 21° 20′N × 157° 39′W) is a small volcanic cone less than 2 km N of the easternmost point of Oahu I., Hawaii. It is a sanctuary for large populations of seabirds, of which Sooty and Noody Terns (Anous stolidus) are conspicuous elements, especially during the breeding season, inasmuch as Manana is one of the main nesting grounds for both species. Aomatsushima I. (38° 52′N × 141° 42′E) is located at the Pacitic coast of Iwate Prefecture, northern Honshu, Japan; it lies about 100 m off the tip of Cape Hirota. Larus crossirostris (Black-tailed Gull) and Nycticorax nycticorax (Black-crowned Night Heron) breed on the island each summer.

Ticks, collected from the nests of birds breeding on the islands, were pooled in lots of various sizes. Some pools contained both nymphs and adults of either sex, but others were segregated according to instar and sex. Pools were triturated in phosphate-buffered saline (PBS) containing the antibiotics penicillin G and streptomycin sulfate, and either 2% calf serum (at NIH) or 50% rabbit serum (at RML). Particulate matter was centrifuged from the triturates, and supernatants were inoculated intracerebrally (ic) in 0.02-ml amounts into two- to five-day-old suckling Swiss mice (sm). Mice were observed daily for signs of illness and for death.

Serological Studies

Complement-fixation (CF) tests were done with immune and hyperimmune sera generated in mice inoculated with sucrose-acetone antigens derived from virus-infected mouse brains [Thomas et al, 1960]. Identity of the various isolates from ticks was determined by CF screening tests in which immune serum from the Hirota strain of virus was tested against antigens prepared from 51 tick-borne (nonflavivirus) viruses, and immune serum from the Sand I. strain was tested against antigens of 40 arboviruses (including flaviviruses) and 11 other agents. Sand, Kure, or Manana island isolates were tested also against hyperimmune sera prepared from 44 arboviruses, mostly tick-borne, of various genera and serogroups. In all, the various isolates of Midway virus were compared with 79 different viruses of at least 27 known serogroups (Table II). Serological relationships between Midway and Nyamanini viruses were also explored by CF cross-box titrations in which hyperimmune sera and antigens prepared from two or more stains of each virus were used.

Cross neutralization (N) tests of Midway and Nyamanini viruses were done in mice by the serum dilution method. Serial two-fold dilutions of antisera, beginning at 1:800 in homologous and at 1:10 in heterologous systems, were mixed with equal volumes of about 100 sm ic LD_{50} of each virus, incubated overnight at 4°C, and inoculated ic into sm. Controls, in which each virus was mixed with an equal volume of virus diluent, also were inoculated into mice in dilutions of 1:10 and 1:100 to ensure virus infectivity. Plaque reduction N tests were performed in Vero cells according to the method of Earley et al [1967].

Microimmunofluorescence (MIF) tests were previously described [Yunker et al, 1979]. Briefly, antigens produced in Vero cells were identified by an indirect immunofluorescence technique, in which serially diluted, immune mouse sera were used.

Hemagglutination tests were performed with a microtiter-modification of the standard technique. Attempts were made to agglutinate goose erythrocytes with a sucrose-acetone extract of mouse brains infected with Hirota (Cap-15) strain of Midway virus. The antigen was prepared at the fourth mouse-passage level of the virus. Tests were performed at 37°C and over a pH range of 6.0–7.0.

Cell Culture

For observtion of CPE, an established line of baby hamster kidney cells (BHK-21) was used. About 6×10^5 cells were inoculated into test tubes and cultured at 37°C in Eagle's minimal essential medium supplemented with 2% calf serum. Each tube was then inoculated with 0.1 mL of virus serially diluted in cell culture medium. After virus was adsorbed at 37°C for one hour, each tube was given 0.9 mL of medium and incubated at 37°C. Five tubes were prepared for the inoculation of each dilution of virus. Infectivity was titrated as tissue culture dose 50% endpoints (TCD_{50}). In some experiments African green monkey kidney (Vero) cells were used to produce viral plaques according to the method of Cory et al [1974].

Physical and Chemical Characterization of Midway Virus

Size of the virion of the Hirota strain was roughly estimated by comparing virus titer of infected sm brain material that had been centrifuged at $1000 \times g$ for ten

minutes with that of the same material that had been centrifuged at 8000 × g for 20 minutes. The virion size of the Sand I. strain was estimated by passing lightly centrifuged, sonicated virus-infected material through a series of graded Millipore® filters and titrating virus infectivity of the filtrates [Casals, 1968].

Nucleic acid type was judged by comparing the infectivity of the virus with and without exposure to metabolic inhibitors actinomycin-D (ACT-D) or 5-bromodeoxyuridine (5-BUdR). At NIH, BHK-21 cells infected with ten-fold dilutions of the virus were cultured in medium containing 10 μg/mL 5-BUdR, whereas this substance was omitted from the medium in infected control cultures. At RML, Vero cells were used, and procedures followed those detailed earlier [Yunker et al, 1979].

Sensitivity of Midway virus to lipid solvents, sodium deoxycholate (DCA), and diethyl ether was evaluated. At NIH, the effect of exposure of virus to DCA (final concentration, 0.1%) at 23°C for one hour was tested by using BHK-21 cells as the assay system. At RML, sensitivity of the virus to ether was evaluated in Vero cells as previously described [Yunker et al, 1977].

Heat sensitivity was tested by exposure of paired virus samples in PBS containing 0.5% bovine phosphate albumin to temperatures of 41.5° or 56°C [Saikku and Brummer-Kovenkontio, 1973]. Samples were removed at intervals and stored frozen. Later they were thawed, pairs were pooled, and pools were titrated simultaneously in Vero cells.

Sensitivity to acid pH was determined by the method of Borden et al [1971], except that all samples were held at 27°C instead of 4°C for three hours before titration [Yunker et al, 1977].

Bird Plasmas

Heparinized blood samples were obtained from a wing or neck vein of nestling Larus crassirostris and Nycticorax nycticorax of Aomatsushima I. The samples were lightly centrifuged and plasmas were removed and frozen in dry ice. Isolation of virus from each undiluted plasma was attempted by ic inoculation of sm. Detection of Midway virus antibody in these plasmas was done as follows: Each heat-inactivated, undilute plasma was mixed with an equal volume of about 100 sm ic LD_{50} of virus (Hirota [Cap-15] strain), incubated overnight at 4°C, and inoculated ic into sm.

RESULTS

Virus Isolations

In 1966, two collections made by Keith Smart (K.S.) of O. (A.) capensis ticks—one from Midway I. (in a Sooty Tern colony) and the other from Kure I. (host not specified) of the Hawaiian Archipelago—yielded a virus unrelated to any under study at RML (Table 1). Two additional tick collections were made by K.S., one from a Noddy Tern taken on French Frigate Shoals, Hawaii, and another from a Sooty Tern on Howland I., Phoenix Is., also were tested, with negative results. Ticks were not segregated according to instar or sex, and pools contained both nymphs and adults of either sex. The virus isolates, called Midway (Sand I. [RML 47153] strain) and Kure (RML 47156), were obtained by ic inoculation of sm, which became ill nine days later.

In 1971, at NIH, a single isolate of a virus tentatively called Hirota (Cap-15 strain) was obtained in sm by ic inoculation of supernatant fluid obtained by high

TABLE I. Isolations of Midway Virus Form Ornithodorus (Alectorobius) Species, Parasites of Seabirds, on Islands of the Central Pacific and Japan

Tick species	Date collected	Locality	Virus isolations[a]		Strain designation
O. (A.) capensis	7/12/66	Midway (Sand) I., Hawaii, USA	1/2	(78)	Sand I. (RML 47153)
	8/6/66	Kure I., Hawaii, USA	1/1	(32)	Kure (RML 47156)
	10/31/66	French Frigate Shoals, Hawaii, USA	0/1	(70)	
	7/21/66	Howland I., Phoenix I.	0/1	(20)	
	6/22–23/71	Aomatsushima I., Honshu, Japan	1/22	(220)	Hirota (Cap-15)
	7/21–22/71		0/6	(300)	
	6/6/72		3/13	(65)	Hirota (Cap-39, -40, -41)
	6/20/72		2/16	(130)	Hirota (Cap-43, -44)
O. (A.) denmarki	11/10/73	Manana (Rabbit) I. Oahu, Hawaii, USA	2/17	(74)	Manana (RML 63668)

[a]No. pools positive/no. pools tested (no. ticks tested).

speed centrifugation (10,000 rpm/10 min) of a triturated pool of ten nymphal O. (A.) capensis collected on Aomatsushima I., Honshu, Japan in nests of Larus crassirostris. An additional 27 pools of ticks proved negative. However, in 1972, after the virion of the Cap-15 isolate was found to be unusually large, additional attempts were made to isolate virus from supernatant fluids obtained by low speed centrifugation (3,000 rpm/10 min) of tick triturates. This resulted in the isolation of five additional strains of Midway virus from 29 pools (Table I).

In 1973, a collection of O. (A.) denmarki was made from cracks and crevices of the top and outer crater rim of the volcanic cone of Manana I., Oahu, Hawaii, and sent to RML by the collector R.C.A. Rice. Viruses serologically indistinguishable from Midway (Sand I. [RML 47153] strain) were isolated from 2 of 17 pools of these ticks inoculated ic into sm (Table I). Pools that yielded virus were RML 63668-9 (of ten males) and RML 63668–13 (of ten females). Two pools of ten males each yielded other viruses: RML 63668–1 proved to contain Johnston Atoll virus [Clifford et al, 1968] and RML 63668–4 Soldado virus [Jonkers et al, 1973]. The former is an unclassified virus of the Quaranfil serogroup; the latter, a Nairovirus (Bunyaviridae) of the Hughes serogroup. Antigen prepared from one isolate of Midway virus (Manana [RML 63668-13] strain) also showed a low but significant degree of reactivity to Soldado virus, indicating that the latter was probably present in one or more of the ticks of that pool.

Serological Tests

In a screening CF test done at RML, 18 viral antigens were tested at a 1:2 dilution against a battery of 32 viral immune sera diluted 1:4. Antigen of the Sand I. (RML 47153) strain of Midway virus reacted only with its homologous immune serum and with Nyamanini (EgAr 1304) immune serum, while Nyamanini antigen reacted only with its homologous antiserum. Subsequently, antigen or antisera of various strains of Midway virus were tested against 53 arboviruses and 11 other pathogens (Table II). The only reactive systems, other than homologous, were

TABLE II. Arboviruses and Other Pathogens Represented in Complement-Fixation Tests of Midway Virus Strains*

Arboviruses	Nonarboviruses
Togaviridae	FA 660
Alphavirus (4) A	GD-VII
Flavivirus (16) B	Rickettsia spp. (9)
Bunyaviridae	
Bunyavirus (7) BUN, C, CAL	
Nairovirus (54) CON, DGK, DHO, HUG, KEM, LS, NSD, SAK	
Phlebovirus (1) SSF	
Uukvirus (5) UUK	
Other serogroups (10) BAK, BHA, KSO, THO	
Reoviridae	
Orbivirus (6) CTF	
Arenaviridae	
Arenavirus (1) TCR	
Rhabdoviridae	
Unclassified (3) HP, SAW	
Unclassified serogroups (19) NYM, QRF, QYB, UPO	
Miscellaneous arboviruses (11) Aride, Chobar Gorge, EgAr 1475, Jos, Keterah, Makindu, Matucare, RML 64423-8, Wanrowie	

*Numbers in parentheses indicate number of viruses or strains represented in tests. Capitalized abbreviations of serogroups follow Berge [1975].

TABLE III. Cross-box Complement-Fixation Relationship of Midway and Nyamanini Viruses*

	Immune serum	
Antigen	Midway (Sand I.) RML 47153	Nyamanini (EgAr 1304)
Midway (Sand I.) RML 47153	128/64	16/16
Nyamanini (EgAr 1304)	4/32	64/128

*Figures indicate reciprocal of serum titer/reciprocal of antigen titer.

Midway and Nyamanini. Cross-box CF tests (Table III) later confirmed the relationship of Midway and Nyamanini viruses, but heterologous titers were significantly lower than homologous ones. An additional CF titration failed to distinguish among isolates from three Hawaiian islands, Sand, Manana, and Kure. Anti-Midway (Sand I., RML 47153) serum having a homologous titer of 1:128 was reactive in its 1:96 dilution with undilute Manana (RML 63668–9) antigen and in its 1:192 dilution with Kure (RML 47156) antigen diluted 1:8. Anti-Kure serum having a homologous titer of 1:32 reacted in its 1:64 dilution with Midway antigen diluted 1:8 and in its 1:32 dilution with undilute Manana antigen.

Antiserum of the Hirota (Cap-44) isolate was tested against 51 tick-borne virus antigens (Table II). This serum reacted only with its own antigen (serum titer 1:128) and with that of Nyamanini (EgAr 1304) virus (serum titer 1:16). The Hirota isolate and two strains of Nyamanini virus were further studied by cross-box CF titrations, revealing a close relationship between the two viruses. However, serum titers of heterologous systems were three- to fourfold lower than those of homologous ones (eg, homologous serum/antigen titers [reciprocals]: Hirota, 128/128; Nyamanini 256/1024. Heterologous titers: Hirota/Nyamanini, 32/256; Nyamanini/Hirota, 64/128). After we learned that the Hirota isolate was related, but not identical, to Nyamanini virus, the former was compared with Midway virus in CF tests (Table IV). Both early immune serum and hyperimmune serum reacted strongly with antigens of either virus.

In an MIF test, antisera prepared against the Hirota (Cap-44) and Midway (Sand I.) isolates were titrated for reactivity with Nyamanini (EgAr 1304) virus (Table V). As with CF results, the relationship between the first two was much stronger than between either of them and Nyamanini virus.

Cross-box mouse N tests between Hirota (Cap-44) strain and Nyamanini (EgAr 1304 strain) also demonstrated that these two viruses are quite distinct. Reciprocals of homologous serum titers were 3200 (Hirota) and 6400 (Nyamanini), whereas those of heterologous titers were 10 (anti-Nyamanini/Hirota) and <10 (anti-Hirota/Nyamanini).

Cross-box plaque reduction N tests in Vero cell cultures showed a marked one-way relationship of the Sand I. and Kure strains of Midway virus with Nyamanini virus (Table VI). In these tests, the three Hawaiian strains—Sand I., Kure, and Manana—were indistinguishable.

TABLE IV. Cross-box Complement-Fixation Relationship of the Hirota Isolate and Midway Virus*

	Immune serum			
	Hirota (Cap-44)		Midway (Sand I.) RML 47153	
Antigen	30-d antiserum	Hyperimmune serum	30-d antiserum	Hyperimmune serum
Hirota (Cap-44)	128/128	2048/128	⩾256/256	1024/64
Midway (Sand I.)	⩾256/256	256/256	⩾256/⩾512	256/512

*Figures indicate reciprocal of serum titer/reciprocal of antigen titer.

TABLE V. Indirect Microimmunofluorescence Relationships Among the Hirota and Sand I. Strains of Midway Virus and Nyamanini Virus*

	Immune serum		
Antigen	Hirota (Cap-44)	Sand I. (RML 47153)	Nyamanini (EgAr 1304)
Midway (RML 47153)	512	⩾ 4096	64
Nyamanini (EgAr 1304)	64	128	256

*Figures indicate reciprocal of highest serum dilution giving a positive reaction with undiluted antigen.

TABLE VI. Serological Relationships of Hawaiian Strains of Midway Virus and Nyamanini Viruses, As Revealed by Plaque-Reduction Tests

	Immune sera			
Virus	Control[a] (Normal mouse serum)	NI[b] Nyamanini Ar 1304	NI Midway (Sand I) RML 47153	NI Midway (Kure) RML 47156
Nyamanini (EgAr 1304)	6.5	⩾4.6	3.5	3.9
Midway (Sand I.) RML 47153	4.6	1.1	⩾2.6	⩾2.6
Midway (Kure) RML 47156	5.5	1.2	⩾3.5	⩾3.5
Midway (Manana) RML 63668-9	4.0	nt[c]	⩾2.0	⩾2.0

[a]Virus titer in Vero cell plaque-forming units (PFU) mL after incubation with normal mouse serum.
[b]NI, Neutralization Index (Dex reduction of Vero cell plaque titer [PFU/mL] after incubation of virus/immune serum mixture).
[c]Not tested.

Antigens of the Hirota (Cap-15) strain of Midway virus did not agglutinate goose erythrocytes within the pH range 6.0–7.0.

Virulence for Mice

Midway virus (Hirota [Cap-15] strain) of the fourth mouse-brain passage killed sm when inoculated ic. Virus titer was 5.2 LD_{50}/0.02 mL, and deaths occurred between 6 and 15 days after inoculation. Intraperitoneal (ip) inoculation of the same material (0.05 mL) failed to kill sm. Neither ic (0.03 mL) nor ip (0.2 mL) inoculation of this material killed 4-week-old mice. The Sand I. strain of Midway virus (RML 47153, tenth sm passage) produced nearly identical results, except that scattered deaths were seen in sm inoculated ip with the highest concentration of virus. Nine-day-old hamsters, adult guinea pigs, and wet chicks all survived challenge with the Sand I. strain of Midway virus, regardless of route of inoculation.

Virion Size

The virion of the Hirota strain of Midway virus was judged to be unusually large when it was found that prolonged high-speed centrifugation significantly reduced its titer. About $10^{5.2}$ sm ic LD_{50} of virus were recovered after centrifuging a suspension at 1000 × g/10 min, whereas only $10^{1.4}$ sm ic LD_{50} could be recovered after centrifugation at 8000 × g/20min. Thus, over 98% of the infectious virus became sedimented at the higher speed. The large size of the Midway virion was also evident from results of filtration experiments. A 10^{-1} sm brain suspension of the Sand I. (RML 47153) strain of virus was sonicated, centrifuged at 1000 × g/20 min, and the supernatant fluid was sequentially passed through a series of Millipore® filters. Titers, in Vero cells (dex PFU/mL), of this material were 6.1 (unfiltered), and 5.8, 3.6, and ⩽ 0.7 after serial passage through filters of 450-, 220-, and 100-nm average pore diameter, respectively. Thus, the largest and most significant loss of infectivity, nearly 98%, occurred on passage through the 220-nm APD filter, and the average size of the Midway virion, like that of Nyamanini [Casals, 1968], is between 220- and 450-nm.

Nucleic Acid Determination

Both the Sand I. and Hirota strains of Midway virus, as well as Nyamanini (EgAr 1304) virus, were relatively stable in the presence of the DNA inhibitor BUdR (Table VII). Two strains of Japanese encephalitis (JE), an RNA virus, reacted similarly, whereas vaccinia, a DNA virus, was greatly inhibited. Similar results were seen when actinomycin-D was used as a DNA inhibitor. Titers of Midway (Sand I.), Nyamanini (EgAr 1304), and JE (Nakayama) were not significantly changed in the presence of this substance, whereas that of herpes simplex, a DNA virus, was greatly reduced.

Effects of Lipid Solvents

A marked loss of infectivity occurred when Midway virus (Sand I. and Hirota strains) was exposed to the lipid solvents diethyl ether and sodium deoxycholate (Table VIII).

TABLE VII. Effects of 5-Bromodeoxyuridine (BUdR) and Actinomycin-D on Infectivity of Midway and Other Viruses

	Virus titer					
	10 μg/mL BUdR[b]		3 μg/mL BUdR[c]		1 μg/mL ACT-D[c]	
Virus[a]	Control	Test	Control	Test	Control	Test
Midway (Sand I.) RML 47153	—	—	4.0	3.3	3.3	2.1
Midway (Hirota) Cap-44	3.6	3.5	—	—	—	—
Nyamanini (EgAr 1304)	—	—	5.9	5.7	4.8	3.8
JE (Nakayama)	—	—	10.5	10.3	5.4	5.5
JE (JaGAr #01)	9.8	10.5	—	—	—	—
Vaccinia (vaccine)	—	—	4.5	⩽ 0.9	—	—
Vaccinia (DIE-26)	8.5	3.5	—	—	—	—
Herpes simplex (I)	—	—	—	—	7.5	1.9

[a]JE = Japanese encephalitis virus.
[b]Dex TCD_{50}/mL in BHK-21 cells.
[c]Dex PFU/ml in Vero cells.

TABLE VIII. Effects of Lipid Solvents on Infectivity of Midway and Other Viruses

	Virus titer			
	Diethyl ether[a]		Sodium deoxycholate[b]	
Virus	Control	Experimental	Control	Experimental
Midway (Sand I.) RML 47153	4.6	⩽ 0.9	—	—
Midway (Hirota) CAP-44	—	—	6.8	⩽ 1.5
JE (Nakayama)	8.9	5.8	—	—
Chenuda (Ar 1152)	5.9	5.7	—	—

[a]Titers in dex PFU/mL (Vero cells).
[b]Titers in dex TCD_{50}/mL (BHK-21 cells).

Heat Lability

Midway virus (Sand I. [RML 47153] strain) was rapidly inactivated by heat. Thirty minutes after a virus suspension titering 3.4 dex PFU/mL was exposed to a temperature of 56°C no virus could be recovered in Vero cells. When exposed to a temperature of 41.5°C, the loss of infectivity was somewhat delayed. Here, a sample of the above suspension, which lost 1.7 dex/mL of titer in the first 30 minutes, was still infective after three hours; however, by six hours the virus had been completely inactivated.

Acid Sensitivity

The Sand I. strain of Midway virus, as well as Nyamanini, and two acid-sensitive control viruses (JE and Chenuda) were significantly affected by exposure to pH 3.0 (Table IX). Infectivity of a similarly treated, resistant control, reovirus-3, was undiminished.

Midway Virus and Antibody Among Birds of Aomatsushima Island

No virus was isolated from plasma of 112 Larus crassirostris or 60 Nycticorax nycticorax bled on the island during 1971 and 1972. However, N antibody was quite prevalent among nestlings of L crassirostris, especially in June, when ticks were most abundant in nests (Table X). Some nestling N nycticorax also were positive for Midway antibodies during the time of highest prevalence of antibody in L crassirostris.

TABLE IX. Acid Sensitivity of Midway and Other Viruses

Virus[a]	Infectivity (dex PFU/mL or sm ic LD_{50})[b]		
	pH 7.4	pH 3.0	Loss
Midway (Sand I.) RML 47153	4.9	$\leqslant$ 2.9	$\geqslant$ 2.0
Nyamanini (EgAr 1304)	5.2	$\leqslant$ 2.9	$\geqslant$ 2.3
JE (Nakayama)	9.8	3.0	6.8
Chenuda	8.0	$\leqslant$ 2.9	$\geqslant$ 5.0
Reovirus-3	2.5	2.8	(+ 0.3)

[a]Japanese encephalitis (JE).
[b]Reovirus-3 titrated in suckling mice; all others in Vero cells.

TABLE X. Prevalance of Neutralizing Antibody Against Hirota Virus Among Nestlings of Black-Tailed Gull (Larus crassirostris) and Black-crowned Night Heron (Nycticorax nycticorax) on Aomatsushima Island, Japan*

Bird species	1971		1972		Total
	June 22–23	July 20–21	June 6–8	June 20–21	
L crassirostris	26/34 (76.5)	7/27 (25.9)	11/24 (45.8)	4/27 (14.8)	48/112 (42.9)
N nycticorax	4/19 (21.1)	0/17 (0)	—	0/24 (0)	4/60 (6.7)

*Figures indicate no. positive/no. tested (percent positive).

DISCUSSION

Midway virus, described here, was first mentioned by Clifford et al, [1968] as [unidentified] isolates from seabird ticks of the genus Ornithodoros on islands of the Midway group, Hawaii. Later, the relation of these isolates to Nyamanini virus was noted [Clifford, see Yunker, 1970] and an additional viral focus on Manana I., Hawaii, was reported [Yunker, 1975]. Although Midway virus was shown to multiply well in tick-cell cultures [Bhat and Yunker, 1979], no further descriptive information concerning this virus has been published. When a virus isolated from Ornithodoros capensis ticks in northern Honshu, Japan [Takahashi et al, 1980] was found to be identical to Midway virus, a detailed description of this agent was deemed necessary.

Our tests show that Midway is an enveloped RNA virus of unusually large size and is sensitive to heat and acid pH. It is serologically unrelated to all other viruses tested except Nyamanini, an unclassified virus also of unusually large size. Nevertheless, Midway and Nyamanini viruses are readily distinguishable by serological tests and, in addition, differ biologically. The latter virus has been isolated from egrets and a heron, and their tick parasites (Argas spp.) in South Africa, Egypt, India, Nepal, Nigeria, Sri Lanka, and Thailand [Taylor et al, 1966; Hoogstraal, 1973; Theiler and Downs, 1973; Berge, 1975; Kemp et al, 1975]. Hence, it is associated primarily with freshwater wading birds of the family Ardeidae and ticks of the genus Argas. Midway virus exists in seabirds and in Ornithodoros ticks of the capensis group.

The Ornithodoros capensis group consists of seven seabird parasites and one additional species parasitizing pigeons, swifts, and swallows [Clifford et al, 1980]. The former ticks comprise a complex of morphologically similar species parasitizing nesting and roosting marine birds, principally gulls and terns (Laridae). Characteristically, members of this species-complex are found in equatorial and subequatorial climates, but they also may occur in higher temperate latitudes invaded by warmer oceanic currents. Man may be bitten by certain of these ticks, at times suffering severe reactions [Hoogstraal et al, 1976; Clifford et al, 1980]. Thirteen viruses of at least five serogroups are known from various members of the complex. Eight of these viruses—Midway (NYM serogroup), Johnston Atoll (QRF serogroup); Upolu (UPO serogroup); Huacho (KEM serogroup); and Soldado, Raza, Farallon, and Punta Salinas (HUG serogroup)—are known from islands of the Pacific Ocean. Some of these, or related viruses (Huacho, Soldado, Punta Salinas, Zirqa), have been associated circumstantially with human illnesses [Hoogstraal et al, 1970, 1976] or mass mortalities of seabirds [Converse et al, 1976]. Although Midway virus has not been implicated in either of these events, it exists in the same biocoenose as those that have. Thus, its potential for infection of man and animals deserves investigation.

Repeated isolations of Nyamanini and Midway viruses from ticks might indicate that tick-vectors represent the principal way these viruses are transmitted, although this had not been proven experimentally. Antibody to Nyamanini virus has been detected in man, goat, and donkey [Berge, 1975], as well as in dog, camel, and buffalo [Darwish et al, 1975], which may indicate alternate means of transmission of the virus. However, our serological data from Aomatsushima I. (Table X) show a prevalence of Midway antibody among nestling gulls, but not nestling herons in close proximity to them, except during the time when the infection rate in gulls was highest. Thus, infection of herons in June 1971 may be attributable to the use of an aberrant

host during the season of peak tick activity. Such a host-parasite association might also help to explain the transfer of virus between land- and seabirds, which could result in the ecological isolation and eventual emergence of serologically different viruses, such as Nyamanini and Midway.

ACKNOWLEDGMENTS

Gratitude is expressed to the following persons who facilitated our work in various ways: Dr. C.B. Philip, formerly of RML, arranged for the testing of ticks that yielded the first (1966) isolates of Midway virus. Likewise, the first isolation of the Hirota (Cap-15) strain is owed to Dr. S.P. Chunikhin, Institute of Poliomyelitis and Viral Encephalitides, Moscow. Dr. J. Casals, formerly of Yale Arbovirus Research Unit, New Haven, kindly performed screening CF tests of the Hirota strain; and Dr. S. Kitaoka, National Institutes of Animal Health, Japan, identified the ticks from Aomatsushima Island. Drs. Keith Smart and R.C.A. Rice collected the Hawaiian ticks. Technical support was provided by Dr. T. Yanagihara, Dr. S. Ishimoda, Mr. F. Yazawa, Mr. S. Yabe, Mr. M.D. Corwin, and Mr. J. Cory. Dr. L. Goff, Bishop Museum, Honolulu, kindly provided certain literature dealing with Midway and Manana islands.

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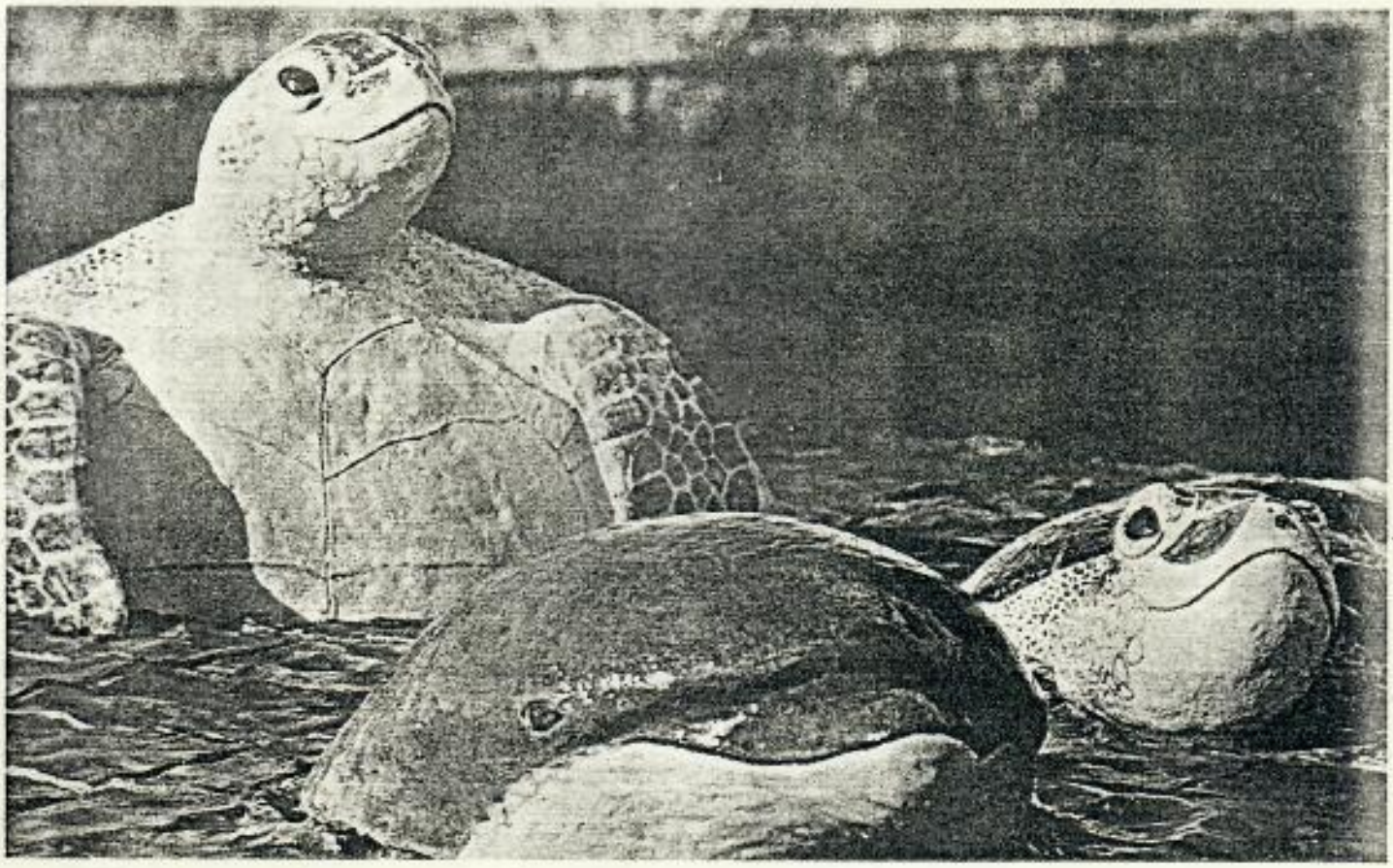
Ceramics in Hawaii by Shige Yamada

Pool Committee, ceramic sculpture, two feet by nine feet by eleven feet, by Kay Mura Davidson, 1977, located at the Lanai Gymnatorium, Lanai. Photo: Robin Kaye.



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Man-made Objects on the Surface of the Central North Pacific Ocean

IN August 1972, on the Scripps Institution of Oceanography's expedition C'BOG I in the Central North Pacific, there was a rare combination of clear warm weather and calm seas which tempted the scientific personnel to spend their leisure time on the bow of the ship. From this vantage point it was obvious that the sea surface is littered with a startling array of man-made objects, even 600 miles from the nearest major civilization (Hawaii) and outside the major shipping lanes.

A junk log was established and maintained (not continuously) for four days, during which time the ship travelled from 34° 29′ N, 145° 36′ W to 35° 00′ N, 155° 00′ W, and then south to 31° 00′ N, 155° 00′ W. Record was kept of the duration of watch, ship's speed and viewing conditions, and an effort was made to categorize each object, even though exact identification was often uncertain.

The results of this log are presented in Table 1. During 8.2 viewing hours during which time the ship travelled 156 km, and in approximately 12.5 km², a total of 53 man-made objects was recorded. Twelve of these were glass fishing floats, approximately 5 to 14 inches in diameter, which may claim some historic or aesthetic place on the sea surface. The remaining 41 objects were encountered with an average frequency of one every 12 minutes. At least two-thirds of these were plastic.

Succumbing to the temptation to extrapolate from our sample of six plastic bottles, we have calculated an average concentration of 0.5 bottle km^{-2} (95% confidence interval, assuming a Poisson distribution: 0.2–1.0 bottle km^{-2}) and a total of 35.4 million plastic bottles (14.2×10^6–70.8×10^6) currently adrift in the North Pacific Ocean (as well as 5.9 million red rubber sandals). A more conservative estimate may be derived from the observed ratio of plastic bottles to fishing floats, of which there are an estimated ten million afloat in the Pacific Ocean[3]. Our ratio predicts five million plastic bottles.

Table 1 Tentative Identification of Man-made Objects adrift in the Central North Pacific Ocean

Plastic		Glass		Miscellaneous	
Bottles	6	Fishing floats	12	Rope	1
Fragments	22	Bottles	4	Old balloon	1
Total	28	Total	16	Finished wood	1
				Shoebrush	1
				Rubber sandal (red)	1
				Paper items	3
				Coffee can	1
				Total	9

On two of the plastic bottles, algal growth was evident. A third was covered with gooseneck barnacles. Floating plastic, like a glass fishing float, provides a long-lived substrate for transport of sessile animal species as well as algal and bacterial growth; whether the increased availability of such "micro-arks" might alter distributional patterns or attract local concentrations of associated pelagic organisms is an open question.

In the growing concern over global pollution, the accumulation of plastic products has received little attention. Widespread concentrations of plastic pellets have been reported in the Sargasso Sea[2]. Although plastic objects may directly injure wildlife[3], the inert nature of plastic means that it is unlikely to enter the food chain and threaten human welfare. As a pollutant, its effect is chiefly aesthetic, which is difficult to evaluate and easy to ignore. We find it alarming that "disposable" items now litter even the most remote surfaces of the oceans.

The production of plastics has evolved rapidly during the past twenty years—annual production of plastic bottles now exceeds 1×10^9. The development of degradable plastics may bring some relief[4], but unless we find adequate means of disposing of our plastic products soon, we can anticipate that the "Wynkin, Blynkin and Nod" of our children will set sail into a plastic sea, accompanied by all the "no-deposit—no-return" products of our technology.

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Received October 16, 1972.

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Induced Nucleophilic Substitution in Benzo[a]pyrene

Cavalieri and Calvin have proposed[1,2] that the carcinogenic action of benzo[a]pyrene (BaP) may arise from aryl hydroxylase induced binding to nucleophilic cellular components. Their theory proposes that attack by electrophilic oxygen, produced in the hydroxylase system, occurs at the 6 position of the hydrocarbon to give a carbonium ion, localized primarily at the 1 and 3 positions, which can undergo attack with nucleophilic cellular components. Alternatively, initial attack could occur at 1 or 3, followed by nucleophilic reaction at 6.

Some evidence for the theory has been obtained by using iodonium ion as a model for the hydroxylase system. Benzo[a]pyrene and iodine dipyridine nitrate react to give either the 6-iodo or 6-pyridinium derivative or a mixture depending upon reaction conditions. Effects of solvent, concentrations and ratios of reactants were investigated and are summarized in Table 1. Equimolar quantities of the reagents react within 10 min in chloroform to give 6-iodo-benzo[a]pyrene in nearly quantitative yield. All other reactions listed required up to 24 h to reach completion. Formation of the pyridinium derivative requires a 2 : 1 molar ratio of iodonium reagent to BaP.

Table 1 Effect of Reaction Variables on Product Formation

Concentration of BaP	Molar ratios py/BaP *	(py-I-py)†/BaP	Solvent	Yield, % I-BaP	Yield, % py-BaP
		1	$CHCl_3$	99	Trace
		1	MeOH	95	
		1	DMF	95	
			Pyridine	No reaction	
1 mg ml.$^{-1}$	32	2	1% py/$CHCl_3$	50†	50†
0.5 mg ml.$^{-1}$	64	2	1% py/$CHCl_3$		95
5 mg ml.$^{-1}$	30	2	5% py/$CHCl_3$		95
5 mg ml.$^{-1}$	30	1	5% py/$CHCl_3$		50
1 mg ml.$^{-1}$		2	CH_3CN		10

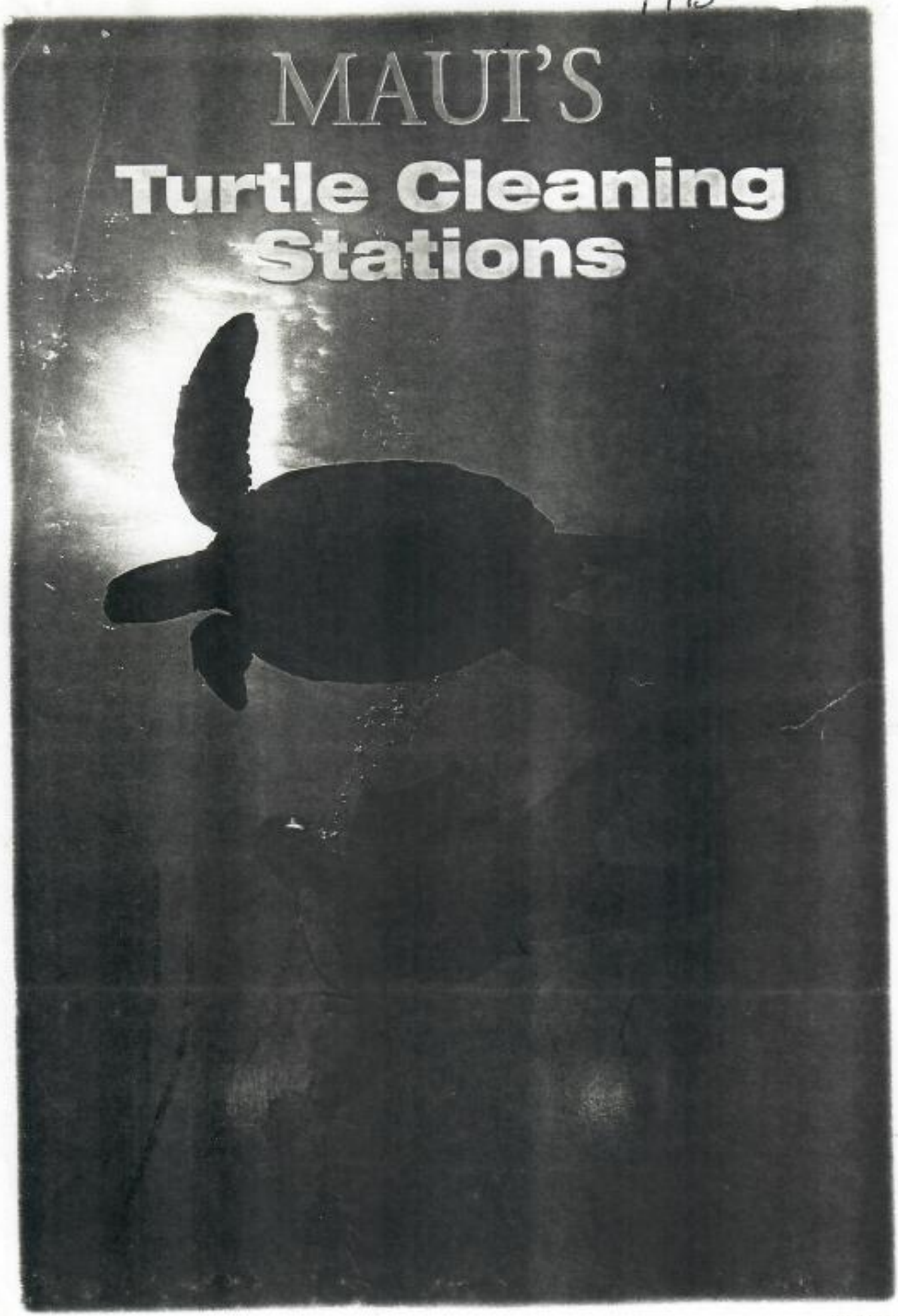
* Added pyridine.
† Approximate yields.

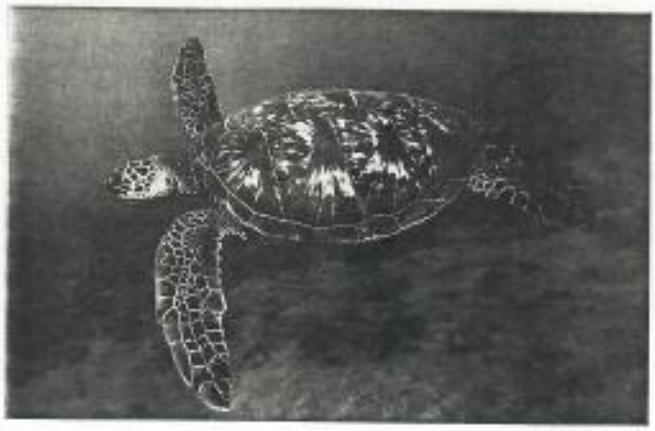
The formation of the 6-pyridinium derivative may be interpreted as arising *via* the proposed ionic mechanism with initial electrophilic attack occurring at position 1 or 3 rather than at position 6 as occurs in the formation of 6-iodobenzo[a]pyrene. The position of attack might change for steric reasons because different reagents could be involved as indicated by the following equilibria:

$$(\text{py-I-py})^+ \rightleftharpoons (\text{py-I})^+ + \text{py} \rightleftharpoons \text{I}^+ + 2\ \text{py}$$

1995

MAUI'S Turtle Cleaning Stations

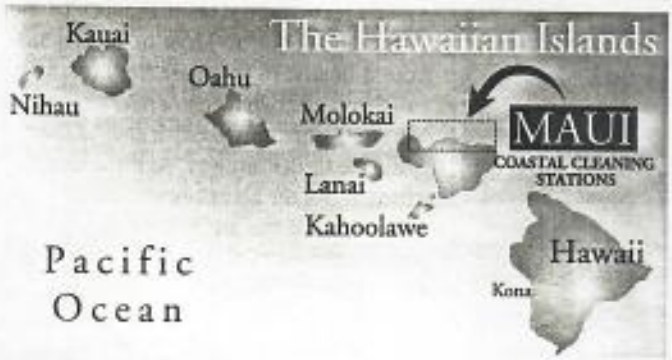




WHAT EVERY DIVER SHOULD KNOW

FEW ANIMALS ARE AS FASCINATING as the green sea turtles. In the clear blue waters off Maui, they congregate in small communities on the shallow reefs that surround the island. It is almost impossible to do a dive and not attract the attention of an engaging turtle. Often, divers will see many on a single dive. Their antics are entertaining and they often approach divers to exchange curious glances. Why do they remain in specific locations for long periods of time? Why are certain dive sites known as turtle dives? How can divers observe turtle behavior and not interfere with it? Having a knowledge of basic turtle biology can help to answer these questions!

Because turtles must keep their shells free of algae that would slow them down, cleaning stations are often the focal point of each turtle community. After discovering a reef that provides adequate food and shelter, one of the first things turtles do is set up a cleaning station. This usually involves finding a conspicuous coral head. Living amongst the antler-like branches are damselfish, angelfish, and other algae eaters. Taking turns, often sharing, and at times crowding about, the turtles present themselves to the fish for a picking over. As they hover patiently over corals or sit on the bottom,



the hungry fish eagerly perform the task. Turtle shells are sensitive and they can feel the slightest touch.

When turtles are encountered hanging out on or near large coral heads, this is an indication that cleaning is about to take place. Smart divers wait patiently to watch this ancient ritual. The animals will come and go calmly if undisturbed. The best way to watch them is to stay low and go slow. Divers should not do anything to change a turtle's behavior. Turtles allow the experience to continue only if they do not feel threatened.

Carefully gliding up to the cleaning station, the turtles surprise divers with their graceful movements. Though they often sit directly on the fragile corals, they rarely damage them. In an amazing adaptation to conserve energy when inactive, turtles slow their heart rates and reduce the blood flow to their muscle tissues. Gathering minute amounts of oxygen though highly vascularized nasal passages, they can extend their bottom time by resting in this non-pulsed mode. Even-

OPPOSITE PAGE: **Diver and turtle hover in the sun rays, just under the surface.** TOP PHOTO: **Illuminating this turtle with a strobe shows off its beautiful shell.** ABOVE TWO PHOTOS: **Turtles being cleaned at one of the most popular cleaning station for turtles in Maui.**

TEXT & PHOTOGRAPHY BY CORY WILLIAMS

tually, they must surface for air, as an oxygen debt is built up in their tissues. Because breathing the water has a chilling effect on their bodies, they will float on the surface and bask in the sun after an extended dive. If undisturbed, they may remain motionless for over an hour.

When numerous turtles wish to share these stations, it can lead to confusion. Sometimes two or more will sit on one coral head simultaneously. If there is no room on top, they may lie on the bottom near the main area. Unfortunately, when they do this they often intrude into the habitat of their friends, the damselfish. Damselfish cultivate small farms of algae; some are for food, and others are beds for their eggs. The furious little damsels will attack anything that gets near their habitats. They care little if the offender is a two hundred-pound diver or a four hundred-pound turtle. The damsel has a tiny little mouth, but strikes with the intesity of a jackhammer, the message is clear: don't mess with me! Not able to ignore the aggressive damsel, the beleaguered turtle has few options and will usually reposition himself until the attack stops. If there is no room near the stations, some turtles will wait parked on the bottom; other times they may circle impatiently. Older and larger turtles usually get the prime spots, and they need them because they have a greater accumulation of algae on their shells.

As is the case with many species, scientists wonder which came first, the turtle cleaning or the cleaning station? On many reefs there is an abundance of food and shelter but no large or conspicuous coral heads. In this case the turtles find shelter under overhangs or near large rocks. In these situations, the fish always seem to find the turtles anyway. At these locations there is not the abundance of damsels that one finds at the antler corals, and often other species of fish are observed doing the cleaning. With less fish to do the job, fewer turtles will inhabit these stations. Almost any time a turtle lights on the bottom, cleaning will commence shortly thereafter, and this could then be called cleaning behavior. The term cleaning station implies that there is more going on than random cleaning behavior. There appears to be a social hierarchy amongst the turtle communities and the cleaning station is like their town hall. There is no doubt that specific cleaning stations do exist; whether or not the turtles consciously set them up is not known.

When not basking in the sun, hiding from danger, or being cleaned, turtles feed on the thick carpet of algae that blankets the rocky shoreline. Holding on with their sharp beaks, they use the motion of the waves to help them tear off pieces of dense growth. In the afternoon, when trade winds are up and creating some surface chop,

turtles can be observed feeding actively close to shore.

At many dive sites, turtles are at ease with divers, and it is at these places where turtle watching is best. Maui's west and south coasts provide many excellent turtle dives. Dive sites like Honolua Bay, Honokaoo beach park (near the Hyatt Regency), and Olowalu are the best sites on the west side near Lahaina. On the south coast near Kihei, try diving at **Wailea Point, Five Graves,** or **Pu'u O'lai** (also called Red Hill). These places are famous for turtle cleaning station behavior. However, almost any coral reef or rocky shoreline will have a resident turtle population to enjoy. The turtles do move locations from time to time, so check with local charter operators and dive shops for more specific information about which dive spots are currently most active.

The United States government has laws in place designed to protect turtles from harm. They are an endangered species, and it is illegal to touch or harass them. These lovable creatures, once hunted to near extinction, are now an everyday sight on Hawaiian reefs. Divers here have a unique opportunity to observe turtle behavior. If divers act responsibly around them, the turtles will stay near the area for all to enjoy.

Experiencing and understanding the turtles cleaning behavior is one of the great thrills about diving on Maui. There are few places left on Earth where turtles will allow divers into their private lives. On Maui they are accustomed to having divers near them and at times they even seem to enjoy our company.

DISCOVER DIVING®

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Text & Photography by Dan Auber

photo by Dan Auber

ON THE COVER

Photo by Al Bruton • This issue's cover features a photo of underwater photographer Beth Bruton at Los Animos, Baja, Mexico. The photo was taken using a Subal N-90 with a 20mm lens and two MCD strobes. The exposure was f/5.6 at 1/60 using Fuji 1000 film.

TRENDS & TECHNICAL

DIVE INFORMATION

NOAA Technical Memorandum NMFS

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AUGUST 1988

HAWAIIAN MONK SEAL AND GREEN TURTLE RESEARCH ON LISIANSKI ISLAND, 1986

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ABSTRACT

The endangered Hawaiian monk seal, *Monachus schauinslandi*, and the threatened green turtle, *Chelonia mydas*, were studied intermittently on Lisianski Island throughout the summer in 1986. Field personnel were present on three occasions: 3 May, 30 May-2 June, and 5-26 August 1986. A total of 10 censuses were conducted; seal beach counts ranged from 76 to 107 (excluding pups), with a mean of 94. Twenty live pups were tagged after weaning, and two pup carcasses were found. Two adult female seals were seen with fresh dorsal wounds, and up to six adult and subadult females were seen with older, healing dorsal wounds. Eight green turtles were identified by tags: five were tag resightings from previous years and three were newly tagged in 1986. An adult green turtle was found dead, and 15 individual turtle nest sites were located. A total of 174 net and debris items capable of entangling seals and turtles were inventoried and destroyed. Two seals were found entangled in debris and were immediately released.

CONTENTS

INTRODUCTION

Lisianski Island is one of the nine reported haul-out and pupping locations of the endangered Hawaiian monk seal, *Monachus schauinslandi*, and is also a nesting, basking, and feeding area for the threatened green turtle, *Chelonia mydas*, in the Northwestern Hawaiian Islands (NWHI). The National Marine Fisheries Service (NMFS) Honolulu Laboratory has established annual 1- to 6-mo field camps on Lisianski Island since 1981 for monk seal and green turtle research (DeLong et al. 1984; Stone 1984; Johanos and Henderson 1986; Johanos and Kam 1986; Kam 1986; Alcorn et al. 1988; Kam[1]). The purpose of the research is to monitor these two species and aid in their recovery.

The primary objective of this paper is to report the findings of the 1986 Lisianski Island field research. It is not intended to present and review other monk seal and turtle research.

STUDY SITE

Lisianski Island (lat. 26°02'N, long. 174°00'W) is a low-lying, coral and sand atoll located on Neva Shoal, a shallow reef bank in the NWHI (Fig. 1). The island is situated 905 nmi northwest of Honolulu. The interior of the island is densely covered with vegetation (vines, grasses, and shrubs), and the beaches are fairly steep and narrow, except for the southeast portion where they are quite flat and wide. There are also rocky ledges scattered along the east side of the island. The maximum elevation of Lisianski Island is just over 6 m. For more detailed information on geography, flora and fauna, and history of Lisianski Island, see Clapp and Wirtz (1975).

The island perimeter (about 5.2 km) was divided into 49 sectors (Fig. 2) in 1982 (Stone 1984) for recording the locations of animals and other observations; these sectors have been used in successive years' research, including 1986.

METHODS

The NMFS personnel visited Lisianski Island on three different occasions during the 1986 field season (Appendix A): 3 May, 30 May-2 June, and 5-26 August. On 3 May, personnel conducted an island circuit to photograph and draw scar cards of nursing female monk seals, tag weaned pups, resight tagged animals, and note any injured, dead, or entangled seals. Similar activities also were conducted from 30 May to 2 June when a short field camp was established.

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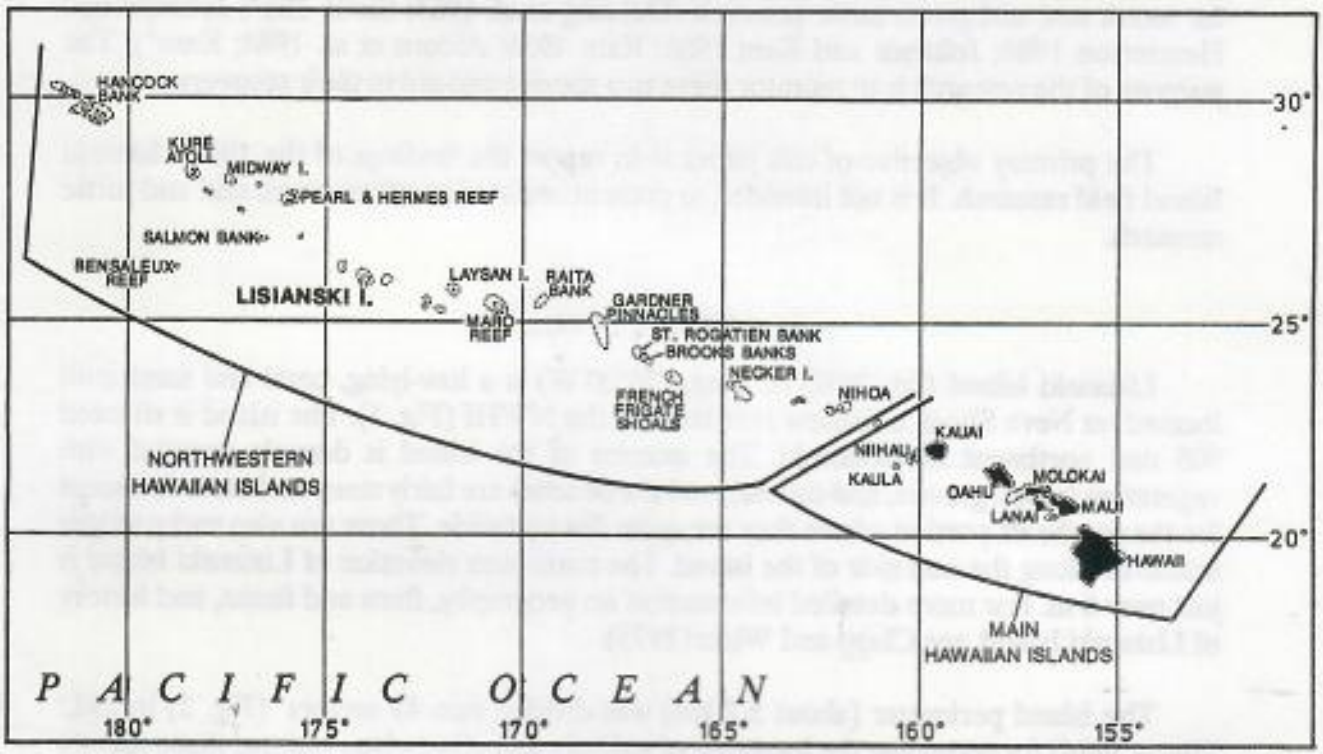

Figure 1.–Chart of Hawaiian Archipelago, showing location of Lisianski Island.

INTRODUCTION

Lisianski Island is one of the nine reported haul-out and pupping locations of the endangered Hawaiian monk seal, *Monachus schauinslandi*, and is also a nesting, basking, and feeding area for the threatened green turtle, *Chelonia mydas*, in the Northwestern Hawaiian Islands (NWHI). The National Marine Fisheries Service (NMFS) Honolulu Laboratory has established annual 1- to 6-mo field camps on Lisianski Island since 1981 for monk seal and green turtle research (DeLong et al. 1984; Stone 1984; Johanos and Henderson 1986; Johanos and Kam 1986; Kam 1986; Alcorn et al. 1988; Kam[1]). The purpose of the research is to monitor these two species and aid in their recovery.

The primary objective of this paper is to report the findings of the 1986 Lisianski Island field research. It is not intended to present and review other monk seal and turtle research.

STUDY SITE

Lisianski Island (lat. 26°02'N, long. 174°00'W) is a low-lying, coral and sand atoll located on Neva Shoal, a shallow reef bank in the NWHI (Fig. 1). The island is situated 905 nmi northwest of Honolulu. The interior of the island is densely covered with vegetation (vines, grasses, and shrubs), and the beaches are fairly steep and narrow, except for the southeast portion where they are quite flat and wide. There are also rocky ledges scattered along the east side of the island. The maximum elevation of Lisianski Island is just over 6 m. For more detailed information on geography, flora and fauna, and history of Lisianski Island, see Clapp and Wirtz (1975).

The island perimeter (about 5.2 km) was divided into 49 sectors (Fig. 2) in 1982 (Stone 1984) for recording the locations of animals and other observations; these sectors have been used in successive years' research, including 1986.

METHODS

The NMFS personnel visited Lisianski Island on three different occasions during the 1986 field season (Appendix A): 3 May, 30 May-2 June, and 5-26 August. On 3 May, personnel conducted an island circuit to photograph and draw scar cards of nursing female monk seals, tag weaned pups, resight tagged animals, and note any injured, dead, or entangled seals. Similar activities also were conducted from 30 May to 2 June when a short field camp was established.

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[1]Kam, A. K. H. 1985. Green turtle research on Lisianski Island, 1983. Southwest Fish. Cent. Honolulu Lab., Natl. Mar. Fish. Serv., NOAA, Honolulu, HI 96822-2396. Southwest Fish Cent. Admin. Rep. H-85-11, 11 p.

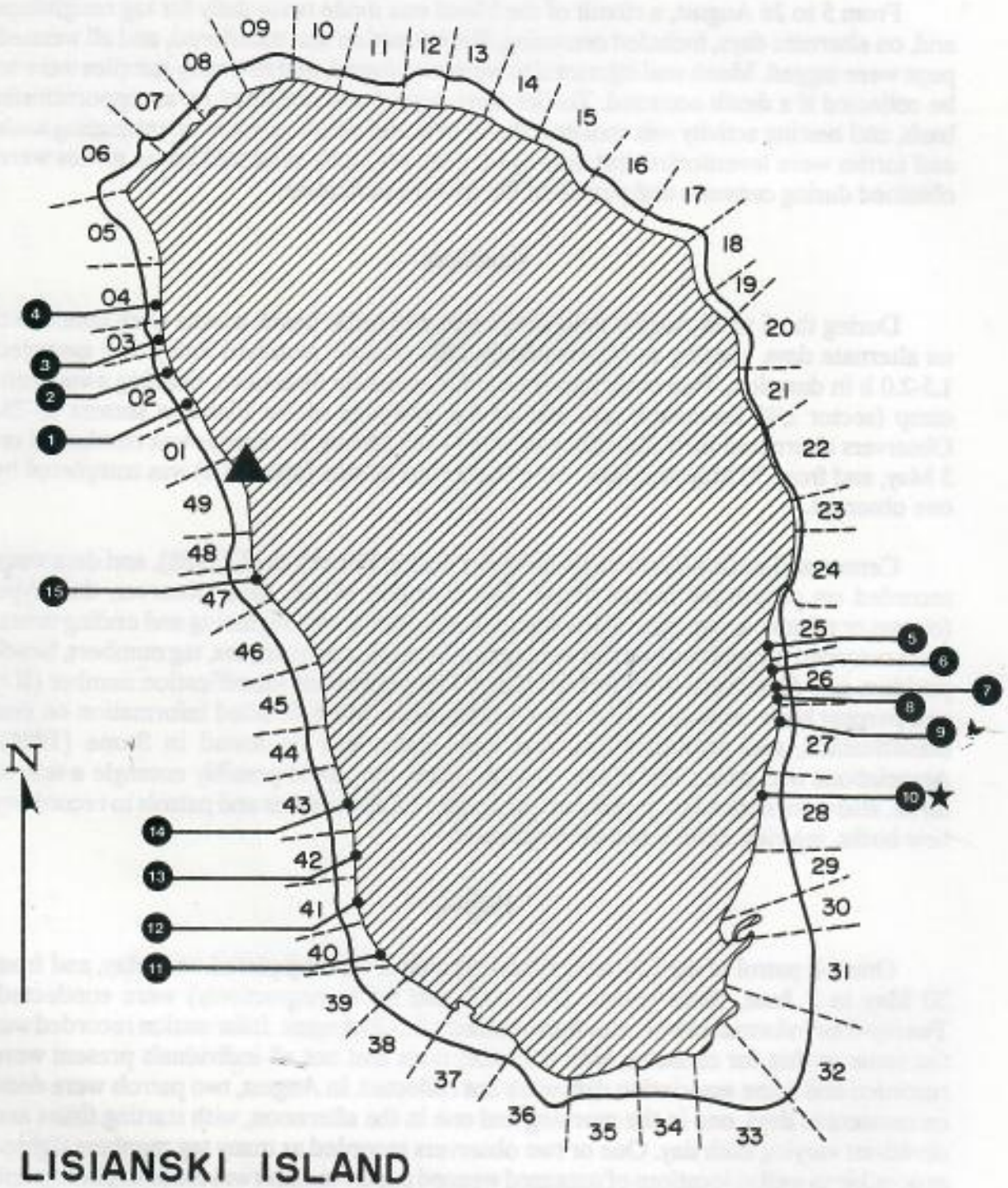

Figure 2.--Map of Lisianski Island showing 49 sectors and 1986 turtle nesting site locations. (▲ denotes campsite. ★denotes nesting sites dug during the August field camp.)

From 5 to 26 August, a circuit of the island was made twice daily for tag resightings and, on alternate days, included censusing. Reproduction was monitored, and all weaned pups were tagged. Monk seal injuries also were monitored, and necropsy samples were to be collected if a death occurred. Turtles were tagged and resighted on an opportunistic basis, and nesting activity was monitored. All nets and debris capable of entangling seals and turtles were inventoried and destroyed. Data on monk seals and green turtles were obtained during censuses and patrols of the island's perimeter.

Censuses

During the 5 to 26 August field camp, seal and turtle beach counts were conducted on alternate days, starting at approximately 1300 (Hawaii standard time), and averaged 1.5-2.0 h in duration. Two observers traveled in opposite directions, heading away from camp (sector 1/49 boundary) and met on the east side of the island in sectors 25-28. Observers alternated their directions traveled each census. No census was conducted on 3 May, and from 30 May to 2 June, only one formal census (about 5 h) was completed by one observer.

Census and coding instructions are described in Forsyth et al. (1988), and data were recorded on preprinted forms. These data included island, date, observer, data type (census or patrol), a summary of the weather conditions, and beginning and ending times. Data recorded for seals and turtles were sector location, size class, sex, tag numbers, beach position, and disturbance by observer, if any. The permanent identification number (ID) and percent body molt also were recorded for seals. More detailed information on size classification, seal identification, and molt status can be found in Stone (1984). Associations with other individuals, or with debris that could possibly entangle a seal or turtle, also were noted. It was standard procedure on all censuses and patrols to record any new births, injuries, deaths, and entanglements.

Patrols

One 6-h patrol of the Lisianski Island perimeter was completed on 3 May, and from 30 May to 2 June, three patrols (2.5, 10.5, and 4.5 h, respectively) were conducted. Twenty-four informal patrols also were conducted 5-26 August. Information recorded was the same as that for censuses, with the exceptions that not all individuals present were recorded and some association data were not collected. In August, two patrols were done on noncensus days, one in the morning and one in the afternoon, with starting times and durations varying each day. One or two observers recorded as many tag numbers sighted as possible as well as locations of untagged weaned pups. An effort was made to photograph and record those seals that had lost one of their two tags or had illegible numbers because of sand abrasion on one or both sides of a tag. Because field camp time was limited for identifying animals spending minimal time ashore, morning patrols also were conducted by one observer on census days. No taggings were done during these patrols in order to minimize disturbance prior to the afternoon census. Completion times of the morning patrols varied but were as close as 45 min before census began.

Individual Seal Identification

A small number of untagged seals in the Lisianski Island population were identified on the basis of scars and natural markings. Time was a limiting factor; hence, priority was given to identifying nursing females to gain information on individual reproductive histories. During patrols, scar patterns were drawn and photographs were taken of these females and injured animals. Photographs and scar drawings of previously "known" seals also were collected to update photo ID's. New ID numbers were assigned to seals only if they could not be matched with any seals from previous years but had relatively distinct scars, markings, or both. Scar cards and photos with the new ID numbers were filed for future reference.

Tagging Weaned Pups

Weaned pups were restrained by two or three persons to minimize the tagging time. A green, plastic Temple Tag[2] was placed on each hind flipper as described in Gilmartin et al. (1986). Tags had an engraved, resined letter and number on both sides and a unique, drilled hole pattern for year of birth. Axillary girth, straight body length (see Table 1), and other data were recorded on tagging cards for each pup. Pups were watched for 5 to 10 min after tagging to monitor their response to the procedure.

Turtle Research

Green turtles basking on the beaches or seen offshore were recorded during all censuses and most patrols. Foreflipper tags applied in previous years were read on an opportunistic basis while turtles were basking. One or two Inconel alloy tags were applied on untagged, immature turtles after they had been captured in shallow water with a scoop net; they were then measured (straight and/or curved carapace length and width) and released. Turtle nesting sites around the Lisianski Island perimeter that appeared to be from the 1986 nesting season were noted in August.

Debris Inventory and Disposal

In August, fishing nets, lines, and other debris that had accumulated on the Lisianski Island beaches and could possibly entangle monk seals and green turtles were sampled, and each item was cataloged. More detailed information on data collected can be found in Johanos and Kam (1986). This debris was then gathered into large piles on the beaches and burned. Samples were brought back to Honolulu for further analysis.

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[2]Reference to trade names does not imply endorsement by the National Marine Fisheries Service, NOAA.

Table 1.--Summary of pups born at Lisianski Island, 1986. (F = female, M = male, and ? = unknown.)

ID No.	Green tag		Sex	Date tagged	Measurements (cm)[a]		Birth date	Wean date
	Left	Right			AG	SL		
GL00	L00	L01	F	5/3	95	122	<5/3	--
GL02	L02	L03	F	5/3	115	136	<5/3	--
GL04	L04	L05	M	5/3	84	122	<5/3	--
GL06	L06	L07	F	5/3	83	125	<5/3	--
GL08	L08	L09	M	5/3	117	130	<5/3	--
GL10	L10	L11	M	5/3	117	129	<5/3	--
GL12	L12	L13	M	5/3	85	115	<5/3	--
GL14	L14	L15	F	5/30	--	--	<5/30	--
GL16	L16	L17	M	5/30	--	--	<5/30	--
GL18	L18	L19	F	5/31	111	136	<5/30	5/31
GL20	L20	L21	M	5/31	--	--	<5/30	--
GL22	L22	L23	M	5/31	--	--	<5/30	--
GL24	L24	L25	F	5/31	--	--	<5/30	--
GL26	L26	L27	M	5/31	--	--	<5/30	--
GL28	L28	L29	F	5/31	--	--	<5/30	--
GL30	L30	L31	F	6/2	--	--	<5/30	--
GL32[b]	L32	L33	M	8/7	109	132	<8/7	--
GL34[b]	L34	L35	M	8/10	--	136	<8/7	--
GL36[b]	L36	L37	F	8/10	115	138	<8/7	--
GL38[b]	L38	L39	M	8/15	--	--	<8/7	--
GL98[b]	Not tagged		?	Dead	--	--	<8/7	--
GL99[b]	Not tagged		?	Dead	--	--	<8/7	--

[a]AG = axillary girth and SL = straight length; measurements were taken at time of tagging.

[b]Two adult nursing females (GA01 and G105) were identified early in June; it is not known which of these six pups belonged to them, nor whether their pups were lost and never seen during the 2-mo period between observations on Lisianski Island in 1986.

RESULTS AND DISCUSSION

Monk Seals

Censuses

During the 10 censuses of Lisianski Island in 1986, seal beach counts excluding pups ranged from 76 to 107, with an average of 94. Counts including pups ranged from 88 to 121 and averaged 105. A more detailed census summary appears in Appendix B. These counts are higher than in 1982-85, with the average number of seals excluding pups ranging from 86 in 1983 to 68 in 1984 (Johanos and Kam 1986; Alcorn et al. 1988). Higher beach counts in August 1986 could have been due to more adult male seals hauling out because of their annual molt in late summer, in comparison to the 1982-85 field seasons when most or all of the research was conducted earlier in the summer. Adult males comprise the largest size-sex fraction in the Lisianski Island population (Stone 1984; Johanos and Kam 1986).

Pup Production

Twenty live monk seal pups (11 males and 9 females) were seen on Lisianski Island in 1986; all had been weaned prior to the August camp (Table 1). Two pup carcasses found during this time appeared to be of nursing size, but the sexes were unknown. The number of known births was greater than in 1984 (16 pups) and 1985 (15 pups; Alcorn et al. 1988). but still appeared to be below the numbers in 1982 (28 pups; Johanos and Henderson 1986) and 1983 (25 pups; Johanos and Kam 1986). Adult female migration to and from Lisianski Island may have somewhat influenced pup production in previous years, but that alone probably would not account for the low numbers in 1984 and 1985 (Alcorn et al. 1988). The 1984 and 1985 Lisianski Island camps were short, however, and pups that may have died or possibly emigrated would have been missed. Two of the three visits in 1986 were near the peak of the weaning period, allowing for more complete coverage.

When camp disbanded on 26 August, no pregnant females were apparent. Most adult females on the beaches had partially or completely molted, which occurs approximately 2 to 3 mo after weaning or earlier in the season for nonparturient adult females (Johnson and Johnson 1984). It is unlikely that any more pups were born in 1986, although births have occurred at least once in every month of the year in the NWHI (W. Gilmartin[3]).

Identification of Parturient Females

On 3 May, eight nursing females were observed and photographed, but a camera malfunction resulted in poor photographic quality, which precluded matching ID's. Of the

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[3]W. G. Gilmartin, Southwest Fish. Cent. Honolulu Lab., Natl. Mar. Fish. Serv., NOAA, Honolulu, HI 96822-2396, pers. commun. September 1986.

three nursing adult females in early June, two were identified as GA01 and G105. Both pupped in 1982, and GA01 pupped again in 1983 (Johanos and Henderson 1986; Johanos and Kam 1986). It is not known whether these females gave birth in 1984 and 1985, because of the short camp durations. There were no nursing females in August 1986.

Tagged Pups

Twenty pups were tagged intermittently over the summer (Table 1), and all but one pup (GL20) were resighted in August. All 1986 tagged pups had retained both of their hind flipper tags when last seen.

Eleven pups tagged in 1982, 19 pups in 1983, 12 pups in 1984, and 14 pups in 1985 were sighted at least once throughout the 1986 field season (Table 2). First-year survival of the 1985 tagged pups was 100%. One pup, still nursing when the 1985 camp disbanded, was not tagged, and it is not known whether any pups were born later in the season. This first-year survivorship of 1985 pups is excellent; their large yearling size (subjective comparison with yearlings at other locations) may well indicate that food around Lisianski Island was not a factor limiting their survival.

Interisland Movement

Four monk seals moved to or from Lisianski Island during the 1986 field season (see Table 3). Three of these individuals (G027, TT14, and T25F) were seen in 1985 on Laysan Island, which is 110 nmi away, and immigrated to Lisianski Island since that time. The fourth individual, a 1985 Lisianski pup (GK24), moved to Laysan Island and was sighted during a 3-mo field camp there in 1986. Green algae throughout her pelage indicated she had spent much time at sea.

Deaths

There were two pup carcasses of unknown sex discovered in 1986 on Lisianski Island. Both appeared to be of nursing size; their skulls were broken and bones were scattered, with pieces of black pelage adhered to their skeletons. One carcass (GL98) was found near the sector 22/23 boundary in a rocky area, and the other carcass (GL99) was partially buried at the vegetation line in sector 19. A baculum was not found with either carcass but could have been lost.

Injuries

Fresh injuries inflicted upon seals could not be monitored for any great length of time because of the short duration of the camps. An adult female (temporary ID JUNE), attended by an adult male, was seen on 1 June with a large, deep, fresh dorsal wound. She was later seen in August, with the healing wound having partially closed. Another adult female had a healing back wound reopened in August, probably by an adult male. She bore

Table 2.--Number of pups born, tagged, and resighted at Lisianski Island, 1982-86.[a] (M = male, F = female, and ? = unknown.)

Year tagged	No. of known births	No. tagged that year	No. of tags resighted by year			
			1983	1984	1985	1986
	Total (M, F, ?)	Total (M, F)	Total (M, F)	Total (M, F)	Total (M, F)	Total (M, F)
1982	28 (16, 11, 1)[b]	13 (7, 6)	11 (5, 6)[c]	11 (5, 6)[d]	11 (5, 6)[e]	11 (5, 6)
1983	25 (7, 18)[f]	24 (6, 18)		21 (6, 15)[e]	20 (6, 14)	19 (5, 14)
1984	16 (10, 5, 1)[f]	15 (10, 5)			14 (9, 5)	12 (9, 3)
1985	15 (6, 9)	14 (5, 9)				14 (5, 9)[e]
1986	22 (11, 9, 2)[b]	20 (11, 9)				

[a]Data for 1982-85 births and taggings are from the following sources: 1982, Johanos and Henderson (1986); 1983, Johanos and Kam (1986); 1984 and 1985, Alcorn et al. (1988).

[b]Total includes two dead, nursing-sized pups.

[c]There were 24 pups from 1982 resighted: 11 were identified by tags, and 13 were identified by bleach marks applied in 1982 on untagged pups.

[d]Total includes one pup not seen that year at any location but resighted in 1985.

[e]Total includes a Lisianski pup resighted at Laysan Island that year.

[f]Total includes one dead pup.

Table 3.--Interisland movement of monk seals to and from Lisianski Island in 1986. (A = adult, S = subadult, and J = juvenile; M = male and F = female.)

ID	Tags		Tag color	Size and sex	Movement from		Movement to	
	Left	Right			Location	Date last seen	Location	Date first seen
GK24	K24	K25	Green	JF	Lisianski	7/13/85[a]	Laysan	5/10/86[b]
G027	027	028	Green	SF	Laysan	7/7/85[c]	Lisianski	8/10/86
TT14	T14	T72	Tan	SM	Laysan	11/26/85[c]	Lisianski	5/31/86
T25F	--	--	--	AF	Laysan	7/28/85[c]	Lisianski	8/18/86

Data are from the following sources:

[a]Alcorn et al. (1988).

[b]Alcorn, D. J., and R. L. Westlake. The Hawaiian monk seal on Laysan Island, 1986. Manuscr. in prep. Southwest Fish. Cent. Honolulu Lab., Natl. Mar. Fish. Serv., NOAA, 2570 Dole St., Honolulu, HI 96822-2396.

[c]Johanos and Austin (1988).

a right hind flipper metal tag that was not read, but based on sightings in earlier years, her ID was probably GA77 (tag A1011).

At least six individual adult and subadult females were seen with older back wounds during the August camp. The wounds varied in size, severity, and degree of healing and appeared to be of the type inflicted by adult males, probably earlier in the season or from the year before.

Entanglements

In August, two seals were found entangled in debris. A weaned pup (GL28) was observed entangled in a pile of polypropylene netting attached to a large, heavy pile of mooring line in the wave wash of sector 19. The pup's neck was wrapped around with a strand of netting in front of her foreflippers, slightly cutting into the blubber layer (Fig. 3A). The pup was photographed and released. A subadult male seal (TT14) was seen partially entangled in a polypropylene rope in sector 25 while hauled out on the beach (Fig. 3B). The rope appeared tight on top of the seal's nose and was photographed, but when released, it was found it would not have restricted his movement.

Green Turtles

A total of eight turtles were identified by tags. Five of these had tags from previous years, and three were newly tagged in 1986 (Table 4). Fifteen turtle nesting sites were mapped and inventoried in 1986 (Fig. 2). Two of these were dug while observers were on the island in August; there were no turtle hatchings observed during this time, although effort was not applied to monitor for hatchings. A dead adult turtle (sex unknown) was found half-buried and partially decomposed at midbeach in sector 29. Tags were not found.

Debris Inventory

During the 1986 field season, 174 pieces of net and debris items capable of entangling seals and turtles were removed from the beaches on Lisianski Island. Each item was sampled and inventoried. The remaining debris was put into piles and burned at the end of the August camp. Further analysis as to type and origin of the debris is ongoing and will be presented elsewhere.

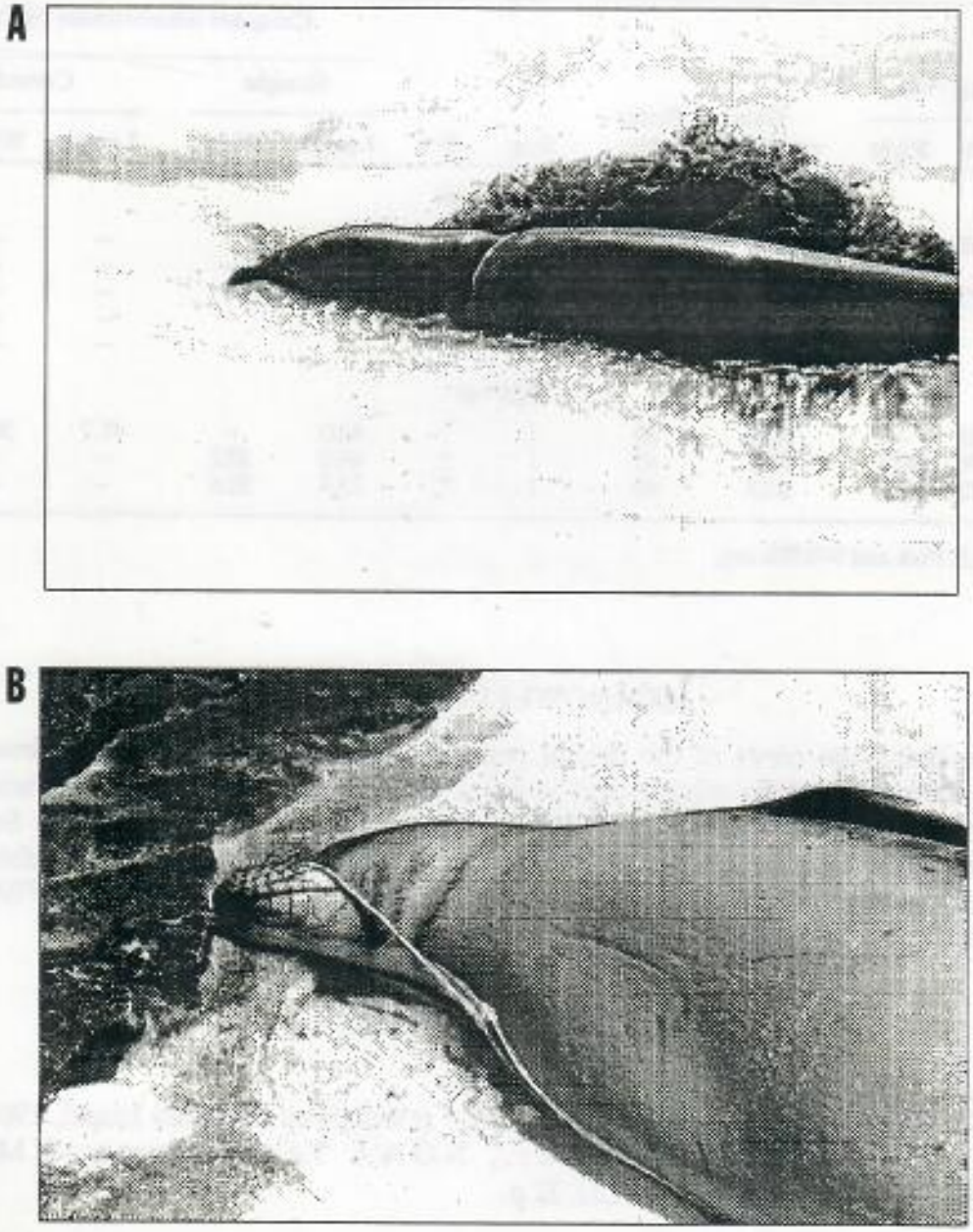

Figure 3.--Seals entangled in debris. (A) Entangled weaned pup in a pile of polypropylene netting, and (B) partially entangled subadult seal in polypropylene rope.

Table 4.--Green turtles resighted and tagged at Lisianski Island, 1986. (A = adult and I = immature; M = male, F = female, and ? = unknown.)

Tag No.						Carapace measurement (cm)			
						Straight		Curved	
Left	Right	Date resighted	Sector No.	Size	Sex	Length	Width	Length	Width
				Resightings					
6768	--	8/22	09	A	M	--	--	--	--
--	A494[a]	8/21	27	A	F	--	--	--	--
6477	--	8/12	09	I	?	--	--	--	--
--	8666	8/09	27	I	?	--	--	--	--
--	2851	8/22	09	I	?	--	--	--	--
				Taggings					
8669	--	8/13	49	I	?	40.0	--	41.7	36.5
8670	8671	8/13	49	I	?	45.0	37.2	--	--
8672	8673	8/13	49	I	?	39.4	31.6	--	--

[a]U.S. Fish and Wildlife tag.

ACKNOWLEDGMENTS

We thank the crews of the fishing vessel *Feresa* and the NOAA ship *Townsend Cromwell* for transporting supplies and personnel to and from Lisianski Island. Their help in assisting the camps was greatly appreciated. The U.S. Fish and Wildlife Service (USFWS) provided a lot of support and made the 30 May-2 June field camp possible. We would like to especially thank Tim Gerrodette of NMFS and Joel Simasko (USFWS) for participating in the 1986 Lisianski Island study.

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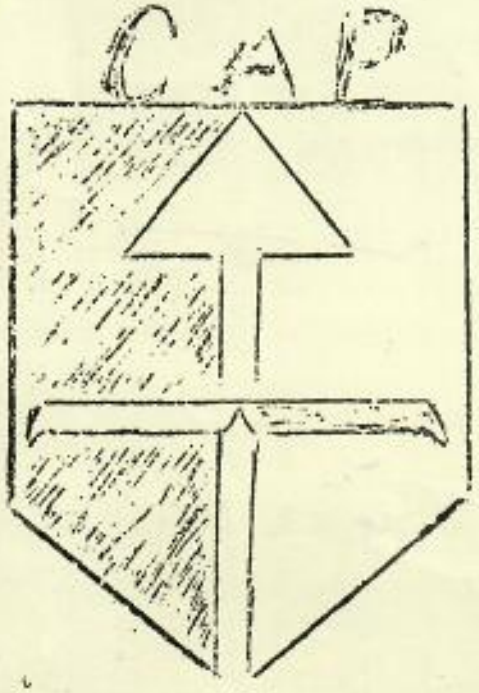
APPENDIXES

Appendix A.–Itinerary for the 1986 Lisianski Island fieldwork.

Date	Event
4/29	The NOAA ship *Townsend Cromwell* departs Honolulu with NMFS Honolulu Laboratory and U.S. Fish and Wildlife Service (USFWS) personnel on board.
5/3	The *Townsend Cromwell* arrives at Lisianski Island and disembarks Honolulu Laboratory personnel (D. Alcorn and R. Westlake), USFWS personnel and volunteers (E. Bean, A. Marshall, and J. Simasko). Alcorn, Westlake, and Simasko circuit the island while others remain near landing cove. The Moana Productions film staff comes ashore with *Townsend Cromwell* crew members in the afternoon. Everyone embarks the *Townsend Cromwell* by 1715, and the ship departs for Laysan Island.
5/30	The fishing vessel *Feresa* arrives at Lisianski Island with Honolulu Laboratory personnel (T. Gerrodette) and USFWS personnel (D. Hu, K. McDermond, and T. Ohashi), and field research begins.
6/2	Shore party ends research and disbands field camp, leaving Lisianski Island via the *Feresa* for Pearl and Hermes Reef.
8/5	The *Townsend Cromwell* arrives at Lisianski Island with Alcorn and Westlake and USFWS personnel (Bean, Marshall, M. Morin, and P. Siepmann). Personnel and crew members disembark with supplies and help set up field camp. The *Townsend Cromwell* departs the same day with crew and staff while Westlake and Siepmann remain to conduct research.
8/7	Monk seal and green turtle research formally begins.
8/26	Research ends, and Westlake and Siepmann disband camp; embark the *Townsend Cromwell* with supplies and head for Pearl and Hermes Reef to pick up Honolulu Laboratory field camp there. Arrive 27 August and depart same day for Midway. Arrive Midway 28 August, and all Honolulu Laboratory and USFWS personnel arrive back in Honolulu via MAC flight.

Appendix B.--The 1986 Lisianski Island seal census summary. (M = males, F = females, and ? = unknown.)

	Non-pups									Pups								
	Adult			Subadult			Juvenile			Weaned			Nursing			Total		
Date	M	F	?	M	F	?	M	F	?	M	F	?	M	F	?	Nonpup	Pup	Grand
6/01	23	10	20	13	14	13	7	3	4	5	5	1	1	0	2	107	14	121
8/08	20	3	9	14	6	11	8	3	2	6	5	1	0	0	0	76	12	88
8/10	26	5	12	19	7	7	8	6	1	6	4	0	0	0	0	91	10	10
8/12	24	4	18	13	4	7	9	4	2	8	5	0	0	0	0	85	13	98
8/14	32	6	23	7	6	12	7	4	2	5	4	1	0	0	0	99	10	109
8/16	28	3	23	8	7	10	6	2	3	7	4	0	0	0	0	90	11	101
8/18	30	6	27	9	8	7	6	5	5	6	5	1	0	0	0	103	12	115
8/20	35	9	22	11	3	12	7	3	5	7	4	0	0	0	0	107	11	118
8/22	34	9	22	8	5	6	9	2	1	7	4	0	0	0	0	96	11	107
8/24	16	2	40	5	1	14	4	2	0	4	3	0	0	0	0	84	7	9



MOLOKAI COMMUNITY ACTION PROGRAM
MAUI ECONOMIC OPPORTUNITY, INC.
P. O. BOX 677
KAUNAKAKAI, HAWAII 96748

NEWSLETTER

66th ISSUE
July 1, 1972

Aloha Molokaians:

Please read the following reminders:

1. Check the County Office and inquire about Summer Fun. Its never too late.
2. Remember to bring an extra box or package to put litter in when going to the beaches. Please also refrain from throwing soda cans and beer bottles along our highways.
3. Those of you who are careless about leaving keys in your cars, not locking your homes and not playing it safe might create temptation for thieves to start their work.
4. This is the beginning of a hot summer. So please be real careful with fire.
5. The pineapple companies are slowing down in their hiring but after weeding out those who do not want to work-jobs will then become available. So if you have not registered, do so, and stand by.
6. To avoid flys from becoming a nuisance, keep food, storage or garbage areas clean and covered. If you have to get rid of animal innards bury them, or drop them in the ocean. They make good food for crabs and other crustacians.
7. Do not bury plastic material because it does not deteriorate and become top soil. It only pollutes the soil. Burn them. Our trade winds will keep our islands relatively free from air pollution.
8. Have a nice, carefree, and SAFE summer. Throw a piece of wood in the ocean where you are going to swim (if you are not familiar with the area) and observe it for twenty minutes. That piece of wood will tell you the strength of the current and the direction. That 20 minutes of observation might save your life.

9. Skin diving hints: If you want to spear an ulua or-(Jack Cravelle) with a snorkel under water, emulate the sound of an ulua by creating a sound deep in your throat that sounds like a balloonfish pumping air in. You will get ulua, papio, and uku come charging at you. After you get the fish close to you stop the calling and this will cause the fish to glide slowly, making a head shot possible.

If catching turtle, try these times of the day-10:30 a.m. and 2:00-2:30 p.m. They seem to rest about this time of the day. Some people gaft turtles, this cause lots of commotion and blood. Others ride and wrestles them. I find that the easiest way is to make a home made spear. The original spear is too heavy and short without barb only & sharp point, the end of the spear hanging about 10-12" over th end of the arbalette (spear gun) (too long will cause spear to whip under water) and propelled by a pair of 1/4" thick, 1/4" center hole surgical rubber. This gives you enough force to penetrate a 50 gal. drum. Naturally, under water there is resistance but accurate and powerful enough to down any size turtle.

Because there is no barb, only a head shot will help you. When looking directly over a sleeping turtle spear it just an inch toward the body, between the eyes. That spot is softer and easier to get a brain shot.

When diving in warm murky water, and you notice fishes (mamo & weke especially) dashing frantically, chances are a big fish is attacking them. If your conscious says, move out-do it, or something else will move you out of the way.

Continue on next page.

Continue from page 2

If you ever come before a shark, do not panic. Keep an eye on it, and swim natural. This is important. Erratic and frantic splashing activate the shark. If it comes towards you, cup your hands and make definite cupping slaps on the water. This will cause it to veer away, but it will come back again, so do it again. After two passes, it will leave. Chances would be better if you would move to another area.

These hints I am sharing with you have proven succesfully for me, especially calling for ulua & uku. A Tahitian Champion skin diver John Tapu, demonstrated that "talking" to fish is not a fluke.

I will be sharing some hints of fishing hunting, and so on as time goes by.

Mahalo for your time,

Hanky Yamamoto, President
Molokai Community Action Council

Fred D. Biccy, Coordinator
Molokai Community Action Program

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THINGS TO REMEMBER

Excessive speeding and drinking are factors in many accidents.
Remember a car is not a play thing.
Driving a car is a full time job with both hands on the steering wheel.
Decide now you will never drive unless you drive carefully.
Let's obey the many good traffic laws and traffic officials.
As you go out on the highways expect

THE GOSPEL OF SAFE DRIVING

It isn't the car that begins to whine
When forced to stop for an old stop sign-
It's the Driver.
It isn't the car that takes a drink, then quickly loses its power to think-
It's the Driver.
It isn't the car that fails to heed the dangers of reckless, discourteous speed-
It's the Driver.
It isn't the car that steps on the gas

areas, with rain and especially rampant wind erosion, will become like Kahoolawe: BARE, RED DIRT.

So that a fair assessment of deer damage to Kanepuu since about 1930 can be made, I have sent a xerox copy of Mr. Munro's memorandum to the State Animal Species Advisory Committee. I challenge the members to find the species of plants at Kanepuu that existed there before deer overran the island.

Although I expect a wise decision from the Advisory Commission soon, I am surprised that the State of Hawaii had planned to liberate the axis deer "In the higher elevation around Mauna Kea." In a 1968 brochure of the Hawaii Cattlemen's Council entitled "WHY AXIS DEER SHOULD NOT BE INTRODUCED TO THE ISLAND OF HAWAII," is stated the well-known fact that this Indian deer "is tropical and prefers lower, warmer elevations." When flying over the Island of Hawaii, note the deep gulches zigzagging from higher elevations through ranches, cane fields, vegetable and flower gardens, and orchards. Can any one believe that a tropical, fence-jumping animal will remain with little cover for protection from hunters at "higher elevations?" These nocturnal animals will work their way nightly from cold elevations to the warmer lowlands. They will wander preferably along jeep and plantation roads from sunset to sunrise. When sufficiently makai to enjoy the warmth, they will hide in the gulches during the day, coming forth nightly to mingle with cattle and to raid sweet luscious cane, vegetables, flowers, and orchard fruits.

The American Society of Mammalogists, in convention at Yellowstone National Park in 1950, urged our Board of Agriculture and Forestry, then flirting with the idea of introducing axis deer to Hawaii, "to consider the danger and folly of such an introduction...." Will we in the State of Hawaii never learn?

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The Wildlife of Keehi Lagoon, Oahu, by Ronald L. Walker, Wildlife Biologist, Hawaii Division of Fish and Game (Paper presented at the second Hawaii Wildlife Symposium held in Hilo, Hawaii, 12 May 1971)

Introduction: The proposal to construct a Honolulu International Airport reef runway at Keehi Lagoon on the leeward coast of Oahu brought up the question of the effects of the construction on bird habitat and activities. Accordingly, the State Department of Transportation through Ralph M. Parsons Co. hired Dr. Andrew Berger and the author to conduct a field survey and literature search on the bird life of the area. Specifically, the study was to determine population levels and the distribution of migratory, introduced, and native bird species and to record maximum elevations of bird flights as they might relate to aircraft. The study is not yet complete, so these remarks should be considered somewhat premature....

Techniques: Between December 12, 1970 and April 28, 1971, a total of 60 bird censuses were made in Keehi Lagoon and environs. They were conducted under a variety of conditions of tide, seas, weather, and time of day, and varied in duration from 1½ hours to 4½ hours each. A 15-foot skiff with a 20 H.P. motor was used, although when small-craft warnings were up, an automobile was necessary. Initially, there were 23 stations located over open water, on tide flats, on islets, and along the shoreline, but beginning on January 9, 1971, the number was reduced to 17. Generally, each station was glassed with 7x30 binoculars and covered an area with a radius of 250 yards.

History: The literature search has not been completed, but it is clear that little was known of the ornithology of Keehi Lagoon prior to this study. Sporadic records of bird observations have appeared in the journal of the Hawaii Audubon Society and in waterbird census reports of the State Division of Fish and Game. The four common migratory shorebirds and the Hawaiian stilt were known to frequent the exposed mud flats particularly in the winter months. Unusual species recorded over the years included a godwit and a glaucous-winged gull. It was thought that perhaps the Hawaiian stilt nested on some of the islets in the lagoon.

Bird Species: A total of 12 species of common introduced birds was recorded during the survey, and most of these occurred along the coast of the mainland of Oahu. Only the lace-necked dove, barred dove, white-eye, and English sparrow were seen with any frequency in the lagoon itself, primarily associated with mangrove and kiawe trees. Others noted were the rock dove, mockingbird, mynah, Brazilian cardinal,

elevations well below 100 feet while moving around and to and from the lagoon. (The exception being the aforementioned "pre-migratory flights.") The small common shorebirds usually flew at an elevation of about 20 feet between stations, and the stilt never flew above 40 feet. Some maximum flights include: Brown booby 50', domestic pigeon 80', osprey 75', glaucous gull 45', and Hawaiian owl 15'. Disturbance by people caused shorebirds to fly up, circle, and land only a few hundred yards away. Aircraft such as helicopters, jets, and light planes had little effect on feeding or roosting birds, especially if these flights occurred at an elevation of 200' or more. During low- or mid-tides, most birds flew in an easterly or westerly direction, and at high tide movement was predominately mauka-makai.

As this was primarily a study of the avifauna, little effort was made to record the occurrence of mammals or reptiles. House mice were noted on the vegetated islands, and it is likely that rats are found on the islands where the squatters' shacks have been located for many years. Domestic dogs, pigs, and chickens occur in a somewhat semi-wild state on these islands as well. No effort was made to collect skinks or geckos, but they probably occur on the higher islands. Green sea turtles were common in the lagoon, particularly in the western-most channel.

As usual, a study such as this raises more questions than it answers. But this survey does represent over 170 hours of field observation in a relatively limited geographical area. It is hoped that these observations will be of interest to future investigators.

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Audubon's comments on H-3 pre-final environmental impact statement by Vice President Willian P. Mull, 7 March 1972:

The substance of the attached statement was presented orally at a public meeting in Honolulu on February 9, 1972. It is our perspective on the Vegetation and Wildlife sections of the H-3 Pre-Final Environmental Impact Statement, to which the public was given only limited access. Public comment was not solicited by the State Department of Transportation.

This analysis is being circulated for the first time now.

In light of its parallel to conclusions reached by the U.S. Environmental Protection Agency, as announced locally in the press on March 7, 1972, the background details and rationale of our review should interest those officials, conservationists and media people who are concerned with the H-3 controversy and to whom this mailing is addressed.

Impact of H-3 on Vegetation and Wildlife of Oahu--What It Really Means

The Draft impact statement issued by the State Department of Transportation in June 1971 gave the reader the impression that nothing of value in the natural environment would be lost as the result of H-3--but neglected to substantiate that conclusion. The current Pre-Final impact statement conveys the same conclusion and endeavors to back that conclusion with the findings of respected scientists who were hired by the highway planners to survey the flora and fauna along the proposed highway route. The most important area of their survey was the three-mile-long corridor through Moanalua Valley.

Both Dr. Charles H. Lamoureux, who did the flora survey, and Dr. Andrew J. Berger, who did the fauna survey, noted that the Moanalua Valley corridor had suffered disturbance by man and incursions by exotic species introduced by man. They also noted endemic species along the corridor--but none that they regarded as "endangered." They concluded that no native animal or plant species would be threatened with extinction as the immediate result of construction of H-3. Dr. Lamoureux's only significant qualification to his findings was that the long-term effects of H-3 on the flora of the valley are "difficult to assess." Dr. Berger's only significant qualification was that a thorough bird survey of Moanalua Valley should include observations during the spring breeding season, when the birds are more evident than in the fall season, when he conducted his survey.

One must accept the statements of these scientists, within the parameters of their surveys. One must question, however, whether the immediate threat to the overall existence of native Hawaiian species is the sole, or even the most important, consideration in assessing the impact of H-3 on native vegetation and wildlife.

Sharks eat albatross - p115

Shark & seal encounter p119

4/ Refuge on a Reef

Against the illimitable blue of the sky, over the unfathomable blue of the ocean the sea birds of the Pacific wing the cycle of their lives. For them the ocean is a larder: the islands and atolls their mating ground and nurseries. GEORGE C. MUNRO/ *BIRDS OF HAWAII*

Before dawn the sky over the Pacific was like a sheet of dark blue glass. From below the eastern horizon, light and heat began to play on it. The stars squeezed shut and the sky expanded, growing pale and taut. Suddenly the sky shattered, falling in countless tinkling fragments, while overhead, replacing the stars, white birds soared.

The island is small, a sand-covered coral platform only about half a mile long and a few hundred yards wide. There are no trees on it, only broad patches of tough narrow-leaved grass and mats of yellow-flowered puncture vine. Along one side of the island runs a beach of coral sand; on the other there are limestone reefs and shelves. During the night a half-dozen green sea turtles, big as overturned wheelbarrows, have hauled themselves up on the beach to sleep. Not far away two brown-gray seals, each with her single black-velvet pup, are dozing on the sand. In the shallow water near them the silhouette of a little wave, less than a foot high, suddenly turns solid and moves against the grain of the other waves—a shark's fin.

The island is very low. The highest point on it is only 12 feet above the level of the sea. From there one can see about seven miles to the horizon where in all directions there is no smoke, no sail, no ship, nothing. The island is far from any traveled sea lanes; almost no one ever goes there intentionally. The discoverers of it surely went there by mistake.

In 1822 two English whaleships, the *Pearl* and the *Hermes*, cruising in consort, ran into the coral reef and broke up. The survivors built a 30-ton craft out of the wreckage, the *Deliverance*, and navigated it 1,100 miles southeast to Honolulu. Today the charts show this coral bank as Pearl and Hermes Reef.

Pearl and Hermes is in fact an atoll, a half-submerged coral ring about 15 miles wide enclosing a very pale green lagoon in the dark blue sea. There are a few tiny islands along the rim of the lagoon but this one, Southeast Island, is the largest and of greatest consequence. The rest are big sand bars. The atoll marks the place where once there existed a high volcanic island, perhaps as large as Oahu. Now it is worn down by rain, wind and waves so that no trace of it is visible, although if a drill bit were sunk through the sand and coral it would strike black lava roots a few hundred feet down.

In the early-morning light two structures appear on the island. One is a flimsy tower of metal posts and angle irons with something white lashed to its top: a five-gallon metal water can completely covered with sea-bird droppings. It might serve to alert a navigator approaching the low island. The other is a redwood sign. Carved on it in large half-inch-deep letters is "Hawaiian Islands National Wildlife Refuge/Pearl and Hermes Reef/Southeast Island." Below that there is "No Trespassing" in English and Japanese. Aside from the tower and the sign there are not many evidences of human life except for a temporary camp in which a few men are living.

The birds that had replaced the stars were white albatrosses and red-tailed tropic birds. At lower levels shearwaters, petrels, boobies and frigate birds dipped and soared. On the sand, in the grass and on the bare limestone rock there were white eggs and speckled eggs, oval eggs and conical eggs, eggs that weighed less than an ounce and others that weighed three quarters of a pound. Chicks were everywhere. The newly hatched sooty terns were little gray fluffballs spotted with brown. The infant frigate birds were ugly enough to rouse religious thoughts in the mind of a heathen. Surely nothing could be that homely without being part of some grand design: stark naked, without even a visible hair or pinfeather; bright gray skin, the color of a bookmaker's felt hat; covered with permanent large goose-pimples; potbellied, scrawny; mad-eyed and squirming with lust for food.

The young albatrosses, although they were already about six months old, two feet tall and had six-foot wingspreads, were still only chicks and not nearly as ferocious as they tried to appear. Some were just

learning to fly and would make 20- or 30-foot hops that often ended in ridiculous crashes that seemed to embarrass them a good deal. When a man approached them they would snap their beaks rapidly with a sound like castanets but then they would trip over their own feet and fall down. Sometimes they made little peeping sounds. There were about 6,000 of them on the island, so that it was impossible to walk very far without running into one. Perhaps 80 per cent of them were Laysan albatrosses, with white heads, breasts and underparts; the upper surfaces of their wings and their tails are brownish black. The remaining birds were black-footed albatrosses, first cousins of the Laysans, with black bills and sooty brown heads and bodies. When they are standing on the ground both birds, at least at first glance, suggest enormous sea gulls. In the air, with their long, narrow wings outstretched in gliding flight, they look like sailplanes. Their common name is gooney, or gooney bird, a sailor's term that may derive from the old word "gawney," meaning a clownish fool. Still, although they have comical habits and often get into ludicrous scrapes, they are—as birds go—fairly intelligent.

The air over the island was not, as might be expected in a rookery, full of uproar and stench. The trade winds blew steadily from the northeast at about 10 miles an hour and the birds were fairly quiet except when a man intruded directly among their eggs and chicks. At such times they set up an incessant screaming, as they were doing now. Walking in a blizzard of sooty terns so thick he could reach out and catch them in midair in one hand was the man who has charge of the refuge, looking after the interests of the birds and the people of the United States. Although he had arrived on the previous afternoon, a good deal of time had been consumed in setting up camp; and now he was taking his first careful look around. "Please," he said to the terns in a reasonable tone, "stop dropping guano on the administrator."

The name of the administrator is Eugene Kridler, pronounced with a long "i," as in rider. He is a rugged man in his early fifties who works for the Fish and Wildlife Service of the U.S. Department of the Interior. Two or three times a year he leaves his office on Oahu and journeys out to the refuge to see what has been going on there. The refuge extends for more than 800 miles northwestward from the main Hawaiian islands and comprises a chain of reefs, islets and atolls—Nihoa Island, Necker Island, French Frigate Shoals, Gardner Pinnacles, Maro Reef, Laysan Island, Lisianski Island and Pearl and Hermes Reef—that are collectively one of the world's most important sea-bird nesting areas.

The classic semicircular shape of a coral atoll appears on this map of Pearl and Hermes Reef. Only 15 miles wide, Pearl and Hermes covers more than 100,000 acres of reefs, islands and lagoon within the barrier reef (outermost line) separating it from the ocean. The shorter lines mark coral formations that are usually below water; only the islands, which are labeled, stand above the tide level.

The refuge also contains most of the Hawaiian monk seals still surviving on the planet, and is the last remaining nesting ground in the United States of the green sea turtle.

To reach the island, Kridler relies on the cooperation of the Coast Guard and the Navy, which sometimes have ships or helicopters operating in the neighborhood and will take him along. In this instance a big Navy helicopter flying out of Midway Island had set him down on Pearl and Hermes with all his equipment, including aluminum bands for the birds, metal tags for the seal pups and turtles and an enormous slide caliper of the sort used by foresters to determine the diameter of trees. Kridler measures turtles with it.

The Navy had also provided him with a couple of burly assistants to help wrestle the turtles and the seals, which weigh as much as 300 and 700 pounds respectively. One of the assistants, a Chief Hospitalman named Marvin Cunningham, was an amateur naturalist who had accompanied Kridler on previous visits to the island. This time Cunningham hoped to find a seal, dead of natural causes, intact and not too fragrant, so that a skeleton could be secured for a museum. Museums are glad to have the skeletons of rare creatures so long as they are collected by people who know what they are about. Cunningham, whose main medical interest is in bacteriology, spent considerable time in Vietnam and sent back scores of carefully prepared rodent skins and skeletons to the Smithsonian Institution.

On this trip Cunningham was looking for Hawaiian monk seals, so called because the silhouette of their head and neck is thought to resemble that of a monk in a cowl; monk seals belong to an interesting branch of the pinnipeds, or fin-footed mammals. There are (or perhaps were) only three species, unusual among their kind in that they live in warm or subtropical waters. Several hundred of them still inhabit the Mediterranean, principally along the North African coast. At one time monk seals were numerous in the Caribbean, in the Bahamas and off the Florida coast, but they have probably all been slaughtered. The last sure sightings of them were made in 1949. Hawaiian monk seals were nearly wiped out as well, for their oil and skins, but have made a comeback since Theodore Roosevelt established the refuge in 1909. Kridler estimates their number today at about 1,000.

As Kridler made his morning reconnaissance he looked for signs that anyone had landed on the island since his last visit. "Do you know what could happen if there were a shipwreck out here?" he said.

It struck me that this would be a poor place for a man to be stranded.

"I wasn't thinking about people," he said. "What I worry about is rats. If a ship plows into one of these islands and the rats get ashore, they can wipe out a whole species before you know it. Ground-nesting birds are very vulnerable to rats." A few years ago a scientist from the Smithsonian, working in the outer islands, watched a rat attack an albatross on its nest. The albatross was so intent on brooding its egg that it defended itself only feebly and was killed.

Although it would be grim news if rats got ashore anywhere in the refuge, it would be disastrous on a couple of the islands because of the extreme rarity of the species living there. On Nihoa, and nowhere else on earth, live some grayish-brown millerbirds, so called because of their fondness for eating miller moths. When Kridler last estimated their number he put it at about 600. The island also is the only home of the Nihoa finch, a member of the Hawaiian honeycreeper family. In size and color the birds resemble large canaries, with yellow heads and bodies, but they have powerful crushing beaks like those of miniature parrots. About 4,000 of them still survive. On Laysan in the highly saline interior lagoon there are some handsome little ducks, unique to that island, that have been fighting nip-and-tuck with extinction since 1923. In that year only seven of them existed; today there are probably about 175. The ducks, the finches and the millerbirds would vanish quickly if rats became established on their islands. In 1969 a Japanese fishing trawler ran aground at a speed of eight knots on Laysan. After the men were rescued they swore a great nine-jointed oath that rats had never set foot on their vessel, but when he inspected the wreck Kridler found several boxes of rat poison. "I had nightmares about it for some time," he said, "but either there really weren't any rats aboard or they failed to get ashore. That time, anyway."

There were no signs that strangers had been prowling on Pearl and Hermes in the immediate past, so Kridler turned his eye to legitimate visitors, the turtles on the beach. A full-grown green sea turtle is surprisingly powerful and when it is alarmed it moves like a bulldozer across the sand, heading straight for the water. To capture the turtles, which were asleep, Kridler and Cunningham sneaked up on them from the side and turned them over with sudden strong charges reminiscent of interior line play in football. They were careful to avoid the turtles' flippers, which are hard and bony on the front edges and can break a man's wrist with a solid blow. They also took heed of the turtles' mouths —green sea turtles do not snap aggressively, but may bite off a hand if it is carelessly offered to them. The two men turned over four big tur-

Scrawny and bare, a newborn frigate bird (above) hugs its nest in a clump of solanum shrub on Pearl and Hermes Reef, waiting to be fed small pieces of fish and squid that its parents steal from boobies. The adult male at right, gliding to the nest on its seven-foot wingspan, prepares to disgorge tidbits to its young as its mate looks on. Adults also eat tern chicks and turtle hatchlings when such delicacies are in season—mostly in summer.

tles with little trouble. A fifth one awakened, however, and began making for the water. Cunningham jumped in front of it and put his foot on its head, shoving it down hard into the sand. The turtle halted and in a moment Kridler hurried over and flipped it.

When green sea turtles are overturned they cannot right themselves again as can various other members of their kind, including snapping turtles. Upside down they can survive for weeks or months and were often carried in that manner for fresh food on long sailing voyages, to be butchered when needed. Kridler's turtles, as though they had some dim racial recollection of this, lay on their backs without struggling, occasionally uttering long, loud sighs. Two of them already had numbered metal tags attached to the trailing edges of their right front flippers, close to the body, where Kridler or his fellow workers had placed them in previous years. He took note of the numbers and then tagged the others, using pronged tags that are pinched shut with pliers. The turtles seemed not to notice, apparently being fairly insensitive to pain. One of them had been attacked by a shark that had bitten a semicircular piece out of the side of its shell about the size of half a dinner plate. The wound had healed in the manner of bark covering a gash on a tree.

Kridler took the dimensions of the turtle shells with his caliper, measuring length, width and thickness of body, which in a fair-sized creature came to 38.1, 29.2 and 13.7 inches. In weighing the turtles he and Cunningham slid them one at a time onto a piece of heavy canvas that had a slack loop of rope threaded through metal grommets around its edge. When the rope was pulled taut the canvas enclosed the turtle as in a hammock. The rope was then hooked onto a spring scale fastened to the middle of a stout eight-foot pole. They strained to lift the pole on their shoulders and when the hammock was clear of the ground I read the scale. The fair-sized creature weighed 295 pounds. Released, right side up, it rapidly heaved itself over the sand into the water and swam off at what seemed great speed, although it was probably only about 10 miles an hour.

"We're building up a file of information on the migration and growth rates of these turtles," Kridler said. "They're not an endangered species yet, but they soon may be. They're a great delicacy and bring high prices on the market. Right now we're cooperating with a scientist at the University of Hawaii who's trying to figure out if they can be raised commercially." Thus far Kridler has recaptured a number of turtles that have traveled from island to island within the refuge, and to some of the main inhabited Hawaiian islands—as much as 600 miles at times.

It was midsummer noon. Pearl and Hermes is not far from the intersection of the international date line and the Tropic of Cancer, and the sun there is like a sledge hammer. The water and the white, coarse coral sand reflected light and heat. The young albatrosses, facing into the wind, stood with wings outstretched, occasionally waving them to exercise and strengthen them. To cool off, the birds rocked back on their heels, lifting the soles of their triangular webbed feet so that the air could circulate under them. Networks of fine blood vessels enable their feet to serve as radiators, dissipating body heat. It is an effective mechanism except in one regard: unlike land birds, sea birds have no strong rear toes to support them when they rock back, and albatross chicks take some humiliating pratfalls before they get the hang of it.

Not all of the albatross eggs on the island had hatched. Some had been infertile and now, several months old, they were baking in the sun, full of green slime and gas. *Pow!* If a man picked up one of them, joggling it, there was a fair chance that it might explode in his hand. Sometimes an egg would burst spontaneously when no one was near. The sound was like a small light bulb breaking but the smell was thunderous, fortunately soon swept away by the breeze.

Scattered along the beach were scores of corked or capped glass bottles, seemingly a strange litter to be found in the far wilderness of the sea. Almost all of them were liquor or Japanese sake bottles tossed overboard from trawlers, merchantmen and passenger ships in many latitudes and carried to Pearl and Hermes by the wind and the ocean currents—the Kuroshio, the California and the Equatorial—that create a slow-moving clockwise flow of water in the North Pacific. A well-stoppered bottle will float for years or decades in the currents, and since there are literally millions of them adrift, even the most remote islands become strewn with them. In fact the remote islands, rarely reached by beachcombers and souvenir hunters, have many more bottles than the accessible ones. Among perhaps 200 bottles on Pearl and Hermes, two had messages or, at any rate, communications in them. One contained a tract from a West Coast Bible society announcing good news for sinners: the word of the Lord will reach them even at the ends of the earth. The other contained somewhat more earthly comfort: a photograph of a pretty Japanese girl, some Japanese cigarettes and matches.

Among the beached bottles were Japanese fishing floats, beautiful hand-blown glass globes of pale green, light blue and lavender that are used to hold nets upright in the water or to support lines of baited

hooks. Many of them were the size of small grapefruit, others as large as basketballs and one, measured with Kridler's caliper, was nearly 16 inches in diameter. In use the floats are secured by light rope netting that sometimes breaks and sets them adrift. Occasionally in a storm a fishing boat may lose part or all of a tuna line, perhaps a mile long, with dozens of the big glass balls attached. They are eagerly sought by beachcombers in Hawaii, British Columbia, Washington and Oregon, who sell them to collectors and curio shops for as much as $50 apiece. There were at least 100 of various sizes on Pearl and Hermes, waiting for someone to pick them up.

In the heat of the afternoon Kridler took a census of some small birds commonly called Laysan finches. Canary-like, with heavy bills, they very much resemble Nihoa finches, and they too belong to the honeycreeper family. They are the only land birds on Pearl and Hermes and arrived as recently as 1967, when 50 pairs of them were transferred from their ancestral home on Laysan Island. They were in no immediate danger on Laysan, but it seemed a good idea to establish a colony of them on another island as insurance. To make an approximate count of the little birds, Kridler followed the wildlife biologist's standard procedure of sampling by transects, or swaths. At random in all parts of the island he selected 100 pieces of ground, each 100 feet long and 16½ feet wide, and walked down the center of each one, counting finches as he went. The population could be calculated by a ratio: the number of birds counted is to the total number of birds as the area of the 100 transects is to the total area of the island.

I set out to walk a few transects with Kridler. He began in the middle of the island, which was covered with wiry bunch grass in which the finches had built nests. On the ground between the bunches, terns were nesting too. Below the ground, in burrows they had dug in the soft earth, wedge-tailed shearwaters were nesting. Shearwaters are about 18 inches from bill to tail tip, gray brown above and whitish below, and can dig at a remarkable rate. It is very unsettling to walk across their nesting ground. Inevitably one steps on a concealed burrow, sinks to his knees in the earth and stands there horrified, not knowing if he has crushed an adult bird, a chick or an egg. Twice when I caved in their tunnels, adult shearwaters, hopping mad, dug their way out and scuttled and bounced away unhurt.

After 25 transects I left Kridler, found a patch of shade in the lee of a tent and sat watching him. Back and forth he went under the ham-

mering sun, changing direction, counting his steps, counting birds, sinking into the earth and getting up, plodding across the hot sand and coral rock. Kridler believes in the old-fashioned virtues and regards himself as employed not by the bureaucracy in Washington but by his fellow citizens. On that small island, although it was 6,000 miles beyond eyeshot of civil-service headquarters on the Potomac, he seemed to have no thought of dogging the job by walking only 72 transects or even 99. He walked 100. He was dripping with sweat and limping when he came over to the tent and sat down to work out his ratio. The 50 pairs of finches had multiplied in five years and now, he figured, there were about 350 birds.

In the afternoon, isolated clouds drifted over the green lagoon, and the reflection of the sunlight from the water tinted the bottoms of the clouds. It was a good strong tint that must have been visible for many miles, if anyone beyond the horizon had been looking for it. Polynesian sailors, who were among the best the world has known, used to find atolls by searching the sky for green-tinted clouds. At sea they also studied the flight of birds heading from their fishing grounds to their colonies to feed their young, and the men turned the prows of their seagoing canoes to follow. Now the birds were beginning to straggle back to Pearl and Hermes, carrying in their gullets and stomachs small fish and squid that they would regurgitate for their chicks.

Albatrosses feed largely on squid, and their digestive systems contain reservoirs of oily squid chowder. When a chick inserts its beak crosswise into its parent's beak the adult expels a jet of liquid that the chick catches so deftly that not a drop is spilled. Albatrosses continue to feed their young until they are five to six months old and almost ready to fly, and then abandon them. Thereafter the chicks, which drink salt water, may go without food for as long as two or three weeks, living on their body reserves. If they have not learned to fly and fend for themselves by then, they die. Many of those on Pearl and Hermes had already been abandoned and a man could tell almost at a glance which of them were going to live, and which not. The weaker birds would stand in one place day after day, scarcely moving, while the stronger would continue to exercise their wings preparing for their long flight out to sea.

Some of their short practice flights, however, ended in quick death. The chicks would land 20 or 30 yards offshore and while they drifted with outstretched wings sharks would drag them under. The annual feast of albatrosses had attracted to the island a large number of sharks.

Member of a species once found only on Laysan Island, a Laysan finch, shown nibbling seeds of setaria grass, is one of a growing colony introduced to Southeast Island on Pearl and Hermes Reef in 1967. The bird's right leg has been banded for identification. The island's only land birds, Laysan finches feed on insects and grass seeds. In choosing nesting grounds, they favor the dense matting of eragrostis grass on the island's sheltered side.

among them reef whitetips and tigers, which sometimes swam so close to the beach that their bellies appeared to rub the sand. A few years ago on Midway, sailors from the naval station caught a 16-foot tiger shark and strung it up on a pole to take its picture. After a couple of bushels of wet feathers had oozed out of the shark's mouth the sailors cut it open and found 13 young albatrosses inside.

Among the birds coming home to feed their young there were a number of boobies, so called because of their apparent stupidity, although that may not be quite the word to apply to them. The three species on Pearl and Hermes have a persecuted, frantic look that fits well with their names—the blue-faced booby and the red-footed booby, which are white, and the brown booby. The adults are about 18 inches tall and appear to be hard-working conscientious birds. By day they toil in their watery vineyard, dipping into it for squid and skimming over it to catch flying fish, and when they have a full basket for their chicks they try to get it home without being hijacked. They fly low, as though trying to escape the notice of the piratical frigate birds, but this is not much use. The frigates plunder them anyway.

Frigate birds, also called man-o'-war birds, are nearly as large as albatrosses although lighter, blackish in color and with wingspreads that approach seven feet. They have long, deeply forked tails, which in flight they open and close like shears. They are absolute masters of the air, remaining aloft indefinitely by riding currents, although they can also perform acrobatics and can put on a handsome turn of speed. When the boobies and tropic birds come home loaded late in the day, the frigate birds dive down on them and sometimes even grab them, forcing them to cough up their catch. Before the falling fish or squid can hit the water the frigates swoop down and gobble it up. Luckily most boobies carry more than one fish. In *Birds of Hawaii* ornithologist George C. Munro quotes an observer who is "positive that [the booby] always gives up a flying fish to the frigate, retains a squid for its young and a flying fish for itself." Whatever the case, the look of the boobies is not so much one of stupidity as of extreme exasperation verging on lunacy.

Frigate birds have their own problems. I watched one commit a mid-air robbery and take the fish home to its own chick. The frigate glided in, braked, hovered over the nest and then collapsed on it like a broken umbrella. After countless generations of airborne existence the legs and feet of frigate birds are atrophied, weak and useless except for perching. The birds cannot walk. When they land they must come down on a spot with some elevation, however slight, so that they can take off

again without the aid of an upward push with their legs. Their great wings can make the most of the smallest updraft, but if they chance to land on a flat place on a calm day they must do a great deal of flapping and floundering before they can become airborne once more.

After dinner Marvin Cunningham, the Navy hospitalman, said that he had found a dead seal, and we walked over to have a look at it. The animal had been dead for a couple of months and there was no longer much odor. It was on the coral-reef side of the island, lying in a few inches of water in a tiny protected cove. Small waves, only a few inches high, had been lapping at the carcass and had neatly separated most of what remained of the flesh from the bones, so that Cunningham's task was mainly to gather them up and put them in a huge plastic bag. The action of the waves had detached some of the smaller bones and teeth from the skeleton. Cunningham searched carefully for them in the water, meanwhile talking about the unusual characteristics of seals.

Seals can dive to remarkable depths—a few have been caught by accident on fishhooks as far as 500 feet or more under water. One reason for their remarkable swimming ability is that most seals are so streamlined; they have no protuberances anywhere. The sex organ of the male is recessed and can be thrust out through a slit in the body when needed. To assist in this the seal has a baculum, or penis bone, that is also found in some other mammals, although not in the primates. It is not firmly attached by ligaments to other bones and thus it can readily become separated from the rest of the skeleton. In the case of Cunningham's seal this had already happened and he looked right and left for the bone in the shallows. "We can't send an incomplete skeleton to a museum," he said.

"God forbid," said a coworker, joining in the search.

At length Cunningham found the bone, which resembled a small ivory pencil, and put it in the plastic bag with the others. When he got the skeleton back to Midway Island he would put fresh water and detergent in the bag, and after some soaking, scrubbing and drying it would be ready to pack and ship.

Night, in contrast to the shattering dawn, seems to fall slowly in the mid-Pacific. It takes the stars a long time to drill holes in the sky. When it was dark Kridler made another patrol of the island. On the beach, barely visible against the sand, hundreds of little nocturnal ghost crabs glided back and forth. The flimsy tower with its guano-covered jerry can loomed like a scaffold. The sooty terns, which fly all night calling

out their other name, "wideawake, wideawake, wideawake," swooped low overhead. As we approached the grassy center of the island Kridler stopped, listening. At first I could hear only the noise of the terns but then beneath it emerged a hair-raising sound, exactly like the sound of men and women, barely conscious, in agony. There were long-drawn-out feminine moans answered by masculine groans; wordless noises of heartbreak and grief; mournings, wailings and low lamentations. Certainly no other birds, and probably no other living creatures except humans, make such sounds. It was a colony of tunnel-digging shearwaters. They were singing.

In the morning Kridler and Cunningham set out to tag some seal pups. Hawaiian monk seals come ashore on Pearl and Hermes and other refuge islands throughout the year. Like humans, they are fond of wriggling on the sand until they have made a comfortable pillow and bed, where they doze in the warm sun. They are trusting creatures who have no enemies but man on land, and in the sea only the shark. A man can approach within four or five feet of them before they show any alarm, and even then they merely grumble about being disturbed and do not become belligerent. Females with pups will roar and try to bite anyone who threatens their pups, but this is not very surprising. The faces of the seals seem wise and pensive, with drooping whiskers and sad eyes. They appear to be weeping, and in fact they are. Unlike most mammals, seals have no tear ducts to drain off internally the fluid that lubricates their eyes. Instead, the fluid overflows externally, rolling down their cheeks in streams of seeming sorrow.

When seal pups are born they weigh about 35 pounds and are covered with beautiful glossy black fur, for which they would be clubbed to death if hunters could get at them. They grow at an incredible rate, drinking huge quantities of milk, and may reach weights of 200 pounds within six to seven weeks, after which they are weaned. Once on their own, they shrink to perhaps 100 pounds and begin an orderly growth until they become eight feet long and weigh 650 to 700 pounds. They moult their black baby fur six to seven weeks after birth, eventually becoming soft grayish brown above and light gray on their stomachs.

Kridler and his coworkers have been tagging seal pups since 1966 and have become very adept at it. There were a half-dozen pups on the beach with their mothers and he tagged each one in a matter of three or four minutes. Cunningham would distract the mother, waving his arms, jumping and shouting, while Kridler slipped in behind and quickly fastened a tag in the webbing of the pup's hind flipper. During this

operation one of the pups became so far separated from its angry parent that it seemed safe enough to pick it up. I held the pup in my arms for a few moments, looking at its friendly unsuspicious face, and put it down when a big tear welled out of the corner of its eye. The pup hurried off to join its mother and the two immediately touched noses, which is apparently the seals' way of reassuring each other.

After the last of the pups had been tagged, we waited on the beach for the Navy helicopter from Midway to pick us up. An adult seal was swimming lazily about 50 feet offshore and Kridler was taking pictures of it. It was then that we saw the shark's fin cutting through the small waves, fast, in a straight line for the seal. Within seconds there was a thrashing in the shallow water where the two had met.

We wear, all of us, the old mammal school tie. Our blood is warm. We rarely think, until we see and become emotionally involved in a fight between a fellow mammal and a damned shark, just how strong our loyalty is. I glanced at Kridler, who was trying vainly to get pictures of the underwater struggle. He was yelling encouragement to the seal and so was I. We shouted until we were hoarse, both of us prejudiced, bloodthirsty mammalian chauvinists to the core.

What can a seal do against a shark? I had read that porpoises had been known to fight sharks. They form a ring around their enemy, and while a porpoise on one side of the ring makes a diversionary movement, another on the opposite side dashes in and rams the shark with the top of its head. In short order they batter the shark to death. But a lone seal? For an instant as I stared into the water I thought of *The Threepenny Opera* by that outstanding German mammal, Bertolt Brecht, and the translation, "When the shark bites with his teeth, dear/ Scarlet billows start to spread. . . ."

But there were no scarlet billows. God knows what the seal did to the shark, but after a few wild flurries the shark turned tail and swam off, beaten. The seal continued to laze along in the water, parallel with the beach, and then hauled itself ashore about 50 yards away. There was not a mark on her, or him. It is too much to think that the seal understood our cheering, any more than it understood the gigantic bird that soon came rattling down, swallowed us, and flew away.