 Waikiki Aquarium

Hawaii p.170 L. Gaut Case #292
p.170 Case #410 Diamond Head 1904
p.179 Case #424 Pearl Harbor

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Barbers Point

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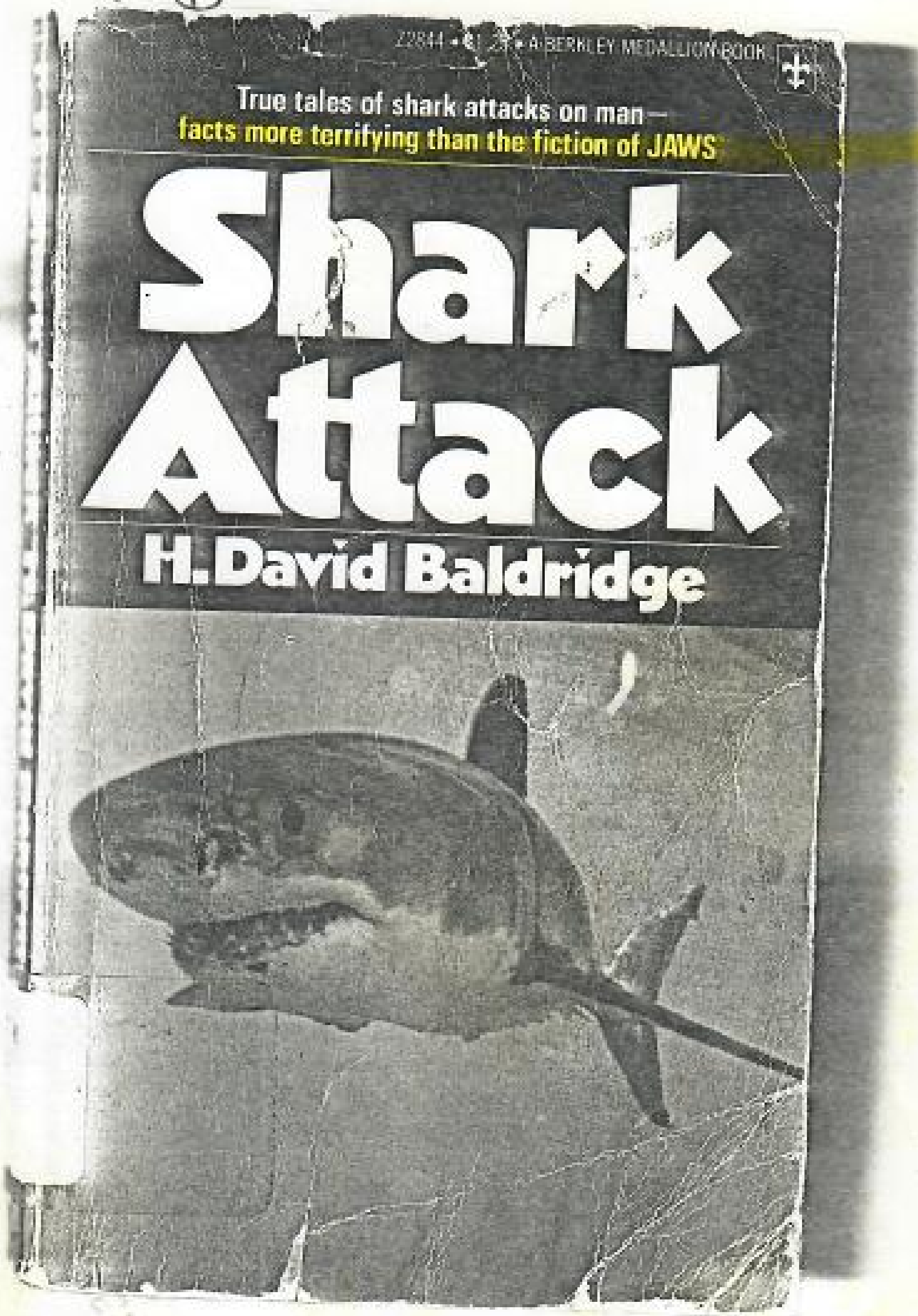
p.235



"The two men carried Jordan to the beach and immediately commenced resuscitation. It was only then that they realized the extent of his wounds. The right leg had been amputated through the knee joint. Behind the leg just above the knee joint there was a gaping wound, the edge of which showed four teeth marks. The inside calf of the leg was deeply lacerated with what appeared to be tooth marks above and below the wound. All efforts failed to elicit any sign of life, and the victim never regained consciousness. Later post mortem findings indicated that he had become unconscious from loss of blood and shock while being brought in, and in that state had inhaled a quantity of water leading to death by drowning."

"WHAT," asks the author of *Shark Attack*, "COULD POSSIBLY EQUAL BEING EATEN ALIVE BY A MONSTER FISH?"

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To my son, David

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CONTENTS

AGE DETERMINATION, GROWTH, AND ENERGETICS OF THREE SPECIES OF CARCHARHINID SHARKS IN HAWAII

A THESIS SUBMITTED TO THE GRADUATE DIVISION OF THE
UNIVERSITY OF HAWAII IN PARTIAL FULFILLMENT
OF THE REQUIREMENTS FOR THE DEGREE OF

MASTER OF SCIENCE

IN OCEANOGRAPHY

AUGUST 1984

By

Mark A. De Crosta

Thesis Committee:

Jed Hirota, Chairman
David M. Karl
Leighton R. Taylor

We certify that we have read this thesis and that in our opinion it is satisfactory in scope and quality as a thesis for the degree of Master of Science in Oceanography.

THESIS COMMITTEE

Jed Pirota
Chairman

David M. Karl

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ABSTRACT

Three species of carcharhinid sharks are the most abundant top predators in the shallow water (< 150m) reef community in the Northwestern Hawaiian Islands (NWHI), but very little is known about their growth and energetics. These sharks are the gray reef shark (Carcharhinus amblyrhynchos), the Galapagos shark (C. galapagensis), and the tiger shark (Galeocerdo cuvier). In order to develop a fisheries management plan for the NWHI, it is necessary to know the diet and energy needs of these top predators as well as their annual production, which is a function both of their population sizes and growth rates.

Vertebral samples from 62 gray reef, 45 Galapagos, and 28 tiger sharks were obtained. Vertebral centra were cleaned and stained with silver nitrate to allow the visual inspection and counting of presumed annual growth rings. These age data were used in conjunction with length and weight information to generate growth curves and growth rates for the three species. The estimated von Bertalanffy growth curves for pre-caudal length (L) were:

$L_t = 134$ cm $(1-e^{-0.294(t + 0.869)})$ for the gray reef shark;

$L_t = 230$ cm $(1-e^{-0.172(t + 0.541)})$ for the Galapagos shark; and

$L_t = 335$ cm $(1-e^{-0.155(t + 0.619)})$ for the tiger shark. These curves correlate well with independent curves obtained from length frequency analysis of earlier fisheries statistics for these sharks in Hawaiian waters. The close correspondence between the two types of estimates of growth used is taken as verification of the annual nature of the

vertebral rings in these sharks.

Respirometry measurements of captive sharks combined with the growth information enabled computation of ingestion rates by solving a simplified energy budget. Estimates of population sizes were made from catch per unit effort data and the sharks' diets were determined through stomach content analysis. All these data were combined to estimate the predatory impact of these sharks on the shallow water reef fauna of French Frigate Shoals, Midway, Maro Reef, and Pearl and Hermes Reef.

This information is of importance in making fisheries management decisions because of the apex trophic position of these predators. The tiger and Galapagos sharks are the two largest vertebrates in the reef ecosystem and therefore have correspondingly large energy needs. This is of some interest since the tiger shark is known to prey on the endangered green sea turtle and Hawaiian monk seal. Future research into the energetics and population dynamics of these species of sharks will help refine estimates of the impact of fisheries development in these ecosystems.

FIGURE 2. -- Growth of Carcharhinus galapagensis with the von Bertalanffy growth curves calculated from the age determination data (solid line), L_t = 230 cm $(1-e^{-0.172(t + 0.541)})$, (mean pre-caudal length of year class indicated by dots, range by bars, and sample size by numbers); and from a length frequency analysis of data from Tester (1969) (dashed line), L_t = 230 cm $(1-e^{-0.197(t + 0.670)})$ (L_t= pre-caudal length in cm, t = age in years)

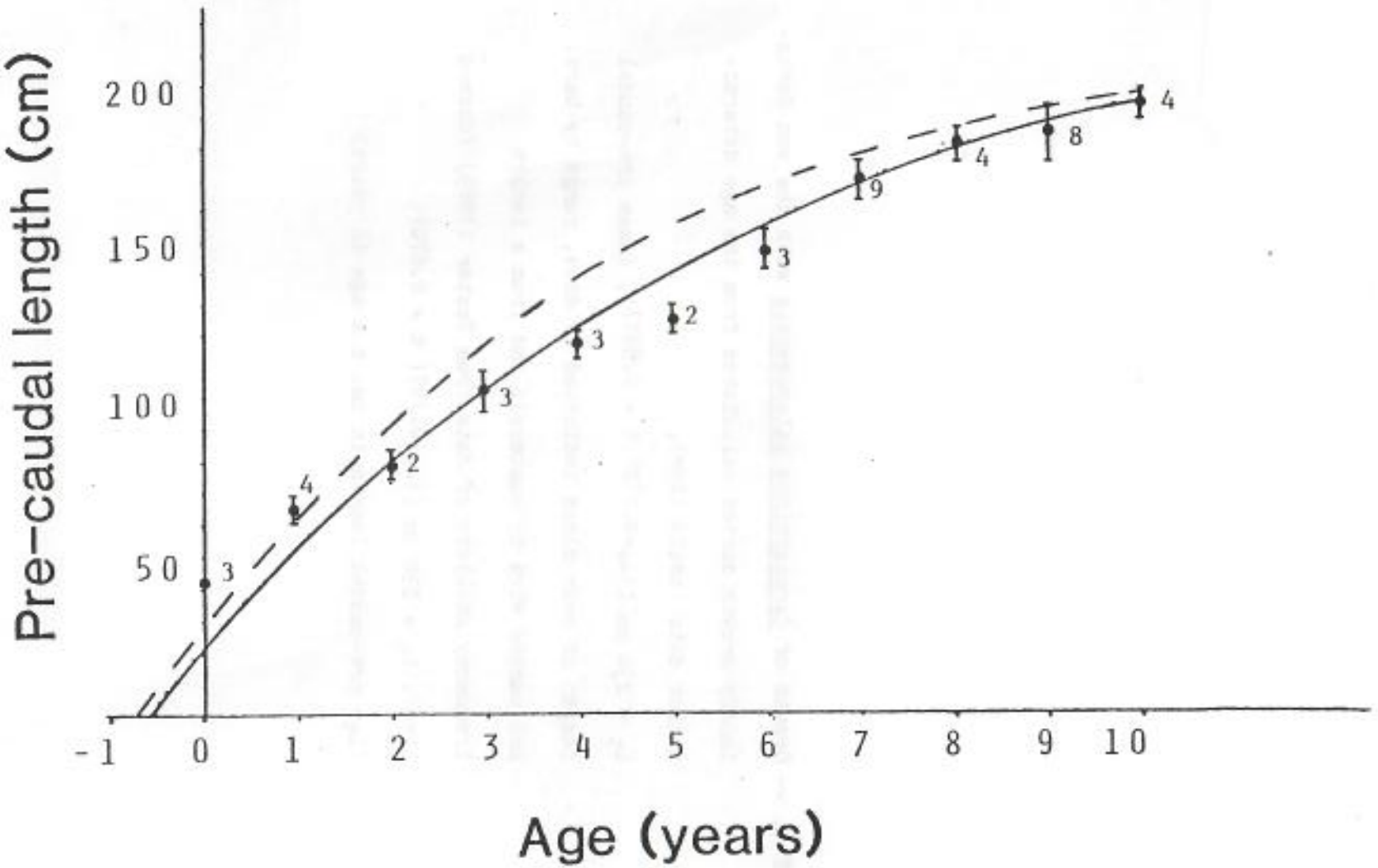
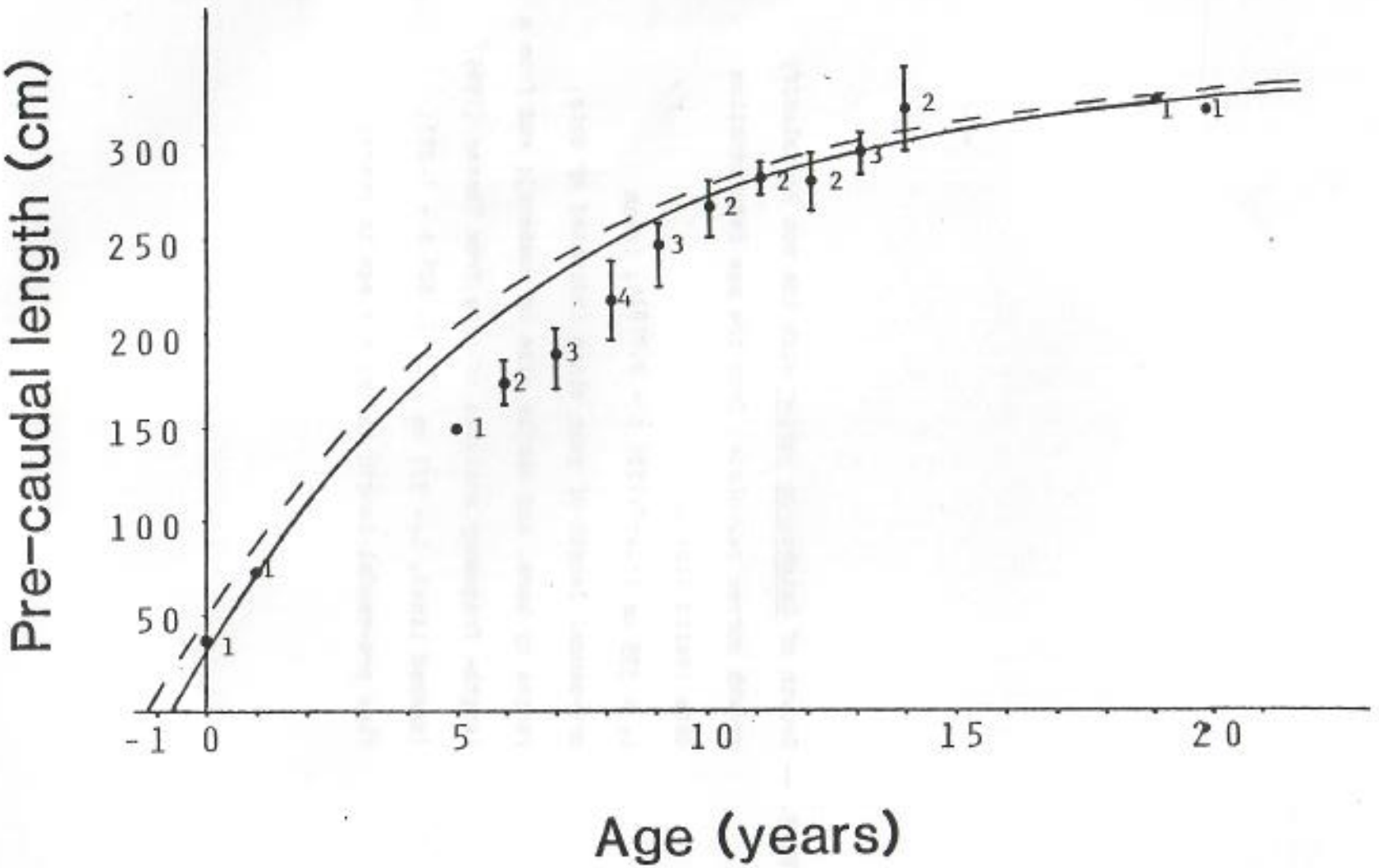

Pre-caudal length (cm)
200
150
100
50
-1
0
1
2
3
4
5
6
7
8
9
10
Age (years)

FIGURE 3. -- Growth of Galeocerdo cuvier with the von Bertalanffy growth curves calculated from the age determination data (solid line), L_t = 335 cm $(1-e^{-0.155(t + 0.619)})$, (mean pre-caudal length of year class indicated by dots, ranges by bars, and sample size by numbers); and from a length- frequency analysis of data from Tester (1969) (dashed line), L_t= 337 cm $(1-e^{-0.150(t + 1.27)})$ (L_t= pre-caudal length in cm, t = age in years)


Pre-caudal length (cm)
300
250
200
150
100
50
-1
0
5
10
15
20
Age (years)

These growth rates in pre-caudal length were then converted from length-mass curves to growth rates in terms of mass for energy budget determinations (Table 4).

Respiration

The mean respiration rate for six individual Carcharhinus melanopterus was determined to be 249 mg O/kg live mass/hr with a standard deviation of 26.9 (Table 5). This value agrees well with the range for lemon sharks (Carcharhiniidae: Negaprion brevirostris), 200-300 mg O/kg live mass/hr (Gruber, personal communication). Because oxygen consumption is related to the surface area of fishes, which is $M^{2/3}$ (von Bertalanffy 1960) or empirically related to the $M^{3/4}$ (Whittow, personal communication), a relation of $B = 665\ M^{2/3} - 493$, ($r = 0.949$) was determined by regression analysis using an assumed exponential of 2/3. This equation was used to extrapolate the oxygen consumption to large sharks for which no direct measurements were made.

Diet

The results of the stomach content analysis are given in Table 6. As shown by these data, the tiger shark is a very opportunistic feeder, preying on a wide range of fauna. Closer examination reveals a high occurrence of seabirds (75%) and green sea turtles (33%) in their diet. Lobsters (30%) and cephalopods (22%) also comprise a large part of the diet. Compared to other sharks, tiger sharks seem to prefer the slower moving "well protected" tetraodontiforms (15%).

The Galapagos shark has a narrower range of diet items and seems

TABLE 5. -- Mass specific respiration rate of juvenile Carcharhinus melanopterus at 24 - 25°C, flow rates of 4 - 6 ℓ/min, and at oxygen concentrations between 3 - 6 ppm.

PRE-CAUDAL LENGTH (cm)	MASS (kg)	SEX	OXYGEN CONSUMPTION (mg O/kg live mass/hr)
45.5	1.36	F	265
47.5	1.50	F	264
48.9	1.84	F	291
46.0	1.62	F	236
44.5	1.10	M	203
45.6	1.40	F	229
			258
		MEAN - 249	
		STANDARD DEVIATION - 26.8	

TABLE 6. -- Percent occurrence of food items in sharks with identifiable stomach contents expressed as those sharks containing a food item out of all the sharks for that species with identifiable stomach contents (N = number of sharks with identifiable stomach contents)

Prey Items	Carcharhinus amblyrhynchos	Carcharhinus galapagensis	Galeocerdo cuvier
Monachus shauinslandi	0	0	7.1
Stenella longirostris	0	0	7.1
Aves	0	0	75
Chelonia mydas	0	0	33.3
Chondrichthyes	0	0	7.1
Anguilliformes	12.4	14.1	3.6
Muraenidae	0	3.6	0
Congridae			
Ariosoma sp.	2	0	0
Ophichthidae			
Myrichthys maculosus	2	0	0
Beloniformes			
Cypselurus sp.	0	0	3.6
Gastereosteiformes			
Aulostomus chinensis	2	0	0
Mugiliformes			
Sphyraena sp.	0	0	3.6
Perciformes	51	28.3	14.8
Apogonidae	0	0	3.6
Carangidae	0	0	3.6
Scaridae	2	7	0
Scarus sp.	2	3.6	0
Calotomus sp.	0	3.6	0
Acanthuridae			
Acanthurus nigroris	2	0	0
Cottiformes			
Scorpaenidae	2	3.6	0

TABLE 6. (Continued) Percent occurrence of food items in sharks with identifiable stomach contents expressed as those sharks containing a food item out of all the sharks for that species with identifiable stomach contents (N = number of sharks with identifiable stomach contents)

Prey Items	Carcharhinus amblyrhynchos	Carcharhinus galapagensis	Galeocerdo cuvier
Tetraodontiformes	2	21.3	14.8
Balistidae	0	3.6	3.6
Monocanthidae	2	14.3	3.6
Pervagor spilosoma	2	10.7	3.6
Diodontidae	2	3.6	7.1
Diodon sp.	2	3.6	7.1
Chilomycterus affinis	0	0	3.6
Decapoda	4	0	29.6
Heterocarpus	0	0	3.6
Palinuridae	2	0	25.9
Panulirus marginatus	2	0	11.1
Scyllaridae	0	0	18.5
Scyllarides squammosus	0	0	11.1
Cephalopoda	22.4	42.9	22.2
Octopus sp.	20.4	39.2	14.8
Teuthoidea	4	10.7	18.5
Charonia tritonis	0	0	7.1
	N = 49	N = 30	N = 28

to prefer cephalopods (43%). This may be expected since these sharks tend to be deeper down on the bank. Fish make up a large part of the diet with tetraodontiforms (21%), eels (14%) and parrotfish (7%) occurring most frequently. Compared to the other two sharks, Galapagos sharks are the most restricted in their diet, generally not feeding on Decapoda or any of the higher vertebrates (Table 6).

The gray reef shark is the most highly piscivorous of the three, with perciform fish occurring most frequently (51%). Gray reef sharks do eat a wide range of fishes, however. Cephalopods (22%) also make up a major part of their diet, but only about half the level found in Galapagos sharks.

Population Size

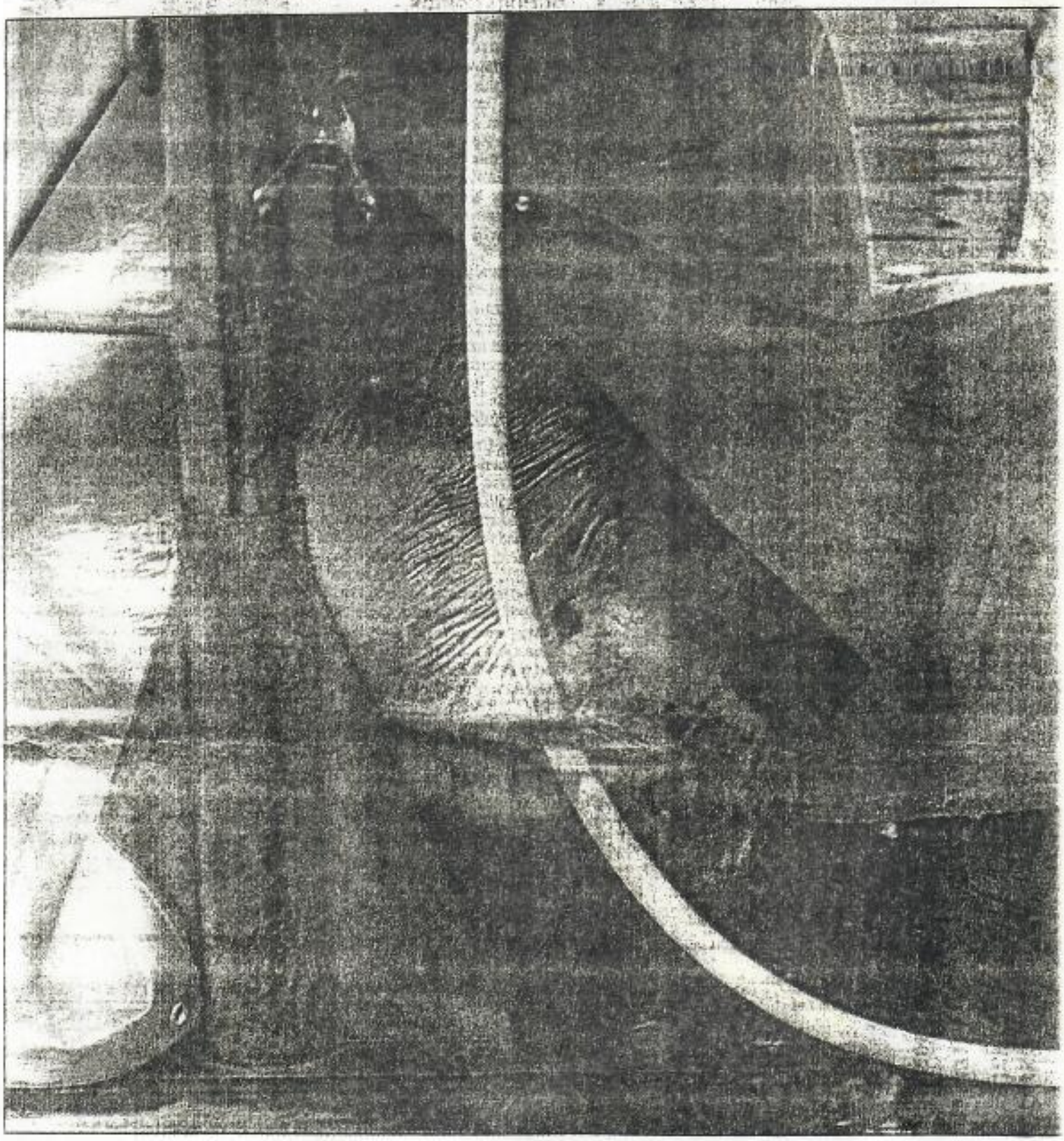
Population estimates for each of the three shark species were made from French Frigate Shoals, Midway, Maro Reef, and Pearl and Hermes Reef (Table 7). The differences between these areas can be attributed to the different sizes of the habitats available to the sharks. While gray reef sharks were caught by handlining at Pearl and Hermes Reef, none were caught by longlining so their population could not be estimated. The values given in Table 7 were used to determine the shark population predation on other species.

TABLE 7. -- Population estimate of each shark species at four areas in the Northwestern Hawaiian Islands (N - number of sharks, r - correlation coefficient of regression of ln(catch/effort) vs. cummulative effort, * - none captured; all r values are significant at the 5% level)

Island	Carcharhinus amblyrhynchos		Carcharhinus galapagensis		Galeocerdo cuvier	
	N	r	N	r	N	r
French Frigate Shoals	826	0.821	703	0.797	504	0.809
Midway	237	0.906	190	0.724	157	0.998
Maro Reef	319	0.934	1452	0.387	105	0.289
Pearl and Hermes Reef	*	*	441	0.739	2605	0.730

March 11, 1994 Maui News

'Crowfoot' has a 'Jaws' proble



Hunting killing

[illegible] of shark for prop in movie angers Native Hawaiians

By ANDREW JACOBY
For The Maui News

LAHAINA — The use of a 14-foot tiger shark as a prop in the TV movie "Crowfoot" now filming in Lahaina has brought critical reviews from a number of Native Hawaiians on Maui.

The shark was caught Tuesday approximately a half-mile off the Lahaina breakwall and covered with a blue tarpaulin until it was strung up for a scene Thursday.

In the Paramount Pictures movie, whose title character is a psychic German-Native American police detective, it is discovered that the shark devoured a female character who was pushed overboard from a speedboat off the Molokai coast.

The sight of the behemoth led several Native Hawaiians to call The Maui News to complain about the shark killing. Native Hawaiian cultural specialist Charles Kauluwehi Maxwell Sr. also heard from upset callers.

"They were very irate about this ....." Maxwell said this morning. "If they killed a shark just for the sake of making a movie then it's abusive to the people who live here and it should be stopped, period.

"This is a prime example of the insensitivity of people who come from the Mainland in regards to the Hawaiian culture," he said. "They think that Hawaii is like any other state in the union, and it's not. This is the State of Hawaii and its culture goes back thousands of years. That culture is surviving today in Hawaii and has to be respected."

Georja Skinner, newly appointed film commissioner for the County of Maui, said this morning she was surprised that a real shark had been caught after Paramount had been advised not to do so.

"We had originally advised them to take great precautions if they were going to use a shark in the show," said Skinner. "We advised them to get a plastic shark or a shark caught outside Hawaiian waters. I was surprised to find that they hired someone to catch a shark and hoped it was outside Hawaiian waters."

The controversy over shark hunting began when the state launched a hunt for the tiger shark that killed Maui resident Martha Joy Morrell Nov. 26, 1991, at Olowalu.

At that time, Maxwell and other Native Hawaiians expressed anxiety that shark fishermen would harm "aumakua," the deified ancestors of some Hawaiian families.

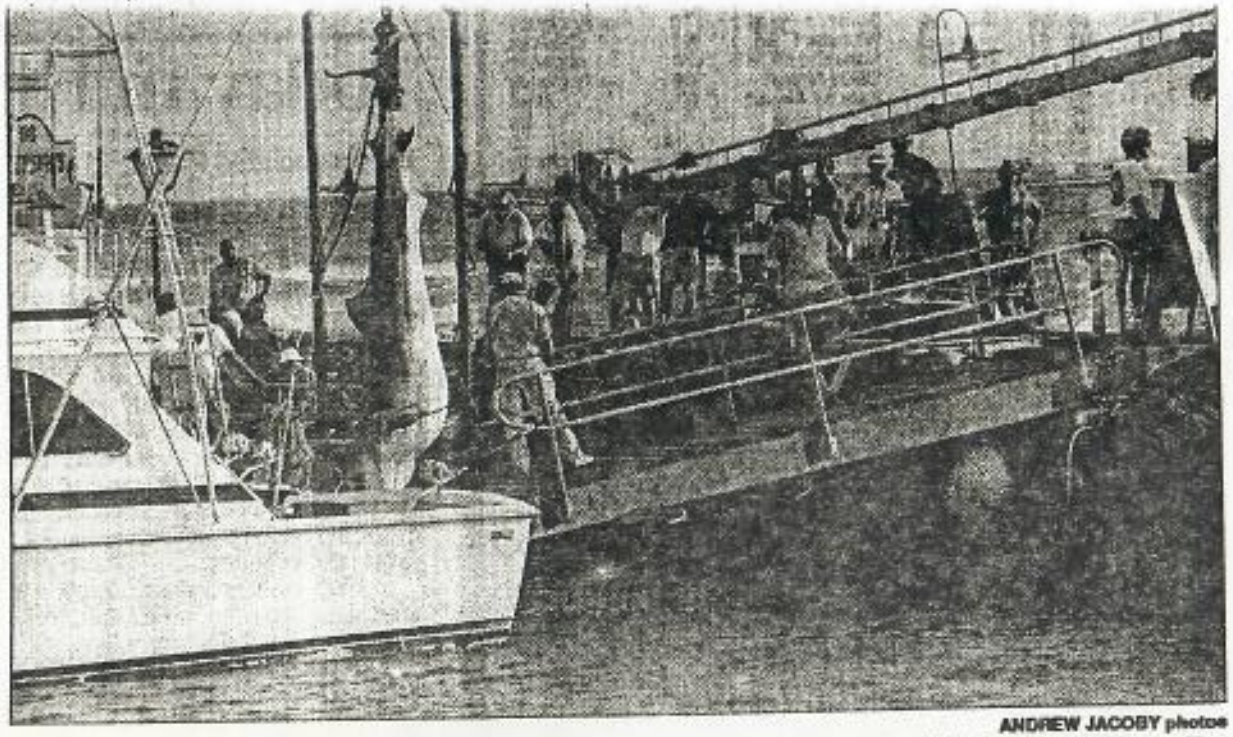
According to Hawaiian culture and history, aumakua are gods created when a family member died. Their spirit would take the shape of a shark or other animals.

In families whose aumakua was the shark, the predatory fish would take on the name of the deceased relative and family members would recognize and know that shark by name, feeding it and taking care of it.

While Maxwell doesn't worship in the manner of the ancient Hawaiian religion, he said Hawaiian culture must be treated with respect.

In January 1993, Maxwell quit the state's Shark Task Force in protest of continued shark hunts by the state, saying he couldn't support the random eradication of

See NATIVE HAWAIIANS on the last page of this section



ANDREW JACOBY photos

Producers of the Paramount Television movie "Crowfoot" hired a fisherman to catch a shark to be used as a prop in the movie. The fisherman snared a 14-foot tiger shark, which was filmed Thursday afternoon at Lahaina Harbor. The bulge in the belly is a sea turtle consumed by the shark. The use of the shark as a prop has angered a number of Maui residents.

The Maui News / MATTHEW THAYER

Robert Mark Edwards reac the jury's guilty verdicts.

Killer still face

By LIZ JANES
Staff Writer

WAILUKU — The Maui proceedings against convicted derer Robert Mark Edwards are ly over, but the 33-year-old man still has a California case in his future.

Edwards was convicted Thur of second-degree murder for the 26, 1993, strangulation deat Muriel E. Delbecq. He faces mu life terms with the possibility o role when he is sentenced May

Murder trial

Killer still faces proceedings in California

Continued from Page A1

background, found he had 18 convictions in California ranging from auto theft to burglary.

According to a report in the Orange County Register, the California parole officer who talked to Maui police was familiar with the 1986 Los Alamitos murder of Marjorie Elaine Deeble, 55, and connected it to details of the Maui case.

Edwards had been a suspect in the California case, but it was not until details of the Delbecq murder became known to California authorities that the capital murder complaint was issued against Edwards on Aug. 11 of last year.

Rick King, deputy district attorney for Orange County, said in a telephone interview following the Maui verdict, that as soon as Edwards is sentenced, a request will be issued for his return to California. King said his office has not yet determined whether they will be seeking the death penalty for Edwards.

The two killings, seven years apart, seem to have much more than coincidental similarities.

Both women were older than 50. Both had the initials M.E.D., initials that make up part of Robert Mark Edwards' name. Both victims were real estate agents and lived alone in ground-floor apartments. Both killings occurred on a Monday night.

In both cases, a window screen was removed to get into the apartment. Both women were asleep in the bedroom at the time the killer entered. Both were strangled, although Deeble was strangled with a rope or cord and Delbecq was manually choked.

Both women were beaten and suffered broken noses. Both were bound with telephone cords on their wrists and ankles. Both were sexually assaulted with a can of hair mousse.

The bedrooms of both women were ransacked and jewelry stolen in both cases. The diamond and platinum wedding ring Delbecq always wore was missing from her finger when her body was found the morning after the murder.

According to Orange County court documents, Edwards lived near Deeble and dated the victim's daughter shortly before and after the May 16, 1986, killing. DNA analysis of semen taken from the murdered woman's thigh matched Edwards's DNA profile but not conclusively.

It wasn't until details of the Maui case surfaced that California authorities saw both killings as possible signature crimes.

Relief filled courtroom after verdict read

Continued from Page A1

lace-up boots.

The jury filed in. Edwards and his attorney stood. The jury foreman handed the verdict to the bailiff, who passed it to the judge.

The guilty verdict was read by the clerk count by count, beginning with first-degree burglary and ending with second-degree murder.

After the final "guilty as charged," there was an almost tangible feeling of relief and completion. Edwards closed his eyes for a moment, but his body betrayed no sign of emotion.

Mossman made a special point of thanking the jurors for their work in what he called "a significant trial in our community."

Members of Delbecq's family tearfully hugged one another. Del-

gut-wrenching detail. They had come from Alaska, Oregon and Ohio for justice and mutual support.

"Just thank you to everyone," said Peggy Ventura, Delbecq's Maui daughter, after the verdict. "Justice really does work."

Family members praised the work of the prosecutors and the police, and expressed thanks to people in the community for their support and prayers.

Later, they met up with a few members of the jury outside the courthouse. There were more hugs, more tears, more thanks.

The jury foreman, who did not want his name used, said it was difficult to sit through the grim evidence presented during the trial without being able to discuss the case with anyone, not even other jurors.

He said the evidence affected him to the point he was hard to live with

Native Hawaiians angered by use of shark as a prop

Continued from Page A1

sharks.

Now that the damage has been done in this latest incident, Skinner said she hopes a lesson has been learned.

"On the positive side, it is a lesson for our visitors from the Mainland who come to shoot here that the culture must be respected," she said. "If there is more filming then we just can't allow this to happen."

Skinner added praise for the Paramount crew. "These are great people to work with. The producers and the directors are all very concerned and want to complete the cycle of what they started, to right the wrong."

Maxwell said he will be meeting with the production crew at around 4:30 p.m. today to get more details about the shark killing and to "culturally put it back together."

He said the skin, teeth and other parts of the shark will be removed so that "at least it served a purpose." The carcass then will likely be discarded back at sea.

Filming in Lahaina town for "Crowfoot" began Monday and is scheduled to conclude Monday.

State expanding Hula Mae housing finance program

HONOLULU (AP) — The way is open for some 1,900 low- and moderate-income Hawaii families to get a much-better-than-market deal on a home mortgage.

Gov. John Waihee announced Thursday that the state's Hula Mae program is being expanded with the issue of more than $237 million in tax-exempt revenue bonds. It offers fixed low-interest loans to qualified first-time home buyers.

Prospective homebuyers can learn more about the Hula Mae loans by contacting a participating bank or mortgage company.

Waihee said the interest rate of 6.375 is the lowest ever in the 15-year-old Hula Mae program and is about one point below the current market rates.

With a down payment requirement of only five percent combined with an increasing supply of "affordable" homes, the program should make home ownership a possibility for

Bosnia lawma

By DAVID BRISCOE
The Associated Press

WASHINGTON — A girl from embattled Bos an acclaimed book, wa let members of Congre to looking at the wo adults do.

Testifying Thursday monitors the Helsinki security and human rig Zlata Filipovic descrit like to be a child caugh repeatedly steered aw views of her polite a awestruck interrogators.

Zlata, whose diary best-seller in France published worldwide, in her hometown of S see themselves as Serbs Muslims.

"We just knew that t that any moment we ca she said.

Rep. Chris Smith, R- impressed with Zlata's testimony, delivered in glish, that he urged her fice when conditions Bosnia-Herzegovina.

But Zlata, sitting at witness table in a scho blue sweater and white all she wants is to g maybe attend a univers ried and lead "just a nor

She also turned aside by Smith that prayer and gave her strength to with deal, which ended wi

Wilfred 'Sonny' T 66, community l politician, busine

Wilfred "Sonny" M 66, of Kula, died Marc his residence.

A wake will be held p.m. Sunday at Borth ary/Norman's, with a p.m. Visitation continu 8:30 a.m. at Holy G with a Mass at 10 a.m

TABLE 8. -- Concentration of sharks (number sharks/100 km^2) at four habitats in the Northwestern Hawaiian Islands over different depth ranges for each species (* - none captured)

	Carcharhinus amblyrhynchos (0 - 90 m)	C. galapagensis (35 - 180 m)	Galeocerdo cuvier (0 - 180 m)
French Frigate Shoals	93	324	50
Midway	81	74	38
Maro Reef	83	333	18
Pearl and Hermes Reef	*	87	264

prey items. The ingestion rate calculated from the energy budget for each age class for each species was multiplied by the number of sharks in that age class as determined by the estimate of the population of sharks for each island and the age class distribution of the sharks caught (Tester 1969, and this study). These values were then totalled by species. French Frigate Shoals yielded a value of 1.25×10^8 kcal/yr for the gray reef shark, 2.56×10^8 kcal/yr for the Galapagos shark, and 3.73×10^8 kcal/yr for the tiger shark (Table 9). An independent estimate of the total ingestion rate was also obtained by dividing the sum of the total growth and energy allocated to reproduction by an assumed average gross growth efficiency of 20% (Table 9). These latter calculated values are between 5 and 8 times lower than the former estimates from the energy budget determinations. This is probably due partially to an underestimate of the value for reproduction and partially due to the uncertainty associated with extrapolation of respiration from small to very large sharks. Using both these estimates, however, a range of possible values can be calculated, and it appears that each shark population ingests approximately $10^7 - 10^8$ kcal/yr at French Frigate Shoals.

An analysis of the diet of these three species of sharks shows the percent occurrence of food items found in the sharks (Table 6). From these data we can see that the gray reef shark is highly piscivorous, though some cephalopods are eaten. The Galapagos shark on the other hand, seems to prefer cephalopods by a factor of two more than gray reef sharks. The tiger sharks seem to be the most

TABLE 9. -- Determination of total ingestion or energy needs for the population of sharks at French Frigate Shoals using a gross growth efficiency of 20% and an assimilation coefficient of 0.90 (kcal/yr)

	Carcharhinus amblyrhynchos	C. galapagensis	Galeocerdo cuvier
$I = \frac{G + R}{0.20}$	1.64×10^7	4.87×10^7	7.80×10^7
$I = \frac{G + B + R}{0.9}$	1.25×10^8	2.56×10^8	3.73×10^8

opportunistic, eating a wide range of diet items, with sea birds and sea turtles appearing to be most important. The large number of lobsters, cephalopods, and tetraodontiforms as well as birds and turtles leads one to suspect that tiger sharks concentrate on the largest and slowest moving prey they can find.

The total caloric value of the diets for the three species of sharks can be determined by taking the total mass of the prey item found in each species of shark and converting it to calories using caloric values (kcal/kg live mass) found in the literature (Leung and Flores 1961; Watt and Merrill 1950; Fisher 1967; Leung et al. 1968; Furness 1978). By dividing this caloric value into the ingestion rates a factor was obtained to multiply through this range of diet items. The values of total biomass needed to be ingested for each prey item species were then totalled to give a value of total shark predation for this area (Table 10). These values for French Frigate Shoals were obtained by using the two estimates of ingestion (Table 9) as a range, and are given in terms of biomass eaten per year. This was converted to a number of prey by dividing these values by the average prey mass. No attempt has been made to compare these hypothetical figures with the actual production of these prey. That is ongoing research by the NWHI ecosystem modeling project (J. Polovina, NMFS, Honolulu Laboratory).

Values were also computed for Midway, Maro Reef, and Pearl and Hermes Reef, for comparative purposes (Table 11), but dere only the presumed maximal value of ingestion was used and only the predation in

TABLE 10. -- Estimate of yearly shark predation at French Frigate Shoals.

	Mass (kg)	# eaten
Monk seals	1000	2 - 4
Dolphins	1000	2 - 4
Sea birds	12,000 - 56,000	4,000 - 18,000
Turtles	42,000 - 200,000	2,700 - 13,000
Sharks	8,800 - 42,000	440 - 2,000
Eels	5,250 - 37,000	5,000 - 35,000
Perciform fish	21,000 - 150,000	13,000 - 100,000
Parrotfish	4,200 - 29,000	2,000 - 14,000
Tetraodontiforms	9,000 - 29,000	4,500 - 14,000
Spiny lobster	600 - 3,000	1,500 - 9,000
Slipper lobster	200 - 1,000	500 - 2,000
Octopus	31,000 - 180,000	45,000 - 220,000
Squid	1,400 - 9,000	10,000 - 80,000
Triton	260 - 1,300	400 - 2,500

TABLE 11. -- Estimate of total shark predation in biomass (kg) at four habitats in the Northwestern Hawaiian Islands

	French Frigate Shoals	Midway	Maro Reef	Pearl and Hermes Reef
Seals	1,000	500	500	1,000
Dolphins	1,000	500	500	1,000
Sea birds	56,000	17,000	12,000	308,000
Turtles	200,000	64,000	43,000	1,090,000
Sharks	42,000	13,000	9,000	225,000
Eels	37,000	10,300	96,000	21,000
Perciform fish	150,000	43,000	500,000	35,000
Parrotfish	29,000	7,500	58,000	18,000
Tetraodontiforms	29,000	8,500	65,000	31,000
Spiny lobster	3,000	1,000	2,200	16,000
Slipper lobster	1,000	400	300	6,400
Octopus	180,000	50,000	386,000	124,000
Squid	9,000	2,400	17,000	8,400
Triton	1,300	400	300	6,400

terms of biomass was used. One can see that as predation by tiger sharks decreases at French Frigate Shoals and Maro Reef, predation on fish and cephalopods increases dramatically because of the larger number of gray reef and Galapagos sharks estimated there. This is consistent with the findings of the shark control programs where the catch per unit effort of the smaller sharks increases towards the end of the study when the catch per unit effort for the larger sharks had dropped fairly low. In this case, the effect is probably due to the high number of Galapagos sharks predicted for Maro Reef.

Midway does not seem to fit this pattern, but instead had a much smaller habitat area and therefore a much smaller total shark population. Pearl and Hermes Reef has very aberrant high values because of the very large estimate of tiger sharks there. The number for sea turtles eaten is probably unrealistically high, but the value for perciform fish is the lowest, probably because an estimate of gray reef shark numbers is lacking.

At French Frigate Shoals where more data were obtained, an average daily primary productivity value of 2.28×10^9 kcal/km^2/yr has been estimated (Hirota, personal communication). Dividing by 10^5, or going through five hypothetical trophic level transfers, a value of 2.28×10^4 kcal/km^2/yr was obtained. The estimated total shark productivity of 2.65×10^4 kcal/km^2/yr is very similar. This would mean that sharks are fourth order carnivores in the ecosystem, but the evidence from stomach content analyses would point to a second or third order carnivore. This would leave production available for

other carnivores such as ulua and other reef sharks, as well as energy shunted out of the reef ecosystem to pelagic sharks and tunas. Thus it seems to be a reasonable estimate for shark population, growth and reproduction, when compared to primary productivity measurements. Taking $\frac{1}{4}$ - $\frac{1}{2}$ of the shark productivity as an estimate of maximum sustainable yield, 6500 - 13,500 kg of shark meat per year would be available for fishing at French Frigate Shoals. The sustainable yield probably falls within this range, but it does not appear to be a very economically viable resource because these sharks are on the top of the food web.

With this fairly good estimate of shark growth and productivity, future studies could be made to refine these first approximations of sharks energy needs. A tag-recapture study would give further estimates of the shark population without killing large numbers of these predators. Further respirometry studies, especially on larger shark specimens (possibly pelagic sharks caught near Oahu) would refine the energy budget estimates. An independent estimate of shark ingestion and growth by performing feeding experiments or maintaining accurate records of the amount of food fed to sharks on display at public aquariums would be useful.

Ecosystem modeling studies are of great importance to the fisheries management decision making process, and the effects of sharks need to be determined because of their important trophic position and their larger individual energy needs. This is especially important for the tiger and Galapagos sharks which are the two largest

fish in the ecosystem. The tiger shark is also a major predator of the endangered green sea turtle and is known to prey on the endangered Hawaiian monk seal. These sharks are also in direct competition with man for the lobster and fish resources in this area. Ecosystem modeling predictions need to be made to estimate what the effects of increasing this competition will be on the rest of NWHI coral reef fauna. Here some preliminary data and insights from the NWHI study area are given to help answer questions about these effects.

Figure 10. -- Vertebra from a 178 cm PCL, 103 kg female Carcharhinus galapagensis stained with silver nitrate. Seven major rings are indicated by bars, and the faint birth mark by the arrow.

Shark attacks: They will happen again

Researchers say they still know little about them

By Paula Gillingham
Advertiser Staff Writer

KAENA POINT — Each spring, 30 to 40 tiger sharks congregate in the waters off Oahu's Kaena Point.

And each year, Coast Guard officials alert Hawaii's shark scientists of the March-April shark gathering.

It's valuable information that researchers at the University of Hawaii's Marine Center are willing to document.

It's sensible, too: In the 1990s, shark research isn't so much focused on attacks or shark eradication. Its thrust is to observe a mysterious predator as it lives, in its own front yard.

And the more they seem to find out, the less Hawaii's most experienced researchers are willing to assume about the tiger's behavior.

None is willing to predict when or where a shark will strike next.

"Because we know so little, because we haven't done anything to change human behavior or understand shark habits, attacks will continue to occur," said Chris Lowe, researcher at

See Sharks, Page A22

Sunday, April 2, 1995 The Honolulu Advertiser

Sharks: Hawaii researchers

FROM PAGE ONE

the University of Hawaii Marine Center.

Shark attacks in Hawaii are actually quite rare — about one a year — but it's enough to keep research afloat. Researcher Kim Holland will put his dime on only two predictions: They will happen; they will never stop.

Surfers, swimmers and other ocean-sports enthusiasts realize that every time they play in shark territory, they are taking a risk. But the odds favor survival.

"I'm not afraid," said professional surfer Buttons Kaluhiokalani, who at 36 years old has never encountered a shark while surfing. "I just accept that they're there, and have respect for their turf."

It isn't a lack of respect that inspires a shark to attack. Scientists won't even say that it's hunger, either. What they do want to discourage, though, is people's reaction to an attack.

Past shark attacks have been followed by fishing expeditions. The Division of Land and Natural Resources would hire fishermen to run their lines to snag the killer shark. Guilty or not, a shark or two gets caught and put on display. And the bigger, the better.

But is it *the one?*

"We have our doubts," Lowe said. "If you were to go to Ewa Beach to try and catch a shark responsible for an attack the previous day, that shark could be very far away."

Tiger Shark

Species: Galeocerdo cuvier
Hawaiian name: Niuhi
Size: Pups are born at 30"-34" in length; females mature at 9-10 feet; Males 91/2-101/2 feet. Maximum reported length is 18 feet.
Physical characteristics: blunt head, small pectoral fins, tiger-like markings along top, which fade with age. Color ranges from brownish to bluish gray.

Possibly as far away as Penguin Banks, an underwater plateau off the southwest coast of Molokai.

Holland and his crew know this because they have strung lines of their own as part of their acoustic telemetry tagging program. Sharks caught off the south shore of Oahu have been tracked as far as the banks. Lowe said they suspect the sharks go even farther.

Each line is baited with a tuna head. The lines have enough lead so the shark can swim in a circle and stay alive. With two boats — a 33-foot power boat equiped with tracking devices, and an 18-foot Boston Whaler to get alongside a shark — the researchers harpoon a transmitter onto its back and set it free.

So far, eight sharks have been tagged and tracked with this acoustic telemetry method. This tracking system has caused fellow researcher Bradley Wetherbee to conclude that "the tentative conclusion that these sharks are territorial" is wrong. He said this erroneously "contributed to the belief that sharks can effectively be eliminated from specific areas."

Surfer Lance Hookano's wiry red head can usually be spotted wherever the waves are breaking. He said he sees sharks all the time — black tips out by Magic Island, sand sharks near the reef — and he has formed his own opinion on their behavior.

"As soon as they see you they dig out," he said. "They

say behavior still a mystery

Advertiser photos by Richard Ambo

Researcher Kim Holland tosses a buoy bearing a hook (like the one above) used for catching sharks so they can be fitted with radio transmitters (like the one below).

are just as afraid as you are."

Holland cautions that people put too much stock in folklore when it comes to sharks.

"One of those things we have to guard against is not to put a human's brain inside a shark's head," Holland said. "It does not distinguish or associate one event with another. There is no evidence any animal can do that."

Holland said sharks have no ability to detect the "fight or flight" reaction in human beings. And he doubts that sharks ever mistake a bodyboarder, a surfer or a swimmer for something else.

"If these sharks were making mistakes because they think you are a fish, a lobster or a turtle, we'd have attacks all year," he said.

All of the researchers assert that simple common sense will help keep water-sports enthusiasts alive.

Although many surfers find "dawn patrol" or a "sunset session" to be the best times to ride the waves, the researchers have determined that these are actually times of "great confusion" in the reef areas along the coasts. Day and night time fishes come out to sleep in the coral — and top-level predators take advantage of that.

"If you have turtles that are around you that take off pretty quickly, that might be a good sign that something big is around," Lowe said. "Their sensory systems are much more tuned to the marine environment than ours. Being aware is the biggest part of the key."

Albatross lovers promote their restoration project

OCEAN WATCH
By Susan Scott

1/16/95 A2 HSB

Ehoi mai ana ka moli. (The albatross is returning.) That's the good news on the Oahu Albatross Project's attractive new T-shirts designed to promote awareness of this seabird restoration effort.

For the second winter in a row, biologists from the National and Hawaii Audubon Societies, Hawaii's Division of Forestry and Wildlife, the U.S. Fish and Wildlife Service and Sea Life Park have worked together to place albatross decoys on Kaohikaipu Island off Makapuu Beach to attract passing Laysan albatrosses. Volunteers use a telescope at Sea Life Park to watch the island for activity.

Last year, a handful of passing birds stopped to investigate. This year, workers were encouraged when the passers-by began landing a month earlier.

When one pair gets bold enough to mate and raise a chick there, the colony will be on its way.

Like most other seabirds, albatrosses are colonial creatures, preferring to nest in the vicinity of other albatrosses. This social attraction is likely a security factor. The presence of other members of their species signals a safe haven, free of predators.

Alien predators are the albatrosses' biggest headache. Bones discovered on Kauai, Molokai and Oahu show albatrosses lived on these islands at least 1,500 years before humans arrived.

But it wasn't long after the ancient Polynesians settled here that the big birds were gone. People killed them for food and feathers, and the dogs and rats that accompanied the settlers likely prevented further nesting.

After that, the birds nested only on the remote islands of Hawaii's northwest chain. That haven came to a rude end in the late 1800s and early 1900s when feather hunters plundered the islands to supply feathers for women's hats. The slaughter ended with the establishment of the Hawaiian Islands National Wildlife Refuge.

But albatrosses continued to clash with humans. In the '50s and '60s, the military killed 60,000 birds to reduce air strikes on Midway.

Over the last 30 years, however, these majestic seabirds with the 7-foot wingspans have lived undisturbed, thanks to protection provided by the military and both federal and state governments. As a result, albatross populations have rebounded. Now, with breeding space tight, brave pioneer birds are rediscovering their historical nesting sites.

Some of those sites, however, are crowded with people, dogs, cats and mongooses, all of which kill chicks and nesting parents. And that's why biologists and volunteers are stepping in — to lure the homesteaders to a safer place. The tiny island of Kaohikaipu is a state sanctuary, free of large predators and off limits to people.

Not everyone thinks this is a good idea. Last year, protest was heard from the Marine Corps station at Mokapu Peninsula. "These birds fly low over the water," said project coordinator Stephen Kress of the National Audubon Society in answer to that concern.

"As long as they aren't trying to nest on runways, they shouldn't be a problem to planes."

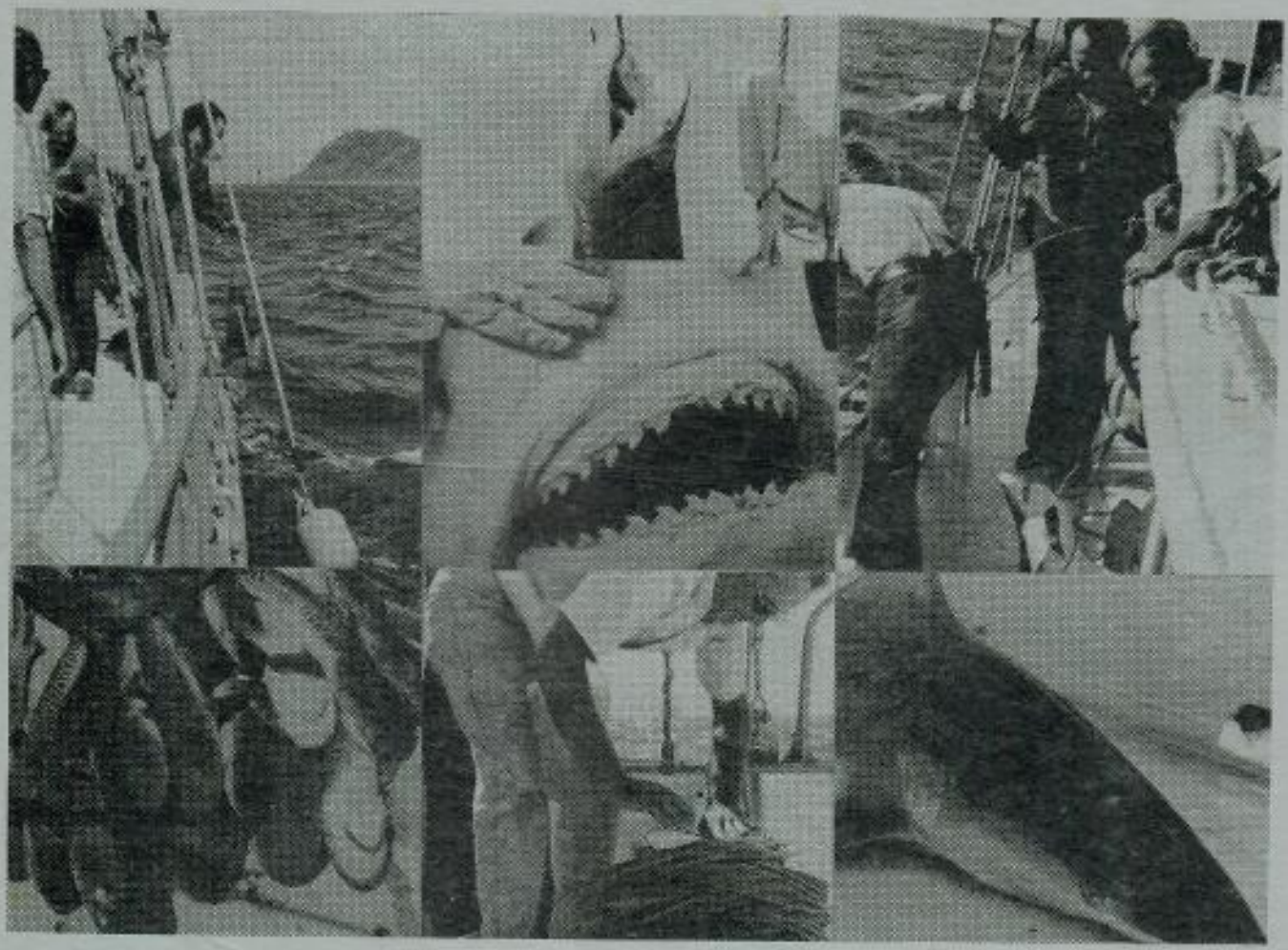
Others believe an albatross colony will attract tiger sharks to surrounding waters. Tiger sharks patrol nearshore waters in some areas of Hawaii's northwest refuge during fledging season, striking downed chicks. Of the shark issue, Kress says, "We don't know if there's a direct relationship between albatrosses and tiger sharks. Besides, we're talking about very small numbers here over a very long period of time. We should be so lucky to have this worry."

You can help restore these native seabirds to Oahu by calling Andy Cowell at 944-6421 for information about the project.

Susan Scott is a marine science writer and author of three books about Hawaii's environment. Her Ocean Watch column appears Monday.

Local artist Patrick Ching donated this drawing, which will be reproduced on the albatross project T-shirts.

The 1971 Shark Control and Research Program Final Report



State of Hawaii
Department of Land and Natural Resources
Division of Fish and Game

Honolulu, Hawaii
November, 1972

ESTIMATIONS OF SHARK ABUNDANCE IN HAWAII AND SOME INFORMATION ABOUT MOVEMENT PATTERNS FOR TWO SPECIES

Marilyn J. Lawrie

Department of Zoology, University of Hawaii, Honolulu, Hawaii

1978

Abstract

There have been four shark fishing programs in Hawaii since 1960 each employing longline fishing methods. There is enough similarity between three of the programs to allow direct comparisons of catch rates. One program from 1967 to 1969 conducted extensive fishing around the island of Oahu, and significant reductions in catch per unit effort occurred. It is possible to apply the Leslie and DeLury regression techniques of looking at declines in catch per unit effort to the Oahu data to estimate the initial population levels and q, the catchability, for two species of sharks, Carcharhinus milberti and Galeocerdo cuvier, around that island. Initial catch rates around the other islands can then be compared to those on Oahu where a population estimate is possible and densities estimated as sharks per mile of coast. The data indicates that there are at best a few thousand sandbar and tiger sharks in the vicinity of the main Hawaiian Islands and that they are very vulnerable to over-fishing. There is evidence that inter-island movement between Oahu and the other islands is negligible over short time periods of one year or so but that some along-shore movement does occur.


KALAKAUA
A. Tsukamoto


G. Tsukamoto
READY?

graduate student has based a Master's thesis partly on Waikiki Aquarium larval research work.

The Waikiki Aquarium's Mahimahi Research Program is indebted to the following organizations, firms and individuals for their suppport and contributions:

State Senator Richard Matsuura
Mrs. Jane B. Dunaway
The Wayne Richardson Jr. Memorial Fund
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Mr. Robert Lyn Nelson
Mr. W. Bruce Wells
University of Hawaii, Sea Grant College Program
State of Hawaii, Department of Land and Natural Resources Aquaculture Development Program

Mahimahi. Coryphaena hippurus

OTHER AQUARIUM RESEARCH

Sharks

The shark research program under the guidance of Aquarium Scientist Gerald Crow has embarked on a multifaceted investigation of shark husbandry. This program is investigating blood chemistry, pathology, nutrition, hormones and parasites of the Aquarium's captive sharks.

In collaboration with Dr. James Brock of the Aquaculture Development Program, State of Hawaii, an unusual case of mortality in captive sharks called intestinal biting was documented for the first time. Intestinal biting is a very unusual source of shark mortality that results from bite wounds to the intestine during intestinal flushing. This process—in which the intestine is everted, flushed out, and then pulled back inside the abdomen—is unique to a certain group of sharks. This natural process appears to remove debris from the intestine. Being able to identify this situation has lead to husbandry improvements which have reduced the Aquarium's already low mortality rate.

In addition, cooperative research with Dr. Betsey Rasmussen of the Oregon Graduate Institute has documented differences in the levels of serum corticosterone in male and female sharks. No previous study has reported a difference in these levels. This continuing study may have important implications for successful long-term care and management of captive shark populations.

Blood sampling of a whitetip reef shark...

Corals

As part of a continuing project on the husbandry requirements of corals in captive environments, Aquarium Director Bruce Carlson has been measuring the growth of several species of South Pacific corals in two outdoor experimental tanks, including 12 species of *Acropora*, many which have never been kept alive in an aquarium.

The corals, collected in Palau and Fiji, were shipped to the Aquarium using a "dry" transportation technique developed by Ed Bronikowski of the National Zoo.

Blacktip reef shark/Carcharhinus melanopterus

MAHIMAHI/*Coryphaena hippurus*

This was a year of several milestones, capping nearly a decade of research at the Waikiki Aquarium on rearing methods for mahimahi and other marine fishes. Mahimahi aquaculture technology is rapidly approaching a "no-limits" status: culturists can now produce thousands of mahimahi using relatively simple methods.

Just two or three years ago, the Aquarium was the only facility in the world capable of consistently growing mahimahi through the hatchery stages in useful numbers. At that time, the methods used at the Aqaurium were too complex for commercial facilities. Now, however, Aquarium research work on larval feeds is being published world wide, and may allow ocean stocking programs for mahimahi to succeed. Today, the Larval Research program at the Aquarium has proven that mahimahi can be raised on a pelletized feed. This breakthrough makes commercial aquaculture programs far more feasible.

In 1982, the Larval Research program began in a humble state. The program dabbled with mahimahi culture, traded fish for rearing tanks from other institutions, and began grant-funded research. The research efforts were fortunate to secure continuous financial support since 1982 from the University of Hawaii Sea Grant College Program and the Hawaii State Department of Land and Natural Resources' (DLNR) Aquaculture Development Program, with partial funding set through 1993.

The research received a tremendous boost from State Senator Richard Matsuura in 1987, when his legislative initiatives helped provide funding for a full-time research staff. The funding helped stablize the program and added momentum to the development of the hatchery technology. Senator Matsuura also sponsored legislation to provide major funding to build the Aquarium's Mahimahi Hatchery exhibit, which opened on January 24, 1991.

The exhibit is a unique public display of mahimahi, both adults and juveniles, and the food web cultivated at the Aquarium to feed the young fish. Mahimahi cultured at the Waikiki Aquarium also inhabit the mahimahi exhibit at the California Academy of Sciences in San Francisco. The program has also allowed shipment of Aquarium-bred mahimahi to aquariums and research institutes from Texas to Tahiti, bringing additional recognition to Waikiki Aquarium research efforts.

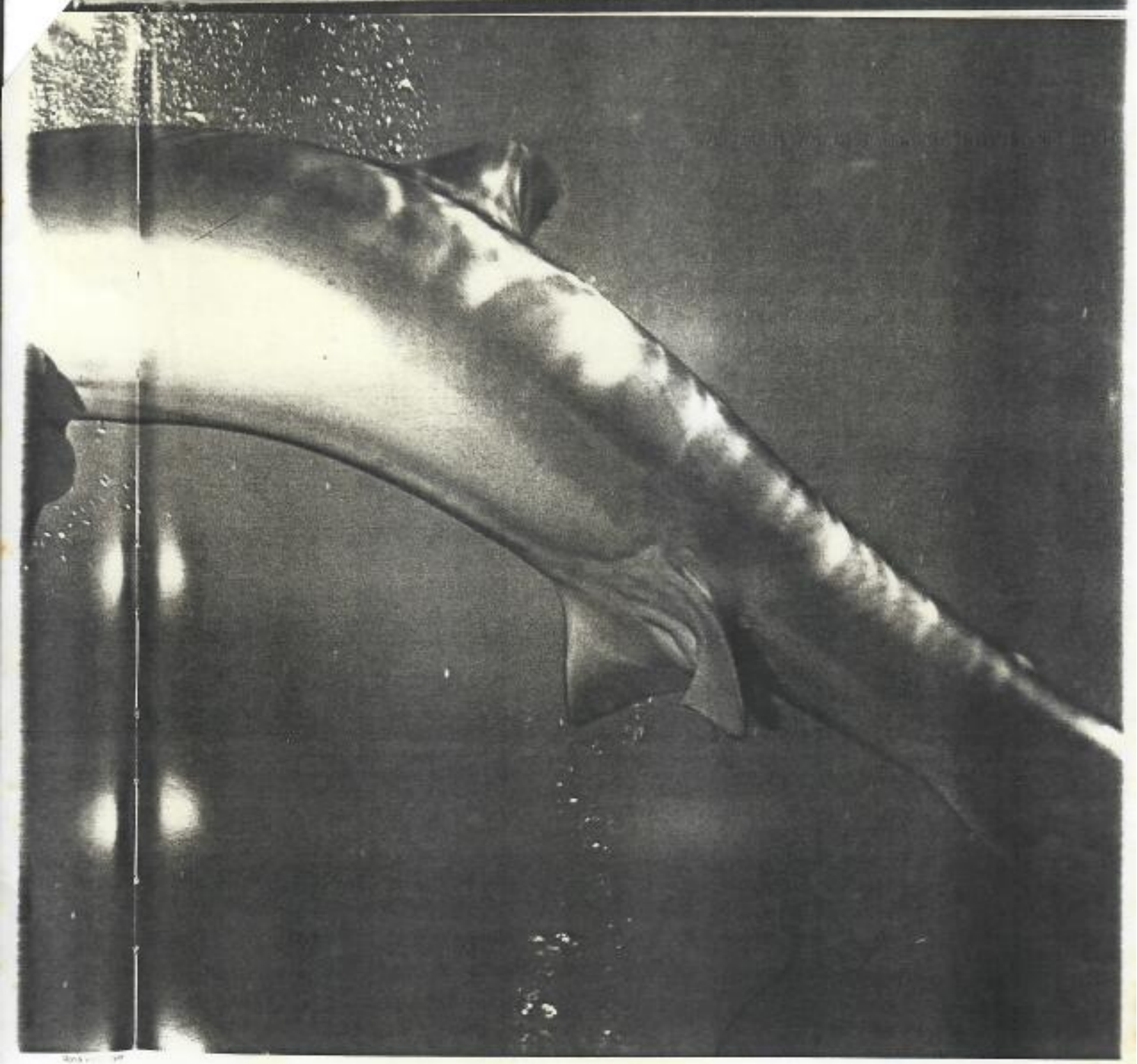
The Mahimahi Hatchery is a functional research facility, and as it is improved, technology developed at the Waikiki Aquarium will be used to explore methods for raising new species, perhaps including marlin and other large pelagic fishes. For now, staff members bask in the reward of listening to fishermen explain the life cycle of mahimahi to their children, and chuckle as they hear visitors compare Aquarium mahi to their dinner entree from the previous evening. School students also find the exhibit a handy resource for Science Fair projects, and at least one university

Pouring the foundation for the Hatchery tank...

Stocking the exhibit with mahimahi...

Watching the adult mahimahi swim past...

p.156 Shark attack in the Tropical Pacific Ocean by L. Taylor



SHARK ATTACK

THE SHARK ARM MURDER CASE

Record books around the world abound with bizarre cases and fascinating tales of shark attack, but none has managed to top what is known internationally as the 'Shark arm murder' case. On 18 April 1935, Albert Hobson set off in his boat to a point off Coogee Beach in Sydney where he had left a line bait. Pulling up the line, Albert was struck dumb with amazement, for he had not only hooked a small half-eaten shark but had also snared a 4.5-metre tiger shark, entangled in the line but still very much alive. Albert secured the giant shark and towed it to the beach. Once there he decided to turn the prize shark over to the Coogee Aquarium for exhibition. Albert's find soon had Sydneysiders flocking to the aquarium to see the 'monster'. For several days the tiger shark slowly cruised around its new home, happily eating all the fish thrown to it. Then, on 25 April, having not taken food during the morning and early afternoon the shark, according to observers, went 'crazy' and began bumping into the aquarium walls and turning in circles. After twenty minutes of this behaviour the shark suddenly startled onlookers by regurgitating a human arm. The shocked aquarium owners immediately called the police and Dr Victor Coppleson was asked to examine the arm in the Sydney morgue. According to police, the arm was that of a very muscular man. On the forearm was a slightly faded tattoo of two boxers shaping up to each other.

Coppleson reported that in his opinion the arm had not been bitten from the body by a shark because it was so cleanly separated at the shoulder joint. He also stressed that a surgeon had not performed the task because the usual skin flaps a doctor would leave were not present. On learning this the police decided to publicise the incident in the hope of solving the mystery. They issued a photograph and description of the tattoo and it wasn't long before a man came forward to identify the arm as that of his brother, 45-year-old James Smith.

Within a short time police had arrested Patrick Brady for murder and questioned another man, Reginald Holmes. Several days after being questioned Holmes was found dead in his car near the Sydney Harbour Bridge. He had a bullet in his head. Smith had last been seen alive on 8 April at 6pm in a Cronulla hotel, and police decided that James Smith, Patrick Brady and Reginald Holmes had been involved in standover tactics, murder threats, forgery and conspiracy to defraud an insurance company. A series of murder trials followed, with the Crown alleging that Brady and Holmes had murdered Smith on the night he had last been seen alive. They believed that Smith's body had been cut up, stuffed into a tin trunk and dumped in the ocean. As the arm could not be forced into the trunk, the men decided to tie it to a rope attached to a heavy weight and sink it to the sea bottom beside the trunk. The police conjectured that the shark must have seized the arm sometime between the night of 8 April and 17 April, when it was caught off Coogee. Surprisingly, the arm remained intact for another eight days in the shark's stomach until it was dramatically disgorged on 25 April.

Three sensational trials later, John Brady was finally acquitted through lack of evidence; he lived a free man until his death in 1965. As to the tiger shark, it became very sick a couple of days after disgorging the arm and the aquarium owners had to kill it. When police performed an autopsy they found that the tiger shark's stomach contained a portion of the other shark and some fish bones but no further human remains.

1987

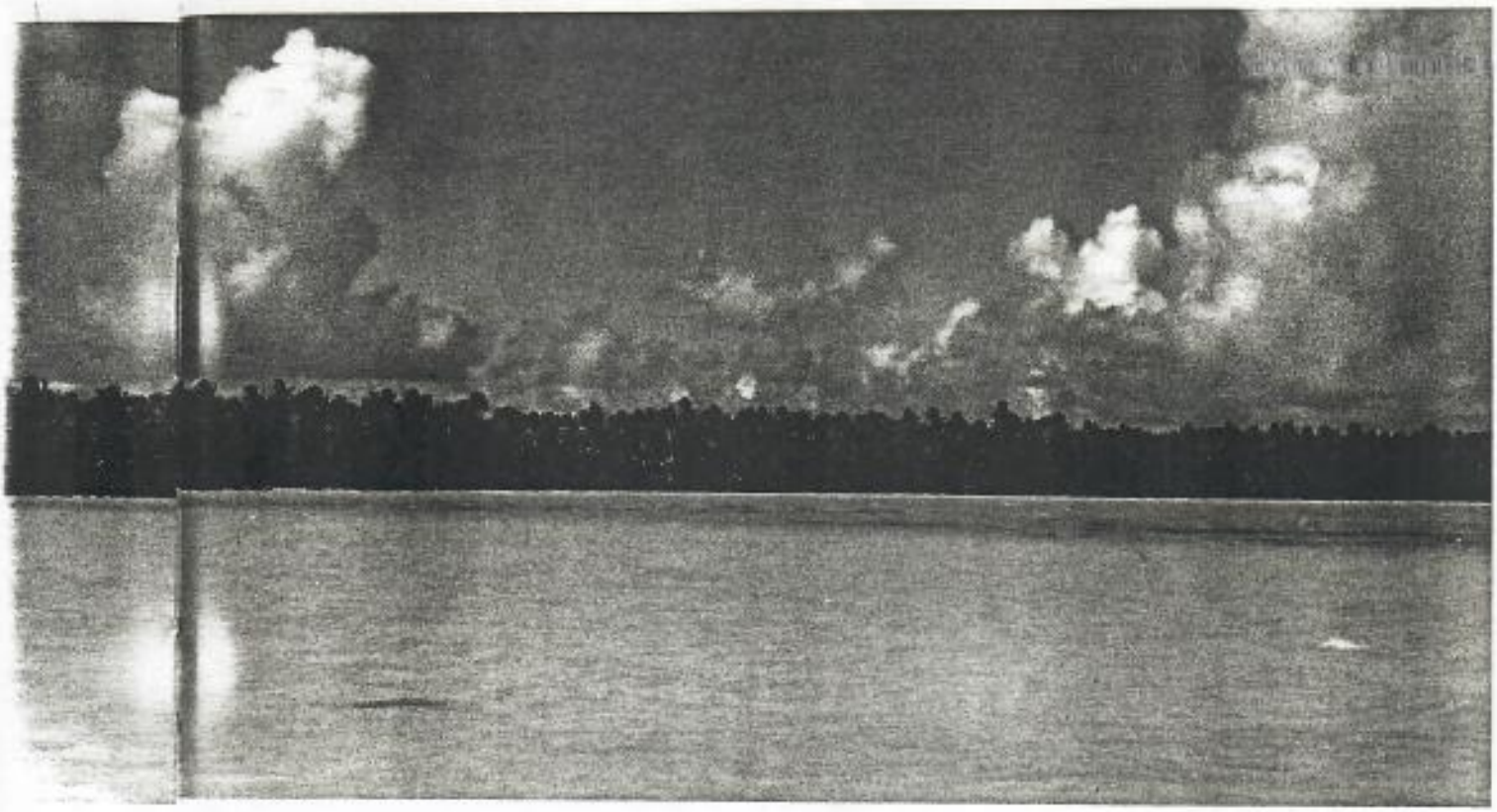
▲ The indigenous peoples of Oceania have an intimate relationship with the sea and interact with sharks on a daily basis. They have therefore come to regard the danger of shark attack in a far more realistic way than the continental inhabitants of Australia, the United States or South Africa, to whom the sea is inherently alien and frightening.

SHARK ATTACK IN THE

Any review of shark attack in the Pacific Ocean is burdened by at least three factors: the huge geographic expanse of the area; the remoteness and isolation of many islands; and the lack or incompleteness of written records. In remote areas many shark attacks go entirely unrecorded. Others are noted only in the files of small medical clinics or dispensaries. At best, attacks may be documented in small, unindexed regional magazines or newspapers of very limited circulation. The shark attacks accounted for in the scientific literature probably represent only a small fraction of those that occur. However, as marine scientists travel widely in the Pacific area and have excellent communication networks, the proportion of attacks reported is probably higher than one might expect.

In researching this chapter I spoke to marine scientists, fisheries officers and residents of many Pacific areas, carefully reviewed the scientific literature and, where possible, reviewed local newspapers. I am convinced, however, that the number of cases I have been able to document is much smaller than the actual total.

Students of shark behaviour owe a large debt to the Shark Research Panel of the American Institute of Biological Sciences (AIBS), formed in 1958 and ably chaired by Dr Perry Gilbert. The panel established the Shark Attack File, which maintained worldwide records of shark accidents for a number of years. Subsequently, the file was maintained by Mote Marine Laboratory (Sarasota, Florida) and later by the National Underwater Accident Data Center (University of Rhode Island). Auxiliary files are now kept by the American Elasmobranch Society (University of Miami, Florida), the



N THE TROPICAL PACIFIC OCEAN

LEIGHTON R. TAYLOR JR

California Department of Fish and Game and the Waikiki Aquarium, Honolulu, Hawaii.

Because of the vastness of the Pacific area it has been possible to cover only part of it in this chapter. The survey is limited to selected major island groups in the tropical Pacific between 140°E and 130°W and between the tropics. Island groups included are Hawaii (including Johnston Island), the Line Islands, French Polynesia, Western Samoa, American Samoa, Fiji, the Phoenix Islands, the Marshall Islands, the eastern and western Carolines, the Cook Islands, the Solomon Islands, Tonga and New Caledonia. The Philippines, Papua New Guinea and southern Japan are excluded.

▼ A shark in shallow water will cause panic among swimmers in most countries, even if it is an inoffensive species such as this zebra shark (*Stegostoma fasciatum*), recognisable by its long caudal fin and unaggressive behaviour. It is common off reefs and atolls of the western Pacific and grows to three and a half metres in length.

The indigenous people of these areas have a long cultural history that has been strongly influenced by the ocean and its living creatures. In most Pacific cultures, sharks are viewed from a variety of perspectives. They play central roles in religion, culture, fishing techniques, folklore, and may provide important resources for tools and weapons. Most Pacific Islanders literally grow up with sharks and, while recognising their danger, have attitudes toward them quite different from those of their fellows from Western, continental cultures.

Peter & Valerie Taylor

A SUMMARY OF SHARK ATTACK RECORDS
FROM SELECTED AREAS OF THE TROPICAL PACIFIC OCEAN

Some cases are recorded by more than one author; therefore a total of cases reported for a given area cannot be calculated by summing all reported cases. Where detailed reports have been published in books, scientific journals or periodicals I have merely listed the reference. More detailed information is included here if the reporting source is ephemeral - such as a personal interview or local newspaper. The bibliographic sources referred to in the table are cited in the bibliography at the end of this publication.

NUMBER OF CASES AND/OR DATE	SPECIES	LOCALE AND RESULT (F = fatal)	SOURCE
HAWAII			
52; 1886–1980	various	various	*Balazs & Kam (1981)*
9; 1981–1983	various	various	*Lipman, V. (1983)*
35; 1941–1968	various	various, including Midway Island	*Baldridge, H.D. (1973)*
26; 1886–1960	various	various	*Schultz & Malin (1963)*
13 June 1962	*Carcharhinus* sp.(?)	Ho'okipa, Maui. Windsurfer; 120 stitches in upper thigh	*Schweitzer, D. (1982)*
5 June 1984	*Sphyrna lewini* (?)	Kaneohe Bay, Oahu. 13-year-old girl swimmer bitten on right foot	*Personal communication with victim's mother*
24 May 1985	*Galeocerdo cuvier* (?)	Makaweli, Kauai. Board surfer severely bumped	*Cook, C. (1985)*
13 October 1985	*Carcharhinus* sp.	Barber's Point, Oahu. Lobster diver's arm gashed	*Anonymous (1985)*
18 October 1985	*Galeocerdo cuvier*	Solitary adult male boogie-boarder lost right hand; board bitten in two	*Personal communication with victim; and Taylor and Thompson (in prep.)*
22 April 1986	*Galeocerdo cuvier* (?)	Only fragments of shoreside drowning victim recovered	*Personal communication with George Balazs*
JOHNSTON ISLAND			
19 December 1965	*Carcharhinus amblyrhynchos*	Lagoon	*Bellows & Murchison (1967)*
1; October 1960	unnamed	Lagoon	*Schultz & Malin (1963)*
FRENCH POLYNESIA			
56	various	Tahiti, Tuamotus (some F)	*Fouques et al (1972)*
10; August 1962–June 1966	*Carcharhinus amblyrhynchos* and others	Tahiti, Tuamotus	*Bagnis (1968)*
14; 1942–February 1972	*Carcharhinus amblyrhynchos* in 10 cases	(some F)	*Lagrauler et al (1972)*
3; 1975	*Triaenodon obesus*	various	*Randall (1977)*
2; 1951	unnamed	Tuamotus	*Schultz & Malin (1963)*
MARSHALL ISLANDS			
3; September 1957–Sept 1960	*Carcharhinus amblyrhynchos*	Enewetak	Schultz & Malin (1963)
1; March 1976	*Triaenodon obesus*	Enewetak	*Randall (1977)*
1; April 1978	unnamed	Enewetak	*Baldridge (1973)*
2; August 1968–January 1972	*Carcharhinus amblyrhynchos*	Enewetak	*DeGruy, pers. comm.*
	Carcharhinus melanopterus	Enewetak	*Randall & Helfman (1973)*
TRUK (eastern Caroline Islands)			
2; July–September 1910	*Carcharhinus albimarginatus*	Truk, Namonuito	*Jones (1972)*
PALAU (western Caroline Islands)			
15 September 1970	*Carcharhinus* sp.	Western Babelthuap	*Read (1971)*
April–May 1970	*Carcharhinus melanopterus*	Babelthuap, Ngerobelobang	*Randall & Helfman (1973)*
PHOENIX ISLANDS			
6 February 1972	*Carcharhinus melanopterus*	Canton	*Randall & Helfman (1973)*
LINE ISLANDS			
2; November 1959–June 1965	*Carcharhinus melanopterus*	Palmyra	*Randall & Helfman (1973) and Baldridge (1973)*
AMERICAN SAMOA			
2; August 1955–Dec 1963	unnamed	Tutuila (F)	*Schultz & Malin (1963)*
WESTERN SAMOA			
1; February 1972	*Galeocerdo cuvier*	Nu'u'lua	*Balazs, pers. comm.*
TONGA			
1; 1930	unnamed	Niua Fo'ou Island (F)	*Schultz & Malin (1963)*
FIJI			
5; 1925–61	unnamed	various (1F)	*Schultz & Malin (1963)*
SOLOMON ISLANDS			
11; 1880–1957	unnamed	various (some F)	*Schultz & Malin (1963)*
NEW CALEDONIA			
2; 1950–1962	unnamed	various	*Schultz & Malin (1963)*

Such late arrivals to the Pacific as the European-derived peoples tend to look on sharks very negatively; they will react significantly to the mere sighting of a shark. It is not surprising, therefore, that an attack or incident in an area such as Hawaii will be more widely reported than one that occurs in an outlying island of the eastern Carolines.

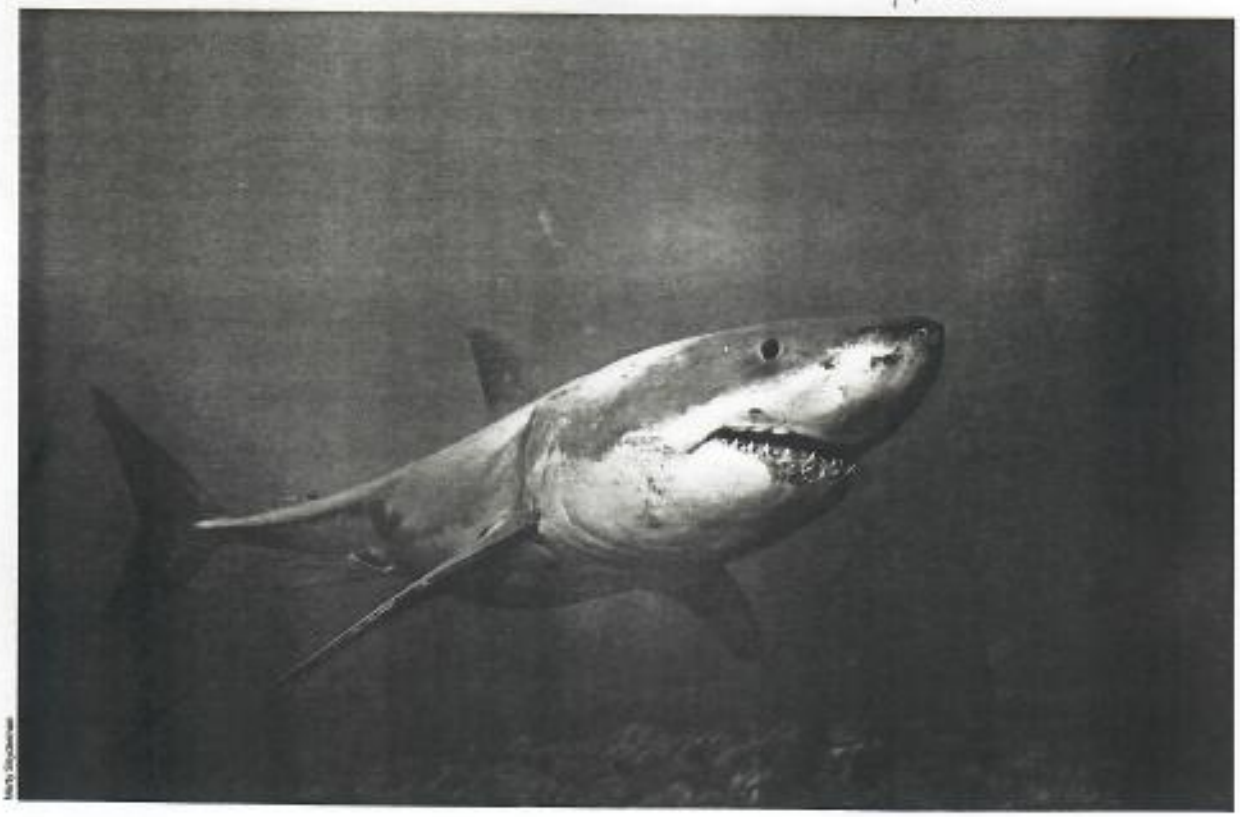
One observer, Dr Charles Jones, MD, chief surgeon at Truk Hospital, estimated that on average there was at least one attack reported every three months. He suspected that many more attacks go unreported and that the 'inherent toughness of island people and their frequent isolation both contribute to the failure of more shark attack victims to seek medical aid'.

Even in areas where shark attacks are likely to be well reported and widely publicised there are ambiguities. For example, occasionally shore fishermen will be washed offshore or fishermen will fall from boats; their remains are seldom recovered. Although these are reported as accidental drownings by medical authorities, the deaths could equally be the result of fatal shark attack.

The nature and result of shark attacks and the circumstances surrounding each incident vary widely. Captain David Baldridge has made a detailed review and statistical analysis of 1165 shark attacks that occurred worldwide between 1941 and 1968 and were carefully recorded in the AIBS Shark Attack File. Of these, 127 were in the tropical Pacific area. While Baldridge reported some interesting and suggestive correlations, he was unable to state any definite principles of cause and effect. This is of course due to the accidental nature of shark attack. Certainly no careful experiments have been conducted in which variables have been scientifically controlled. Such experiments are (let us hope) unlikely ever to be performed and, therefore, any suggested patterns, beyond very general ones, are impossible to verify.

Jim Stone

▲ The Pacific may be an attractive recreational destination, but it has several records of shark attacks on boardriders and windsurfers. Most of these attacks are blamed on tiger and great white sharks, both aggressive species that hunt large marine animals which could be confused from below with surfboards or sailboards.



Marty Snyderman

▼ Great whites are among the very few species of sharks that appear actually to eat humans, perhaps mistaking divers and surfers for seals and sea lions. The only seal populations in the Pacific are found in the northwestern islands of Hawaii; the only great white attacks on humans in this vast ocean are also recorded from Hawaii.

► Most attacks on divers in the Pacific have apparently been motivated by confusion with turtles or by spearfishing, when blood in the water has excited reef sharks. On some occasions, however, a diver's accidental intrusion into a particular shark's hunting grounds will stimulate a sudden attack that can result in severe injury.

Baldridge's analysis includes the following cases from the Pacific Islands. (The number of documented attacks is in parentheses.)
Admiralty Islands (4)
Bismarck Archipelago (28)
Caroline Islands (4)
Fiji Islands (22)
Galapagos Islands, Ecuador (2)
Guam (1)
Hawaii, United States (including Midway) (33)
Johnston Island (2)
Line Islands (2)
Marshall Islands (5)
New Caledonia (3)
Samoa (3)
Society Islands (3)
Solomon Islands (19)
Tonga Islands (2)
Wake Island (3)

Until fairly recently, scientists believed shark attack was motivated by stimuli relating to food and feeding. Starkly stated, this hypothesis held that sharks attacked humans because they wanted to eat them. A booklet prepared by the United States Navy in 1944 for the information of naval personnel who might encounter sharks in tropical waters stated that 'The truth about sharks biting people seems to be this: like most fish the shark is a carnivorous or meat-eating animal ...' Since the publication of that booklet there has been substantial research on the behaviour of sharks, much of it supported by the same Office of Naval Research that prepared the original edition.

▲ Spearfishing is a popular and relatively efficient way of catching fish for the table, but one that increases the possibility of shark attack through the struggles and bleeding of a speared fish. Like all predators, sharks are sensitive to signs of a potential meal and have been known to injure divers while stealing speared fish.

Feeding has certainly been an important motivation in some attacks in the Pacific, particularly in those involving large species such as tiger sharks and great white sharks and in incidents where bleeding, either by an injured victim or speared fish, had occurred. However, it is now widely believed that behaviour relating to a 'territorial imperative' is important in shark attack. This 'aggression' of certain perhaps territorial species may be responsible for most non-fatal

Yves Lancelot/Auscape

▲ The tawny nurse or sleepy shark (*Nebrius ferrugineus*) is common throughout the Pacific and Indian oceans. It is normally docile and will usually react to harassment by grunting and spitting water at its tormentor, however, there are records of tawny nurse sharks biting divers and holding them underwater for extended periods.

shark attacks. Simply put, some sharks bite some people for the same reasons that dogs bite mail deliverers. A well-fed spaniel will sink its teeth into the calf of an intruder into its yard with no thought of eating the poor visitor; the dog is simply defending its territory against an interloper.

A similar explanation probably holds for many Pacific shark attacks. For example, in 1982 a windsurfer was attacked off Ho'okipa Beach, Maui, after rapidly sailing into a turbulent area and falling from his board. The two bites to his right thigh resulted in little tissue loss and were probably caused by a frightened and threatened shark rather than a hungry maneater.

In simple terms most shark attacks can be classified as either 'feed stimulated' or 'aggression stimulated'. Attacks on humans by large species such as tiger sharks, which commonly feed on large prey such as sea turtles, and great white sharks, which commonly feed on seals, are almost certainly related to feeding. Attacks by most other species are probably due to responses other than feeding. Exceptions occur where other stimuli relating to feeding – such as speared and bleeding fish, injured victims or an abundance of the shark's normal prey – are in the water.

Some attacks in the Pacific, such as open-ocean attacks following accidents, have clearly been the result of feeding behaviour. The 1945 tragedy of the USS *Indianapolis* is an example. Four hundred sailors went under when the heavy cruiser was torpedoed; nearly 800 jumped clear and were adrift in the equatorial Pacific, 300 kilometres from the Philippines. During the next four days and five nights nearly 500 perished. It has been estimated between 60 and 80 of them were killed by sharks, many fewer than the 600 that were counted by the fictional Captain Quint in Peter Benchley's *Jaws*.

SHARK ATTACK: ANOTHER PERIL OF WAR

CARSON CREAGH

Prior to World War II, shark attack was an accepted hazard of life in Pacific waters: sharks were certainly treated with caution by native fishermen and European settlers, but they were regarded as an everyday risk. Fatal traffic accidents – barely reported today – were given front-page attention. An objective view of the risks of shark attack in the Pacific was provided by George Llano in *Sharks and Survival* in 1963: 'Concern about the shark menace was noted in a study of some 2500 aviation survival accounts from World War II archives, particularly from men who flew over tropical waters . . . Analysis of these records revealed only 38 shark sightings, of which only 12 resulted in casualties or injuries.'

Those statistics translate as a 1.5 per cent chance of seeing a shark, and a risk of around 0.5 per cent – one in 200 – of attack. Given the number of servicemen in the Pacific theatre, and the chance of shipwreck or aeroplane crash, the risk could hardly be called a major one.

Llano's interviews reveal a surprising number of wartime shark 'contacts' that were no more than sightings. From one interview, we learn that: '. . . I saw a large fin come toward the life raft . . . It rolled over and reappeared on the other side . . . The shark repeated the behaviour several times at varied intervals but at no time seemed concerned with us or touched the raft . . .' From another, 'The raft was followed for a great part of the time [ten days] by sharks . . . each time, the shark sounded and did not bother us again. Aside from the nuisance, they did not bother the raft'.

Many personnel found that the fish that sheltered beneath their rafts, and not themselves, were the focus of attention: 'From practically the first day,' said one pilot, 'sharks were continually hitting up against the boat trying to get the small fish under it. I was quite scared at first, but soon got accustomed to it when I learned what they were after'. That this was a common attitude is borne out by remarks such as 'Sharks around all the time – no bother', and 'He never came very close and did not constitute a problem'. Even aggressive behaviour was regarded as normal; one pilot laconically recalled dealing with a shark that, excited by its companions feeding on fish, repeatedly attacked the pilot's life raft: 'One large one . . . came to the surface and started to bump the boat with his nose. This had become a rather commonplace procedure with me by this time and I put the .45 about six inches [fifteen centimetres] from

Feeding was also the most likely motivation in at least three other documented shark attacks in the Pacific. In February 1972 Alan Banner, a marine biologist studying sea turtle biology in Western Samoa, was taken by a large tiger shark while snorkeling off a beach known to be a turtle hatchery. Sea turtles are a common prey for large tigers. Banner's snorkeling partner looked on in shock as the large tiger dragged him away; no remains were recovered.

On 18 October 1985, boogie-boarder Joe Thomson was attacked off Princeville, Kauai, by a tiger shark, also presumably motivated by turtle feeding. The yellow-contoured bottom of Thomson's boogie-board closely resembled the plastron (the underside of the shell) of a large green sea turtle. Thomson had sighted several turtles in the area, where on the day of the attack the normally clear water was very murky. Thomson survived the attack with the loss of his right hand and a severely injured left wrist.

Attacks involving great white sharks are almost always related to feeding behaviour. In the tropical Pacific records of attack by this species are limited to Hawaii. John McCosker of the California Academy of Sciences has suggested that a growing number of attacks by great white sharks on surfers off the west coast of the United States may be due to similarities both in appearance and behaviour between surfers and seals, sea lions, and elephant seals – the normal prey of coastal white sharks. With the exception of the northwest Hawaiian islands, seals are not found in the tropical Pacific. However, there seems little doubt that the fatal attack by a white shark on William J. Goins while he was swimming near Haleiwa, Oahu, Hawaii on 18 May 1926 was due to feeding behaviour. According to a report Goins gave a sudden shriek and then

Yves Lancaux/Ecoscope

▲ Tawny nurses are usually found resting on the bottoms of reefs or in coral caves, where they also search for their prey of crabs, lobsters, squid and sea urchins. This species employs its muscular pharynx to inhale prey from crevices, and may respond to being disturbed by using its powerful jaws on a diver's arm or leg.

his head . . . to give him his iron for the day . . .'

Even where survivors were harassed or attacked, few succumbed to the sort of panic that would today be regarded as almost mandatory. Eleven survivors of a 1944 plane ditching were approached and occasionally harassed by sharks. The men drove the sharks away by shooting and kicking: one man was 'bitten slightly', became frightened and died during the second night of the 42-hour ordeal.

At five o'clock on the third morning, the remaining six men were rescued. Their rescuers were 'greatly agitated' by the presence of sharks and one survivor remarked that, 'We got a kick out of it'.

A US Navy officer named Kabat, whose ship had been sunk and who was floating in the water, felt a 'scratching, tickling sensation' in his left foot. 'Slightly startled, I held it up. It was gushing blood . . . not ten feet away was the glistening, brown back of a great fish . . . swimming away. The real fear did not hit me until I saw him turn and head back toward me. I thrashed out . . . brought my fist down on his nose again and again. I discovered that he had torn off a piece of my left hand . . .' Kabat's matter-of-fact account continues with details of further attacks: 'The big toe on my left foot was dangling. A piece of my right heel was gone. My left elbow, hand and calf were torn . . .' In the excitement of trying to attract the attention of a passing ship Kabat forgot the shark, which struck again and bit him on the thigh, exposing the bone. Several sailors began firing at the shark: 'A terrible fear of being shot to death in the water . . . swept over me. I screamed and pleaded and cried for them to stop . . .'

An impression of calmness and resignation, due no doubt to shock, is common to many of the reports. A US Navy pilot reported the death of his radio operator: 'A. said he felt something strike his right foot and that it hurt. I told him to get on my back and keep his right foot out of the water, but before he could the sharks struck again and we were both jerked underwater . . . I knew that we were in for it as there were more than five sharks around. He showed me his leg . . . not only did he have bites all over his right leg, but his left thigh was badly mauled. He wasn't in any particular pain except every time they struck I knew it and felt the jerk.'

Although interviews and research revealed a surprisingly low incidence of shark sightings, much less attacks, the fact remains that a great number of servicemen were injured or lost their lives from shark attacks in Pacific waters during World War II. The presence of hundreds of thousands of people in the area, the obviously increased risk of shipwreck or aeroplane crash and the likelihood of blood in the water meant that investigation by predatory and aggressive sharks was inevitable. The final total of attacks will never be known. Allied war records did not list shark attacks as such, referring merely to 'unspecified animal bites'; and as Llano himself notes, 'When sharks are successful they leave no evidence'.

► Marine turtles are important in the diet of tiger sharks and serious attacks have been reported from areas where turtles are common. In one case, a surfer whose board resembled the plastron (the ventral part of a turtle's shell) of a green turtle was attacked and injured by a positively identified tiger shark.

disappeared; his remains were found in a 3.5 metre great white shark that was caught nearby two days later.

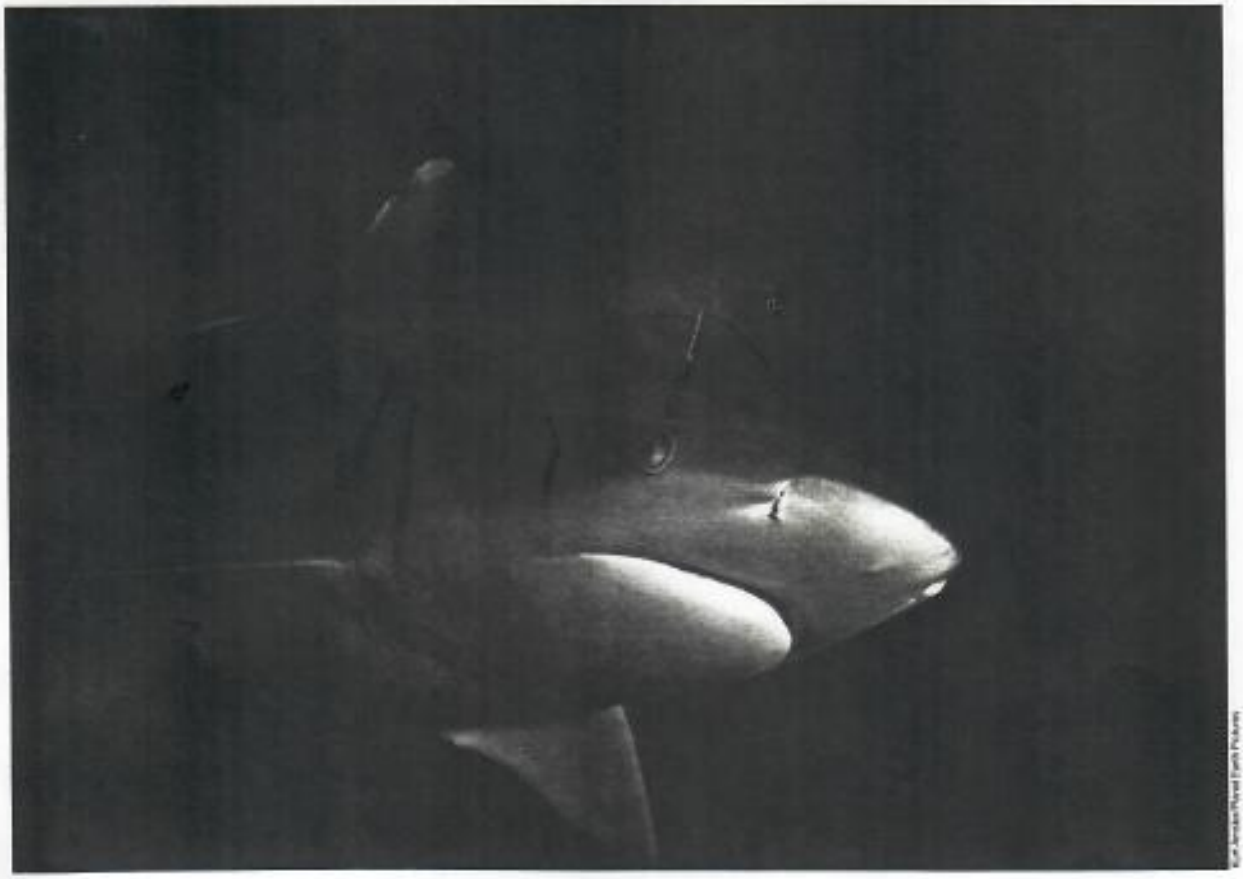
Attacks by smaller species such as the blacktip reef shark and the whitetip reef shark are undoubtedly motivated by factors other than feeding, except in those cases where dead or injured fish were present before the incident.

Although many shark incidents are now attributed to territorial defence, there is little formal experimental evidence that this is the cause. Johnson and Nelson (1972) first described agonistic display in the grey reef shark and suggested in subsequent writings that this was warning behaviour that preceded attack. Although this hypothesis has been questioned by other biologists, no rigorous testing has disproved it. Indeed the attack on Michael deGruy by a grey reef shark in Enewetak Atoll, Marshall Islands, in April 1978, provides empirical evidence that supports the hypothesis.

SPECIES IMPLICATED IN ATTACK

At least eighteen species in four families and nine genera have been implicated in attacks on humans in the tropical Pacific Ocean. Only in a minority of cases have attacking sharks been confidently identified. Such cases include those in which the shark was captured and contained the remains of the victim, or in which the shark species was very distinctive (eg tiger, hammerhead) and the victim or a witness was a trained observer. In many cases, the specific identity of the shark has been guessed at. The following list includes shark species known to occur in the areas frequented by humans and whose size and ecology suggest that they are potentially dangerous to human beings.

▼ At least twelve species of requiem sharks (family Carcharhinidae) have been identified or implicated in attacks in the Pacific region. Several species are especially active at night or around dawn and dusk on tropical reefs, when divers' visibility is more than usually limited and the risk of an attack unconnected with feeding is greatest.



THA

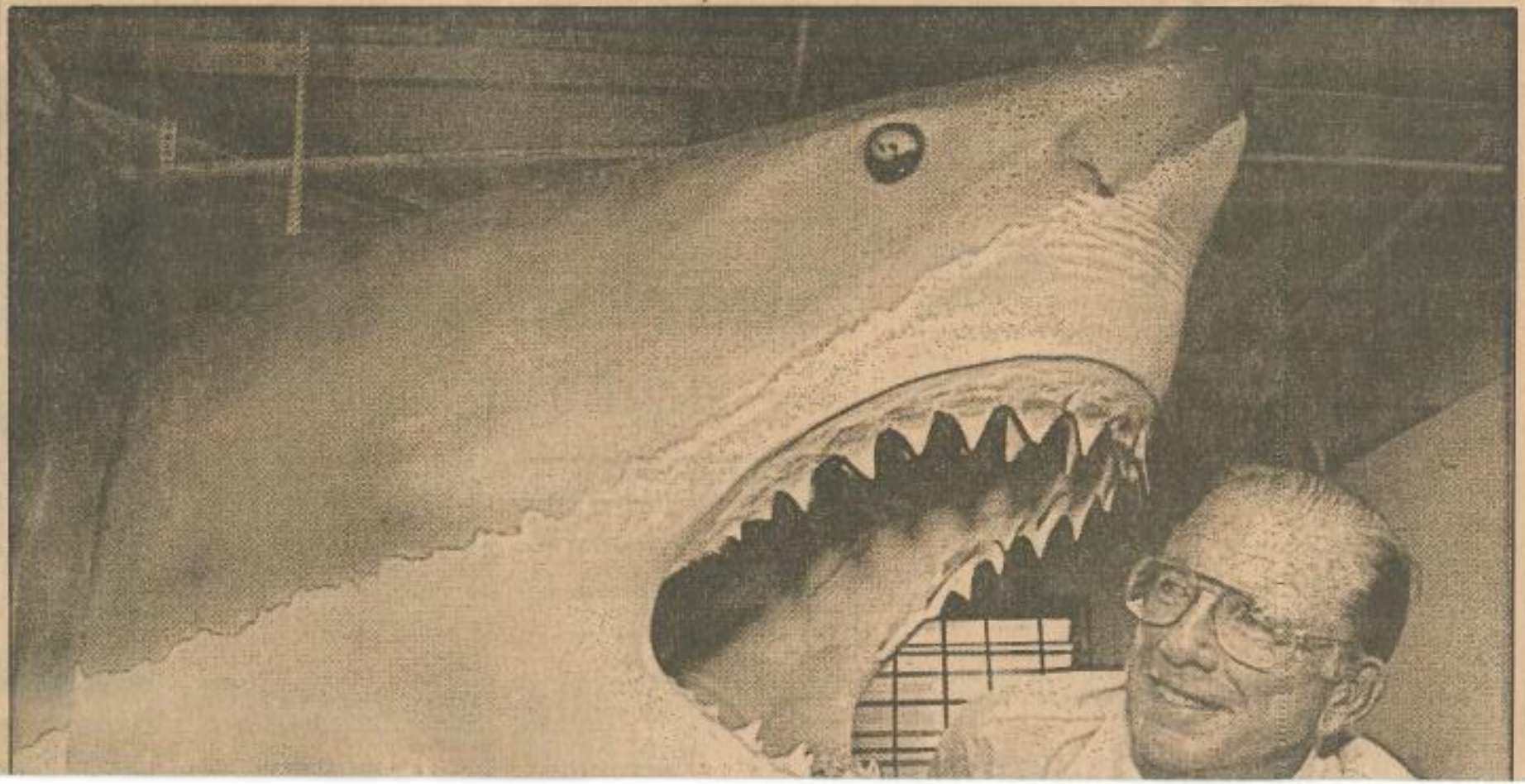
E1

Living

WEDNESDAY, Oct. 16, 1991
The Honolulu Advertiser

TOMORROW: Pau Hana, a preview of weekend flings

The Bishop Museum separates fact from fiction in a big, new exhibit



Advertiser photo by T. Umeda

Senior Bishop Museum fish expert (ichthyologist) John Randall only looks like he's about to become happy shark bait. Actually, he's having a last-minute close encounter with the great white scheduled to be the centerpiece of the museum's newest and largest exhibition.

Everything you always wanted to know about

THE SHARK!

By Will Hoover
Advertiser Staff Writer

HAD writer Peter Benchley and director Steven Spielberg joined forces to produce a movie called "Snouts" instead of "Jaws," the Bishop Museum's colossal new "Sharks!" exhibition would have a very different twist.

But the biting truth is, according to one expert, humans have more to fear from a shrieking hog than a bloodthirsty great white.

"That's absolutely amazing, isn't it?" said John E. Randall, senior Bishop Museum ichthyologist (means fish specialist, like the one Richard Dreyfuss played in "Jaws"), who says that pigs kill more people than sharks do. "Lightning, too. Oh, and bee stings." And falling airplane parts.

WHAT: "Sharks! Fact and Fantasy"

WHEN: 9 a.m. to 5 p.m. daily (except Christmas), Saturday through Jan. 10, 1992.

WHERE: Bishop Museum, Castle Memorial Building.

TICKETS: Included in general admission price of $5.95 for adults and $4.95 for youths 6-17, and military. Children under 6 and Bishop Museum members free.

INFORMATION: 847-3511

In fact, put in proper perspective, Randall says almost *anything* is more life-threatening than sharks. There are five billion humans, after all. Only about 25 of them die each year from attacks by predatory sharks.

That makes getting out of bed and walking to the refrigerator more menacing than a school of voracious fin-bearers. But the point is that even landlocked Iowa humans (who are outnumbered by oinkers seven to one) fear sharks, not pigs.

Which could explain why "Sharks! Fact and Fantasy," will be the largest indoor exhibit in the museum's history (bigger even than its popular dinosaur exhibit).

Funded by the National Science Foundation and organized by the Natural History Museum of Los Angeles County, "Sharks!" is, in the words of those presenting it, "the

See Sharks!, Page E2

Sharks!: Facts — and fantasy

FROM PAGE E1

largest, most comprehensive exhibition about sharks ever displayed."

Why all the fascination with — and fear of — sharks?

"Partly it's because you read about some poor guy who's been eaten alive and there's more horror associated with that than with a car crash and that sort of thing," said Randall. "It's the thought of being eaten piece by piece."

Ironically, humans slay sharks at the bloodcurdling rate of 100 million a year. That the sea's most fearsome creature has far more to fear from two-legged land dwellers than vice versa is but one fact presented in entertaining detail.

We also learn that sharks grow new teeth about once a week, that some sharks have no teeth at all, and that sharks are actually picky eaters.

An exception to that last rule, and the object of one of the exhibit's most entertaining displays, is the tiger shark, described by Randall as "a swimming garbage pail." Among the items found inside tiger shark innards are license plates, a horse skull, a hubcap and — hold the anchovies! — parts of a 17th-century suit of armor.

Museum education chairman Ken Miller said the exhibit will offer an unusual opportunity — a sort of fantastic foot voyage into the world of the hammerheads, leopards, great whites, and incredible megamouths.

"It's a rare diver who has ever seen a shark," said Miller. "Here's an activity that lets people actually experience sharks, become familiar with them and understand them as an animal — to understand how they see, how they sense, how they reproduce."

The effect is produced with rippling lighting effects, bubbling water walls and realistic underwater environments.

"We're not going to fool many people into thinking they are swimming, but it's putting people into a different environment that they're going to have fun with and that will allow them to look at these creatures in a different way," said Miller. "They're not going to be threatened. There's no blood, no gore."

In fact, there is blood. One drop, to be exact. It floats inside a 25-gallon tank of water, illustrating a shark's amazing olfactory ability to sniff out a single ounce of fish blood in one million ounces of sea water.

It's scary to think a shark can do that. But it's a fact — not a fantasy — that the chances of a shark ever catching wind of your blood are about as remote as a wild pig attack in a shower of falling airplane parts.

Miss Hawaii USA contest tickets

Tickets are on sale now for the Miss Hawaii USA pageant scheduled for Oct. 17 at the Dole Cannery Ballrooms. The winner will represent Hawaii in the February 1992 national Miss USA competition.

The pageant is sponsored for the first time by the Susan Page Modeling Agency, which has acquired rights to produce it annually. Contestants compete in swimsuit, evening gown and interview competitions.

The pageant winner will also make appearances at events of the Outrigger Hotels Top Gun Hydrofest at Pearl Harbor, which kicks off the same day.

Tickets are $30 and are available at the door or by calling 545-5270.

away the mask and slashing a wound that required 25 stitches. Blood clouded the

they get, or even how fast they grow. One of Randall's pet projects is correcting the stated lengths of sharks based

TODAY

Friday, October 18, 1991 ■ Star-Bulletin •

B Section

ON BISHOP MUSEUM

Those who were afraid to go back into swimming pools after seeing "Jaws" will find plenty of funky material at "Sharks! Fact and Fantasy," the new Bishop Museum show opening this weekend.

Even though the show is running during Halloween — until Jan. 10 next year — the accent isn't on horror. Still, with those chainsaw gullets rushing at you like a runaway freight train, sharks are prehistoric nightmares. Even John Randall, the Bishop's senior ichthyologist, has a healthy fear of sharks, and he's been up close and personal with the monsters all his professional career.

"We're hors d'oeuvres!" he said. "I still remember that music in 'Jaws.' Duh-dup, duh-dup, duh-dup-duh-dup. But I'm more afraid of tiger sharks than great whites, because great whites are so rare. Even big hammerheads aren't that bad, because they're fish-eaters, and their mouth is small for their size. But the big tigers and great whites — they'll eat anything.

"Even the smaller sharks can be dangerous. The little gray reef shark is very territorial and very dangerous if you annoy it. Once one charged a friend of mine . . ."

Randall goes on to describe how the shark's jaws clamped right over the other swimmer's face, slicing

through night reef, lit by black light and imagineered by kids from the Boys' and Girls' Clubs of Honolulu.

"The creativity of the kids doing this is really phenomenal," said Suzumoto, examining a Day-Glo papier-mache fish. "I'm really impressed."

"I see some new species here," said Randall.

"We better start publishing right away, Jack," said Suzumoto.

As is usual for a long-term exhibit, the museum is offering overnight sleep-ins ("Sleep In the Deep"), night-time flashlight tours ("Sharks in the Dark"), and lectures and reef walks. For more information, call 848-4149.

The long tail of a hanging thresher shark is curved around a small hurricane of anchovies. "That's because this is how we think they eat," said Randall. "The tail whips the water and herds the small fish, and then he slaps them with the fin and eats the stunned ones.

"Threshers aren't good-natured. Nasty brutes. They're pelagic — we don't see them in too close to shore. I saw one once near shore here, just at the limits of my vision, and I was glad he didn't see me."

Sharks are still mysterious, even after being around at least 415 million years without evolving much. No one really knows how big

away the mask and slashing a wound that required 25 stitches. Blood clouded the water, green in the odd way colors change at depth, and the wounded diver clawed his way to the surface, leaving a vertical trail of green blood. Randall vividly remembers the shark spiraling upward around the blood path.

The new exhibit, on tour from the Natural History Museum of Los Angeles County, features a gray reef shark powered by pneumatic pumps that cause it to hula in an approximation of the creature's warning dance. Randall and collections manager Arnold Suzumoto looked over the display this week as it was going up; Suzumoto has co-authored a book for the occasion, "Sharks Hawai'i."

Everything looked good to them except for the life-sized model of the tiger shark. It arrived painted in spots rather than stripes, and was quickly re-camouflaged. A Bishop Museum addition to the show is a walk-

Bishop Museum's John Randall, left, and the collection's manager, Arnold Suzumoto, are framed by a shark jaw.

An assortment of items that have been recovered from the stomachs of various sharks are also featured in the display.

they get, or even how fast they grow. One of Randall's pet projects is correcting the stated lengths of sharks based on jaw sets in museums. "One famous set of great white teeth is in the British Museum and was supposedly from a shark 36 and half feet long. Said so since 1870, when the teeth were found, and textbooks since have said great whites can get this long. But we plotted the real length, based on the enamel-length of the teeth, and found it was really only about 17 feet."

Now, 17 feet or so is the commonly accepted maximum for a great white, but a shark attack on a fishing boat in Rhode Island left bite marks that indicated the creature could be 27-feet long, the size of the shark in "Jaws." So there could be bigger creatures down there. Megamouth, for example, just showed

See **SHARKS**, Page B-2

Story by
Burl Burlingame
■
Illustration by
Kevin Hand
■
Photographs by
Dean Sensui
Star-Bulletin staff

On display

- **Exhibit:** Sharks! Fact and Fantasy
- **Where:** Bishop Museum
- **When:** 9 a.m. to 5 p.m. tomorrow through Jan. 10.
- **Admission:** $5.95 for adults; $4.95 for children age 6-17 and military; free for children under age 6 and Bishop Museum members.
- **Information:** Call 847-3511

Shark bait

Did you know sharks may live 50 years or more? Or that they replace teeth about once a week? Here are few more facts on sharks, courtesy the Bishop Museum:

- Sharks vary in size from 6 inches to 60 feet.
- Sharks have four to 20 rows of teeth — some have no teeth at all.
- Tiger sharks, which are common in Hawaii waters, may shed up to 24,000 teeth in 10 years.
- Sharks can smell one ounce of fish blood in 1 million ounces of salt water.

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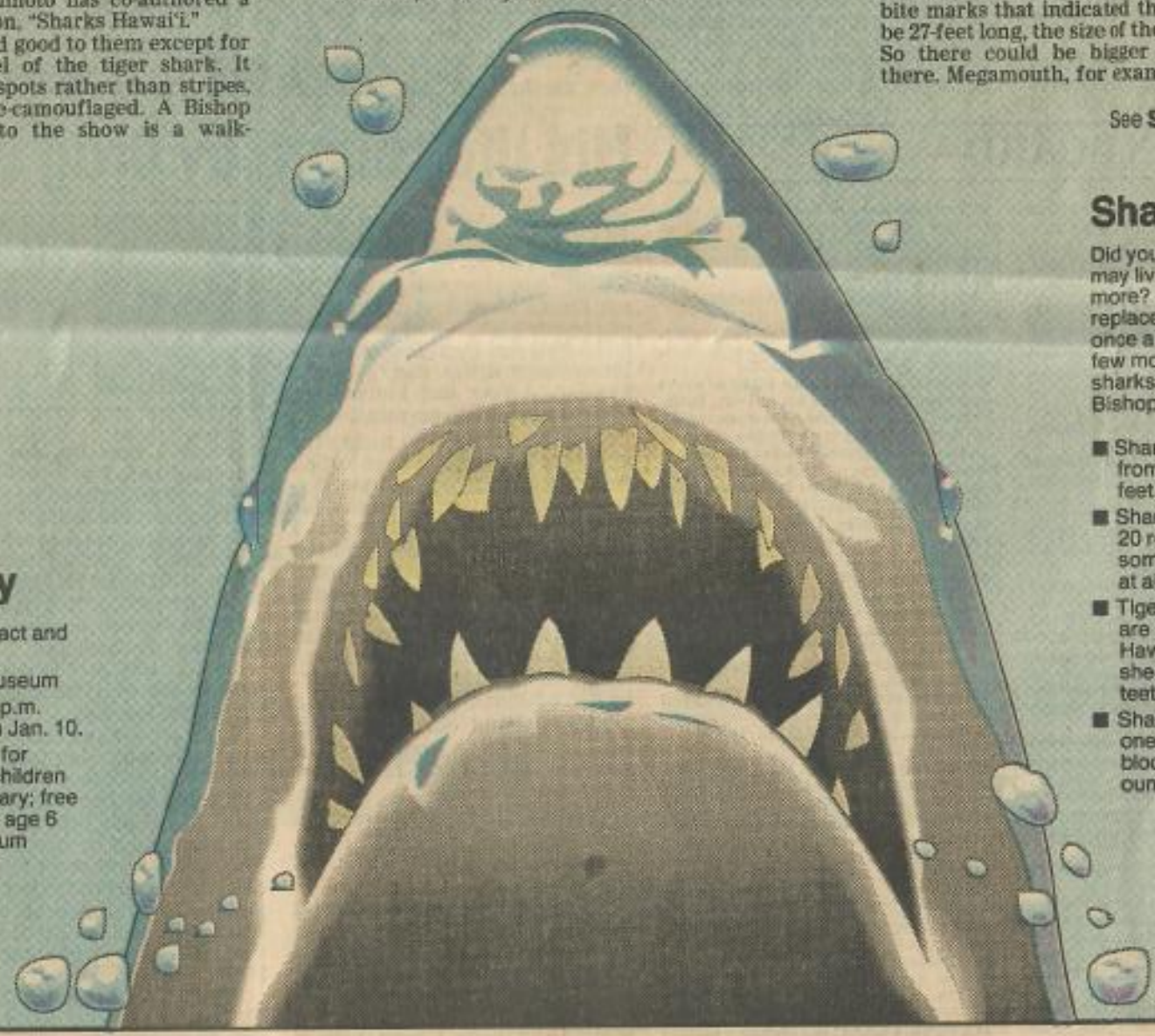

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SHARKS: Take big bite out of Bishop Museum

Continued from Page B-1

up out of the blue one day to every ichthyologist's surprise.

There's a life-sized model of Megamouth at the exhibit, and a set of prehistoric Megalodon jaws from a monster of a fish as big as a school bus that could hold just as many children. Megalodon is long extinct, however, and won't pull a coelacanth, a deep-sea blast from the past. "Meat-eaters like sharks, the top-of-the-chain predators, are pretty rare," said Randall.

"And it's important to keep them, as they keep the other fish populations, in check. In South Africa, where they put up shark mesh-nets around the beaches, small sharks suddenly proliferated. Nature was thrown out of whack."

And yes, it's true that most shark attacks on humans take place in shallow water, some sharks even zeroing in on your kneecap. But that's because shallow water is where humans are. Shark attacks are rare, only about 30 or so a year, said Suzumoto, and only about a third of those are fatal. More people are killed every year by farm pigs, another notion too gruesome to contemplate.

In the meantime, sharks won't be your friends, but they can be reasoned with.

While diving recently at Midway, Randall and Suzumoto were constantly annoyed by Galapagos sharks, which swarmed the divers. "Soon, you're spending all your time looking for sharks instead of working. Of course you didn't dare spear a fish. I once was on the losing end of an argument with a big hammerhead over a fish I speared," complained Randall.

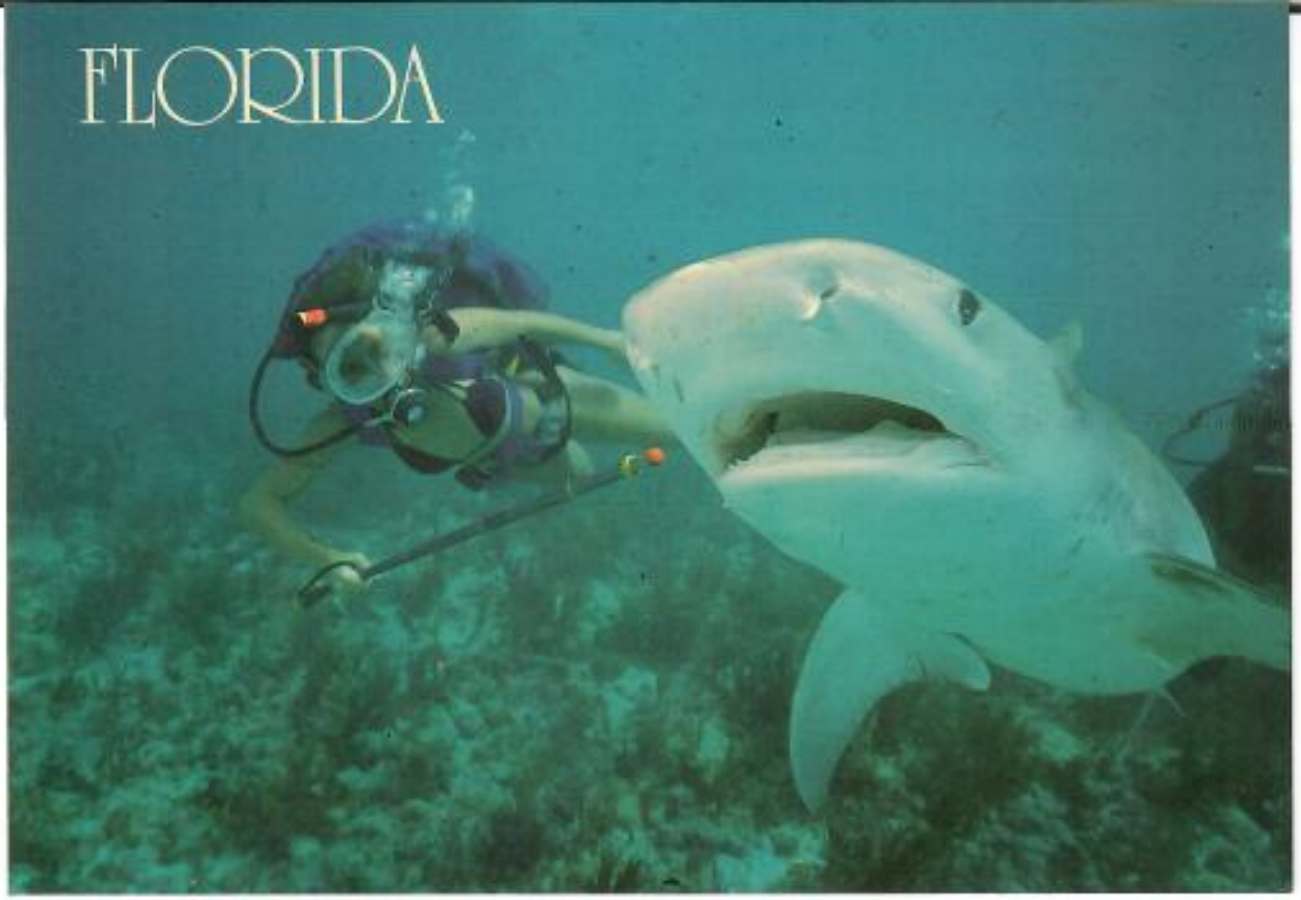
They kept working underwater anyway, careful not to annoy the curious sharks. One morning at Midway atoll, Randall looked into the water with a glass-bottomed bucket and was thrilled to see that visibility extended all the way to the bottom, at least 150 feet.

By Dave Sensui, Star-Bulletin

Bishop Museum staff members prepare one of the many displays.

"We were just about to jump in when Arnold said, 'Ooooh, there's a shark.' And there it was, a Galapagos, swimming around. And then another and another. When we counted 22 sharks, we decided to quit for the day."

Apparently, even when you're on good working relations with sharks, enough is enough.



Heng, Lianhe Zaobao, Singapore

[the following according to Leighton R. Taylor in his unpublished article for Honolulu Magazine; source unknown]

Heloke Mookini told of Kapa'aheo, the shark god of Kohala, on the Big Island:

Long ago young girls enjoyed swimming in a lovely cove in Kohala on the Big Island. Often a swimmer would disappear and never be seen again. The people were afraid and wanted to learn what had happened to the girls. A fisherman noticed that when a swimmer disappeared, a mysterious stranger named Kapa'aheo could be seen sitting on the shore nearby. This fisherman then got all of the other fishermen together and they were on hand when the girls went swimming again. As before the stranger was sitting on the rocks overlooking the cove. When he disappeared the leader of the fishermen ordered the others to dive into the water and form a protective circle around the girls. The shark swam toward the group and a huge fight began. Many times the shark was wounded by the spears of the fishermen. Finally the shark swam away. When the men were back on shore, they found the stranger dying from many wounds that looked like they were made by fishing spears. When the man died from the wounds, he was transformed into the stone found near the edge of the cliff by the ocean.

[Leighton further writes that this: "stone, a 7'6" reclining column of pahoehoe lava, was moved from near the Upolu Airport to Honolulu and eventually to Bishop Museum."]

(7) = Cobb 1902 Comm. Fish. Hawaiian Is. 1900-1901 p. 383-499

(4) = Beckley, E.M. 1887. Hawaiian fisheries and methods of fishing with an account of the fishing implements used by the natives of the H.I. U.S. Fish Comm. Bull. 6: 245-256.

(11) = Emerson, N.B. 1909 Unwritten literature of Hawaii Bureau of Am. Ethnology Bull. 38 Smith. Ins. 2 ref.

Early Hawaiian stories often tell of *niuhi*, a species of man-eating shark that was much feared by the Islanders. There are references to the eyes of this shark being luminous at night, as in the old chant:

Niuhi with fiery eyes
That flamed in the deep blue sea.
Alas! and alas!
When flowers the wili-wili tree
That is the time when the shark-god bites.
Alas! I am seized by the huge shark!
O blue sea, O dark sea,
Foam-mottled sea of Kane!
What pleasure I took in my dancing!
Alas, now consumed by the monster shark. (11)

Fishing for *niuhi* was a great event in ancient times—the sport of royalty. In anticipation, a great store of bait was accumulated. Human flesh was a favorite bait with many chiefs, not only because it was easier to obtain than pig, but its use also provided the chiefs an opportunity to eliminate persons who had fallen from favor. Kamehameha I, a renowned shark hunter, kept his victims imprisoned near the great Mo'okini *heiau*, near Hāwī on the island of Hawai'i. After the victims had been cut up, their flesh was allowed to decompose for several days, thus enhancing its effectiveness as shark bait (7).

One report describes details of an expedition to capture a *niuhi* (4). A fleet of canoes, laden with bait, and with the *po'o lawai'a* and a *kahuna* in the lead, sailed to waters known to be frequented by this great shark. Once at anchor on the fishing ground, they cast great quantities of bait into the sea, for only after the waters for miles around carried the scent—a process that usually took several days—could the *niuhi* be expected to appear. When it arrived, the monster was fed huge quantities of food, which had been mixed liberally with pounded *'awa*, a narcotic herb of the pepper family. Gradually the *niuhi* became lethargic to the point that a noose could be slipped around its head. This was the climax. Once this had been accomplished, the fleet raised anchor and headed home. Groggy with *'awa*, satiated with food, and tethered with a line, the now docile *niuhi* followed the canoes, periodically receiving *'awa*-laced food to ensure its continued cooperation. At home, the fishermen led the stupefied shark into shallow water, where it was stranded and finally killed. Its flesh was not eaten, but the teeth of the shark were prized as weapons, and portions of its skeleton and skin were coveted by the fishermen, who believed that the possession of these objects would endow them with courage. And he who had actually placed the noose around the head of the *niuhi* was confident of being forever victorious in battle.

away upon meeting a human. Also common is the Galapagos shark, *C. galapagensis*, which was once thought to be limited to islands off western tropical America, but is now known to live around tropical oceanic islands worldwide. Although some Galapagos sharks grow to over 12 feet long, most that occur around reefs are much smaller. The shark that swims up to investigate a swimmer near the surface often turns out to be a Galapagos shark. Such encounters simply display its curious nature, however, and upon satisfying this curiosity the Galapagos shark usually fades off into the blue waters from which it appeared. A third species, the gray reef shark, *C. amblyrhynchos* (Plate 1), is the most abundant gray shark around most islands of the central Pacific, including those of the Hawaiian archipelago northwest of Ni'ihau. But except for some localized concentrations, such as occur around Molokini, an islet between Maui and Kaho'olawe, the species is infrequently encountered around the major Hawaiian Islands. The gray reef shark seldom exceeds about 7 feet in length, but is known to have attacked humans.

Another species, the whitetipped reef shark, *Triaenodon obesus* (Plate 2), is included here among the gray sharks even though many ichthyologists consider it more closely related to another group of sharks. The whitetipped reef shark is abundant on reefs throughout the tropical Pacific, including those of the northwestern part of the Hawaiian archipelago, but it is not abundant around the major Hawaiian Islands. Nevertheless, because the species frequents shallow water and tends to remain in localized areas, it is seen regularly near the relatively few major-island reefs that it inhabits. For example, it is a familiar sight around the reefs off Ke'ei and Hōnaunau in Kona. Unlike the gray sharks considered above, which must swim constantly to keep oxygen-supplying water flowing over their gills, the whitetipped reef shark can pump water over its gills while at rest on the sea floor. A diver peering into a cave may be startled to discover one or more of these sharks resting in the shadows.

Two species of hammerheads occur in Hawaiian waters, the scalloped hammerhead, *Sphyrna lewini*, and the smooth hammerhead, *Sphyrna zygaena*. Both grow to over 12 feet long, but only the former is abundant. So far as is known, the early Hawaiians recognized only one hammerhead, referring to it as *manō kihikihi*. Although usually they frequent deep water offshore, female scalloped hammerheads come into shallow, sheltered waters during the summer to bear their young. At that time they are especially numerous in Kāne'ohe Bay, on O'ahu. Otherwise, hammerheads are not ordinarily seen near the reefs.

became sharks upon leaping into the sea. A typical story tells of Nenewe, a shark man, who lived beside a path to the sea in Waipi'o Valley, on the island of Hawai'i (10). Nenewe hailed swimmers and fishermen taking the path and inquired of their destination. Then, armed with this knowledge, he raced ahead on an alternate trail and, taking his shark form in the sea, devoured his victims when they arrived. Because of such folklore, many Hawaiians even today are reluctant to reveal an intent to go fishing.

The submarine homes of the shark deities were revered by the early Islanders, and even into modern times these locations have been considered by many to be sacred places. The twentieth century assumed a collision course with ancient Hawaiian beliefs when, in 1913, the U.S. Navy began building the large drydock in Pearl Harbor. The site chosen was known to belong to the shark goddess Ka'ahupāhau, but the Navy ignored the warnings of old Hawaiians. Construction proceeded without incident until the drydock was nearly completed. Then, in a sudden roar of splintering timbers, the entire structure collapsed. Why? The official record is not clear. Nevertheless, when work was begun again a priest of the old religion, a *kahuna*, was enlisted to appease Ka'ahupāhau. After appropriate prayers, and a ceremonious offering, work on the drydock was resumed. This time the job was successfully completed. Later, when the water was pumped from the drydock, the remains of a 14-foot shark were found at the bottom (45). Those unwilling to accept the influence of Ka'ahupāhau in this incident can readily cite coincidence—but there are still many who sincerely believe otherwise.

The most common sharks around Hawaiian reefs are the various gray sharks of the family Carcharhinidae. Many old Hawaiian names probably refer to these sharks, but whether these names correspond to species recognized today, or just to certain individuals, is uncertain. Examples include *manō pā'ele* (black-smudged *manō*), *manō lele wa'a* (canoe-jumping *manō*), and *(manō pahāha* (thick-necked *manō)* (52).

It has long been recognized that several varieties of gray sharks live in Hawaiian waters, but early ichthyologists assumed that most occur only around these islands. As a result of a shark-fishing program carried out by the late Dr. Albert L. Tester in the 1960s, however, enough specimens were put into the hands of specialists to determine that all the species of gray sharks in Hawaii are wide-ranging in tropical seas.

The gray shark most often encountered around Hawaiian reefs is the sandbar shark, *Carcharhinus milberti*. This species, which is also common in the tropical western Atlantic, rarely exceeds 6 feet in Hawaii. An underwater swimmer will find it to be a timid animal that scurries

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Revised Edition
by EDMUNDSON HOBSON
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Sharks

Among creatures of the sea, sharks have been especially meaningful to Hawaiian Islanders. In the Hawaiian language, sharks, in general, are called *manō*. More than any other marine animal, sharks were worshiped in ancient times as *'aumākua*. Generally, shark *'aumākua* were believed to have had human origins—many were traced to aborted human fetuses that had been cast into the sea (5). Perhaps owing to its appearance, the partly formed fetus may have suggested a supernatural union. The fetus was believed to return to its family as an *'aumakua*, spiritually embodied in the form of a shark. Thereafter, members of that family, including descendants, worshiped what they believed to be the individual shark that represented their *'aumakua*. To them, shark meat, as food, was *kapu*, and they were required to make regular offerings of food and prayer at the place along the shore where their shark *'aumakua* lived. In return, they believed, the shark would protect them from harm while at sea and also would bring them good fishing. Sharks were the *'aumākua* of families among both the royalty and commoners: the family of King Kalākaua worshipped a shark as their *'aumakua*. Although regarded as a god, an *'aumakua* nevertheless was also considered a servant of the family.

Sometimes all the inhabitants of a coastal region regarded a single shark as their *'aumakua*, and its name, history, appearance, place of abode, and other individual characteristics were well known to all. A member of a certain family charged with performing appropriate offerings to their *'aumakua* was known as a *kahu*. The position of *kahu* was hereditary and handed down within a family from one generation to the next (5). The people believed that the *kahu* was endowed with special powers because of his intimate relation with the *'aumakua* and therefore he exerted great influence over the community. Although the shark *'aumakua* was generally thought to protect its devotees, the *kahu* was frequently feared by the community (5). It was believed, for example, that a *kahu* could transmit disease to those who displeased him, and in a village struck by sickness the malady was often attributed to the local *kahu*. Taking advantage of the power he held in the minds of the people, a *kahu* sometimes terrorized his neighbors by adorning himself with trappings that made him resemble a shark and by speaking in a squeaky falsetto tone of voice (34).

It was believed that most shark *'aumākua* could take human form at will—hence sharks believed to be *'aumākua* were collectively called *manō kanaka*, or shark men. There are many old Hawaiian stories of shark men who, in their human form, looked like other men except in having the mouth of a shark on their backs, and who

Note: Dr Henderson who directs Hana

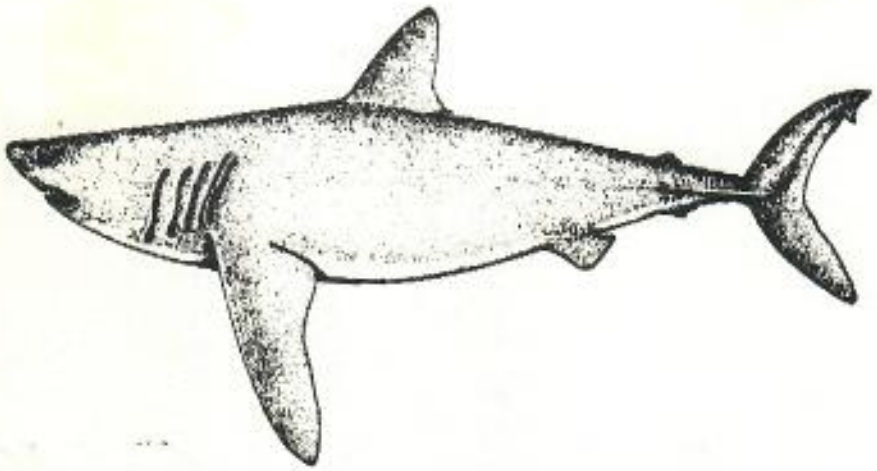
matically conducted, can effectively reduce the numbers of sharks that are active in nearshore waters.

Eels

Most eels in Hawaii are morays, of the family Muraenidae. Collectively called *puhi* by Islanders, these predators are denizens of cracks and crevices in the reef. Because they venture only infrequently into the open, their great abundance cannot be appreciated by the casual observer. Generally only those few that protrude their heads from reef crevices are seen by day, even though the morays include more species than any other family of Hawaiian reef fishes except the wrasse family, Labridae. It was long assumed that morays are nocturnal and emerge from the reef to feed at night. Although this is true of at least one Hawaiian species, *Gymnothorax petelli* (Plate 3), most remain hidden at all hours. Indeed, morays are adapted to activity within reef crevices, and at least most should capture prey best there (22). Many are quick to detect injured fishes, however, and frequently are lured from their hiding places after the spear of a diver has found its mark.

Moray eels were the *'aumākua* of many early Hawaiians (52). One well-known eel-god, called Ko'ona, was worshiped by the people of Wailau on the windward coast of Moloka'i. Many heroic deeds are attributed to this deity, and to this day a large cave on the rock shore is said to have been formed when Ko'ona caused the cliffside to fall on a large shark that had invaded the area. According to legend (35), Ko'ona met his end after raiding the fishponds of Kū'ulakai, god of fishermen, at Hāna, Maui. It was 'Ai'ai, son of Kū'ulakai, who led several canoes on the expedition that destroyed Ko'ona. A large hook was secured to a long line and baited. Weighting himself with stones, 'Ai'ai dived with the hook to the opening of a submarine cave known to harbor Ko'ona. When the huge *puhi* took the bait and was hooked, the canoes trailed the line to shore at Lehaula. Here it was taken up by the people of the area, who pulled together and hauled the giant *puhi* onto the beach. Three *'a'ā* stones, hurled by 'Ai'ai at the stranded eel-god, provided the death blows. On the beach at this place today a rock formation 30 feet long is said to be the remains of Ko'ona's backbone, and another group of rocks awash in the sea a short distance away is claimed to have been the creature's jaw bones.

Despite the probably exaggerated reports by divers of giants over 10 feet long, *puhi* on Hawaiian reefs today do not appear to exceed a length of more than about 5 or 6 feet. The larger eels are a small minority; most Hawaiian species are not longer than about 2 feet when fully grown (14). An example is *Gymnothorax meleagris* (Plate 4),




Sherman's Lagoon
SWIM'N EAT. SWIM'N EAT. SWIM'N EAT.
HEY, HEY, HEY, HEY... KNOCK IT OFF. SHARKS ARE VERY COMPLEX CREATURES, I'LL HAVE YOU KNOW.
NOW YOU MADE ME FORGET WHAT I WAS DOING.
YOU WERE PROBABLY LOOKING FOR SOMETHING TO EAT.
RIGHT.
Sally Forth


GATT
EUROPE
USA
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KAL

Hoping for a face-off

Hanalei fisherman

By ANNE E. O'MALLEY

HANALEI — One thing is clear to Ralph Young. He isn't going to be shark chum when he returns to surf at Hideaways or Summers around the east point of Hanalei Bay.

Taking matters into his own hands, Young, a fisherman from Hanalei, has been stalking a particular shark that he deems a very troublesome predator, indeed.

It was a shark, most likely a tiger shark, local experts surmise, that took a chunk of Hanalei resident Greg Filtzer's surfboard recently, fortunately leaving Filtzer unharmed.

The same shark, they feel, may well be the one which three days prior to chomping Filtzer's board aggressively stalked yet another surfer at a location about a half mile away.

Given the fact that tiger sharks are known to hang out on the same turf for years, Young thinks it's possible that this shark is the same one that amputated the right hand and forearm of his buddy Joe Thompson, five years ago this month.

To add fuel to the fire, Young has had his own close encounter of the dangerous kind, one in which a tiger shark made his life misery for a brief but memorable time about 10 years ago.

At that time, Young was running a restaurant, doing his own fishing for the dinners. Skindiving off the south shore, he would speargun and string up the daily catch. One day, he almost *was* the catch.

"I was diving and I had some fish and I had a real large tiger shark, about 12 or 14 feet go right over me and keep coming at me for about 45 minutes, keeping me from going about 200 to 300 yards into the beach," says Young.

It was his third shark encounter of the day, with the two previous ones being reef sharks, he says, who were after his fish. This one was different.

"It wasn't interested in the fish at all," says Young of the tiger shark.

Still, Young and others don't discount this aggressive shark as one who could attack a human.

"A human being in his area would certainly not be off the menu," says Young. "Some people, like divers, say it's no big thing, but there are potentially real dangers.

"So I would prefer to see him out of the area, especially this one that's bitten the board and already shown aggression," he says.

sive.

"It's like a bear in a park that starts attacking people," he says. "You don't go out and eradicate all the bears."

There is no 100 percent proof that it is a tiger shark, but everything points that way. For example, there are the marks left on Filtzer's surfboard.

"We found no teeth or tooth fragments in the surfboard, so right now

THIS ONE DIDN'T GET AWAY: This 11-foot tiger shark was hauled aboard the R/V Machias during a 1971 state shark control and research program carried out by the Department of Land and

Natural Resources. Sharks are highly adapted for the ecosystem they live in, eating everything and remaining in the same area for long periods of time. Photo courtesy of State of Hawaii Department of Land and Natural Resources Division of Fish and Game.

"It was a definite face-off 30 or more times.

"Every time I'd come up for air--I was free-diving--every time I'd come up for air it would come at me and then I'd go under five to 10 feet and go at him and it was this face-off and then I'd go another 10 feet and come up for air and basically, it'd be the same thing," he says.

Young changed his mode of operation that day.

"That's when I started buying fish instead of diving for it anymore," he says.

Today, Young operates a different business, Hanalei Sport Fishing, which consists of sport fishing and tours on the Na Pali Coast. Young has run into sharks commercially, for sometimes he has to chase them off to get the catch.

The situation with this bully shark is a little different, he says. Hanalei Bay just isn't big enough for an aggressive shark, he thinks. Others agree.

"In this case, I surf in the same area, and I determine that one like this that's biting a surfboard or circling surfers or divers to be possibly one that's even bitten a human before," says Young. "Maybe somebody that's drowned, maybe even the surfer that's drowned off Haena," says Young, speculating on the disappearance recently of a North Shore surfer.

"Normally, they don't go after humans," says Young, saying that's what statistics show. "When it comes to a tiger shark, generally they have their own food source, which is other sharks or turtles or tuna or something," he says.

Young isn't going on a shark-killing spree. He's going after a specific shark.

"They're all different," says Young. "The fact is that he obviously is really chasing humans, so I thought, well, I've got the equipment. I thought I'd go out and give it a go," he says.

Don Heacock, a state aquatic biologist, supports the idea.

"I wouldn't recommend a massive shark eradication program, because we're not after all sharks," says Heacock. "We'd like to just catch that one, because it has been aggressive and we're unable to tell what species it is," says Heacock. "However, it definitely is a very large shark, just from the radius of the bite of the board," he says.

"Also, I could see certain impressions were left in the foam of the surfboard that suggest that it might be a tiger shark," says Heacock.

Heacock has sent photographs of the foam impressions to shark experts John Naughton with the National Marine Fisheries Service and Dr. Richard Wass with the U.S. Fish and Wildlife Service.

"In reality, it probably doesn't

stalks tiger shark

matter what species of shark it is, says Heacock.

"The most likely species is the tiger shark. Tiger sharks are very common in Hawaii. They're more common than a lot of people would like to believe," he says.

Although he says rating is subjective, Heacock says that if sharks were ranked according to their potential danger to people, tiger sharks would be bad news.

"They can be very aggressive. They're opportunistic feeders, feeding on whatever they have an opportunity to try to take a bite out of, says Heacock.

'I had a real large tiger shark, about 12 or 14 feet go right over me and keep coming at me for about 45 minutes, keeping me from going about 200 to 300 yards into the beach.'

Ralph Young

Anything is fair game for these sharks, says Heacock.

They will take bites out of just about anything--tar paper, rubber boots, surfboards, sea lions, people--the list is very long," says Heacock.

"It doesn't all entail all organic matter," he says. "They find nails

and fishing for that fish," says Heacock. "And John Naughton and I both thought it would be a good idea to try and catch that particular shark," he says.

"What you would not want to do is go out, call the hospital, see if they

See SHARK on D-2

boots, surfboards, sea lions, people--the list is very long," says Heacock.

"It doesn't all entail all organic matter," he says. "They find nails and pots and pans in their stomachs. I mean, these things will eat virtually anything."

It's Heacock's job to give fishermen advice about anything related to the division of aquatic resources or water quality, and he's behind Young's efforts.

"He was considering going out

Growth data on large sharks are inaccurate because lengths at tagging were usually estimated while the shark was alongside the boat or off the stern. A good growth record is available for the small tiger shark (L-15069) mentioned above). Over the 207 days at liberty it grew from 131 cm T.L. (51 1/2 inches) to 173 cm (68 inches), corresponding with an annual growth of 74 cm (29 inches).

Data for the 11 small gray reef shark recoveries should be relatively accurate, as they were measured on board both at tagging and at recovery. However, even so, total length measurements are subject to considerable error, with one shark (L-15497) appearing to shrink 2 cm between tagging and recovery. On an annual basis, the average growth of all 11 sharks (including L-15497) was only 3.15 cm (1 1/4 inches). This seems to be a remarkably slow growth rate for these small sharks which averaged only 85 cm (33 1/2 inches) at tagging. The greatest increase (S-17257) may be calculated at 11.59 cm (4 1/2 inches) per year. This apparent slow growth rate for tagged gray reef sharks will be compared with that obtained by Mr. Richard C. Wass on captive gray reef sharks during the next year.

FOOD OF SHARKS

Stomach contents of sharks were examined on board ship by the scientists, and sufficient data were obtained to comment on the food of four species (Table 22). The type of food eaten often provides information on where and how the shark forages and helps define its natural habitat.

The diets of the sandbar, galapagos, and blacktip sharks were generally similar, consisting mostly of fish, but with a significant proportion of invertebrates such as squid, octopus and crabs which live on or close to the bottom. But there were subtle differences in the diets. For example, sandbar and blacktip sharks fed usually on small fish which were swallowed whole, whereas the larger galapagos shark fed mostly on larger fish, including rays and other sharks, which were torn into chunks.

The tiger had the most varied diet of all the sharks. It included,

in addition to the above items, turtles, birds, porpoise or whale flesh, human remains, and a miscellaneous assortment of garbage. Many of the fish were slow-moving puffers or blowfish, which would be easily caught by this large, relatively slow-moving shark. Many of the stomachs contained large chunks of shark, chiefly sandbar, which once hooked on our longline gear, served as bait for the tigers. This will be discussed in the next section, together with the tendency of both tiger and galapagos sharks to prey on free-living sharks, particularly small sandbars.

The stomach of one tiger contained a bird band which identified bird remains as those of a homing pigeon which had been released from Molokai a few days previously and was expected to return to Kaneohe where it had been reared. Garbage, usually present in the stomachs, included tinfoil, milk cartons, rags, sticks, and a lady's white handbag. An 11-foot tiger, caught off Kailua, Oahu, contained human remains, presumably those of a fisherman who had drowned in Molokai Channel a few days previously. Obviously, this shark will feed on almost anything, and more than the other species, is serving a role of scavenger in our inshore waters.

BAIT PREFERENCES

The primary bait used in standard sets was the aku or skipjack tuna (Katsuwonus pelamis) usually cut in halves or thirds depending on the size of the fish. The aku was sometimes fresh caught but more often thawed from frozen storage supplies. The condition of preservation varied from firm and strictly fresh to soft and stale. In using alternate bait techniques we were unable to demonstrate any difference in shark catch between fresh and stale aku (Sets 4 and 14), between half and whole aku (Set 8), between head and tail halves (many sets) or between head, middle and tail thirds (Set 70) of larger aku. Either preferences did not exist or the data were too scanty to reveal their presence.

Aku were not available for bait in standard fishing around Oahu during part of the seventh circuit. Frozen squid, imported from the mainland, were tried as bait twice (Sets 216, 217) but no sharks were

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Kona catch trapped by ocean litter

—WHT photo by JASON ARMSTRONG

SHARK FISHERMAN — 9-year-old AJ Kenna of Long Beach, Calif. poses with the 105-pound shark he caught in waters off Kailua-Kona. The shark had a plastic strap wrapped around it.

A white-tip shark, trapped in a plastic crating strap, was captured off the Kona shoreline yesterday, marking the second marine animal harmed by ocean waste in the past week.

The 105-pound, 6-foot shark was caught at fishing island, about three miles off the coast, by AJ Kenna, 9, of Long Beach, Calif.

Pacific Ocean Research Foundation Director David Grobecker said the female shark was being cut by a plastic strap, wrapped around the dorsal fin area. The strap had strangled the shark, as the young animal grew against it, he said.

Grobecker said that two days earlier a green sea turtle, an endangered species, was found suffering from ingested plastic bags. The turtle was taken to Oahu where it is recovering.

"This is just another example of garbage in the ocean," Grobecker said. He added that while white-tip sharks are common in deep waters off the Kona coast, they have no commercial value and are not captured for their meat.

According to U.S. Coast Guard Petty Officer Allan Dixon, a law prohibiting the dumping of trash into Hawaiian waters, was put into effect last year. The penalty for ocean littering is up to a $25,000 fine in addition to criminal charges of up to $50,000 and five years in jail.

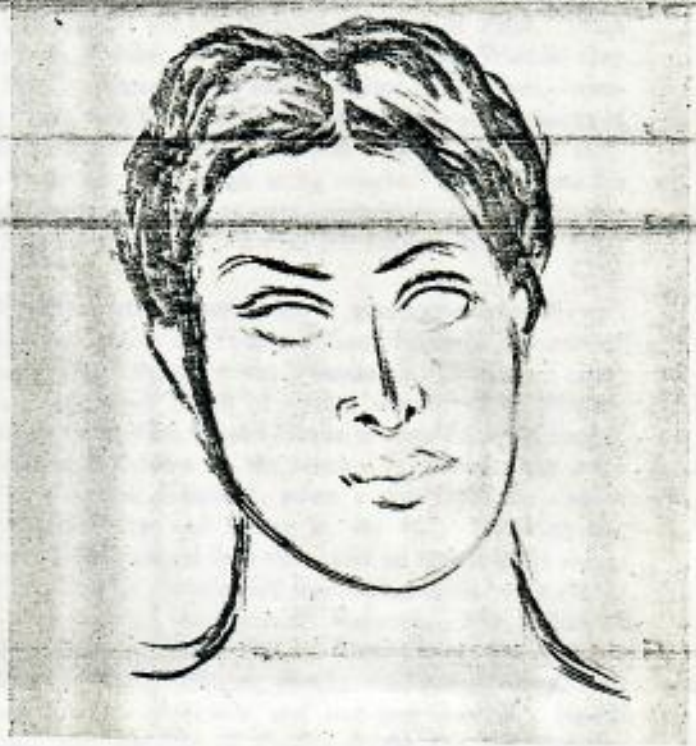
moving in their stately way down an hibiscus fringed street is like meeting a gallery of golden Greek statues and seeing not one Venus of Milo, but a hundred.

And last of all I have found a people who combine the beauties of all these beautiful races—the Hawaiians. As though descended from gods of heroic proportion, the Royalty in Hawaii were almost always at least six feet tall and had weight to match. Intelligent and brave past believing, bearing a strong affinity to the Greeks both in their legends and in their person, their strange perfection increasing always with the various racial mixtures, these super Polynesians are only equalled by those who live in our imagination through Homer.

The virtues of both races are accentuated rather than lost where they are merged in Hawaiian-Chinese, Japanese-Hawaiian, Hawaiian-Irish, Swedish-Hawaiian, Portuguese-Hawaiian, and Scotch-Hawaiian. These mixtures all keep the strength and the beauty of their Hawaiian heritage.

The glory of the Hawaiian race runs through Hawaiian history—from the infant loveliness of the little Prince David, the calm perfection of the youthful Kamamalu and the gallant figure of her husband Kamehameha II, the handsome features of Queen Emma, the impressive presence and dynamic personality of Liliuokalani, the soldierly bearing of High Chief Hoapili and his gentle wife, the classic bronze heads of Kamehameha I and Kalakaua, the wisdom and dignity of Princess Ruth, to Kaiulani whose calm face for serene perfection can only be likened to the Greek Helen.

Today, even the enveloping *holoku*, the costume designed by the early missionaries and not unlike a "mother hubbard", cannot hide the small wrists, the curled back slender fingers, and the columnar arm of even the largest lei-woman. Picking flowers at dawn and stringing them in the street on boat day does not contribute to one ugly or hurried gesture on her part. Her lifted arms, her wistful smile, the ember-like glow of her sunny flesh, are a perpetual and Queenly benediction from one in an honoured profession in the Islands possessing the most beautiful people in the world.



Greco-Hawaiian Mask—*By Madge Tennent*

Legendary Wai-Momi

By Edwin North McClellan

Pearl Lochs, the Sea of Many Harbors! A sea of branching crooked harbor is Puuloa! Thus spoke the Tradition Bearers of old Hawaii-nei, for Puuloa of the Pearl Lochs was one of the favorite rendezvous for the Royoalty of Hawaii-nei and before that of the Mois of Oahu. Men later called it Wai-momi.

Pearl Lochs—East, Middle, West—open out "like the petals of the *fleur-de-lis!*" Like an hospitable open-hand of three fingers! The narrow-entrance-wrist joining the hand to the vast body of the Pacific! Partially filling East Loch is Mokuumeume or Ford Island—once called Rabbit Island—the domicile of Navy and Army aviation!

What Hawaiian sagas of daring and adventure, of romance and sacrifice, of hope and despair, of victory and defeat, that hand-shaped and water-filled form of white coral and black lava could write—if it only would! The answer comes, it has—but we cannot read what it has writ!

Those peaceful lochs—now called Pearl Harbor and dedicated to defensive-war purposes—were there long before the aborigines of the Hawaiian Islands arrived! Long before the ancestors of the present native race landed to drive the aborigines along the path of destiny!

Pearl Harbor was there during the days of the ancientist of Oahuan Sovereigns or Mois, Chiefs and Chiefesses. They played and loved, they fought and died, on its shores in the mythful haze of legendary times. It had its Fish Gods and Shark Gods, its taboos, and its chivalric atmosphere. It is said that the only walled fish-traps of Oahu were on its shores.

Legends and *meles* are filled with references to the Ewa Lagoon, the Pearl River, Puuloa, and other names for these beautiful lochs or places on or near them. There was Keaunui (son of Maweke) the head of the powerful and celebrated Ewa Chiefs. "To him is credited the honor of having cut a navigable channel near the present Puuloa Saltworks, by which the great estuary, now known as 'Pearl River' [Pearl Harbor] was in all subsequent ages rendered accessible to navigation," recorded Fornander. This was about in the eleventh or twelfth century.

Then there is the legend of the magnificent Princess Kelea of Maui, who was carried to Oahu by Lo-Lale. But the inland situation of Lihue at the foot of the Kaala mountains, and far away from the sea, became wearisome and monotonous to Kelea. She informed her husband of her intention to leave. He reluctantly gave his consent. Kelea the "beautiful woman from Lihue," was a superb swimmer

and graceful surfist. "Leaving Lihue, Kelea descended to Ewa, and skirting the head of the lagoon by the way of Halawa, arrived at the mouth of the Pearl River opposite Puuloa," related Fornander. Borrowing a surfboard Kelea excelled all the men and other women engaged in this national sport of Hawaii. Her physical charms and brilliant nautical achievements won the heart of Kalamakua who threw his mantle over the beautiful Kelea and carried her to his grass house,

There is another beautiful legend which must be referred to. It tells us of the "Chant of Kahahana." King Kahahana was the last real Moi or Sovereign of the Island of Oahu. He was the son of Elani of the Ewa line of Chiefs. Betrayed, he was assassinated by order of Kahekili who had conquered Oahu. His body was sent to Waikiki. The "Chant of Kahahana" was composed by his widow, Queen Kekua-poiula, "as the canoe was disappearing with her husband's corpse down the Ewa Lagoon (Pearl Harbor) on its way to Waikiki."

Ka-ahu-pa-hau, the traditional Queen Shark of Oahu, lived in her cave-home "at the entrance to Pearl Harbor (Puuloa)." She "proclaimed a law that waters of Oahu (the island on which Honolulu is located) were forever tabu to man-eating sharks." The husband of this Oahuan Queen Shark was Kuhaimoana, whose habitat was at the islet of Ka-ula, the westernmost of the Hawaiian Group.

When the Pearl Harbor dry-dock was started in 1909 the Hawaiians are said to have voiced gloomy prophecies, for many of them claimed that the home of the Shark Royalty had been selected as the site. Four years later "when the excavation was cribbed with timber structures, and cement was being poured into the bottom by tons and water was pumped to test the stability of a section, the bottom suddenly rose, crushed the huge timbers like matches and four years of labor was annihilated in four minutes."

"Possibly after all the prophecy of the Hawaiians that never on that site could a dock be built had been fulfilled." Judging from the succeeding events, however, the Shark God must have been placated for the dock was completed and is in splendid condition today.

The romantic story of the two good Non-Man-Eating Sharks of Pearl Harbor, who had their cave near the present Coal Pier, adds color to Ewa's "Shamrock Lagoon." Once they were host to a Man-Eating Guest. He ate a fisherman and punishment for such base ingratitude followed. After departing, the Man-Eating Shark led his followers into Pearl Harbor. A tremenduous battle between the invaders and the flotilla of defending Pearl Harbor Sharks ensued. The waters of the Pearl Lochs turned to blood. Finally the Non-Man-Eaters of Wai-Momi won victory.

Then there is the absorbing tale of Ka-ehu-iki-mano-o-Puu-loa (abbreviated Kaehuiki and Ka-ehu)—"the Little Yellow Shark of Pearl Harbor (also called The Small Blond Shark of Puuloa) " who "had been given magic power and great wisdom by his ancestor Kamoliili, the Shark God, brother of the Fire-Goddess Pele." Ka-ehu was named after Ka-ahu-pa-hau, the Queen Shark of Oahu residing at Puuloa.

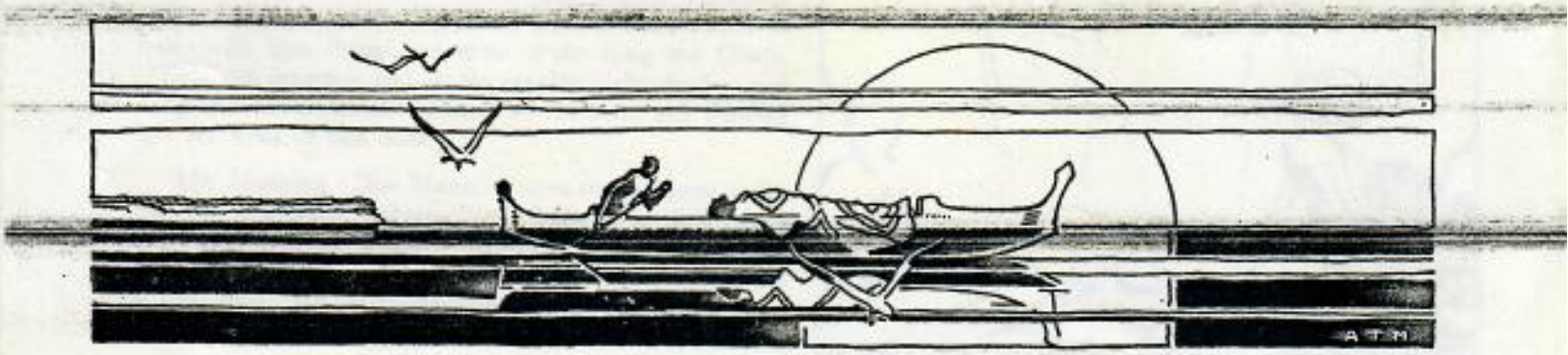
While at Pearl Harbor, Ka-ehu "became homesick for the beauty of Puna," Hawaii, where he had lived with his parents who guarded the sea precipices of the coast of Puna. With his friends, Ka-ehu started for Hawaii. "At Waikiki they met Pehu" a "man-eating shark" visitor from Maui, swimming "back and forth at Kalehua-wike (the surf outside of Royal Hawaiian Hotel). He was waiting for some surf-rider to go out far enough to be caught." Ka-ehu and his friends destroyed Pehu as part payment to the humans for honoring the sharks at "Puu-loa the ancient name for Pearl Harbor."

Mikololou was a strange Shark who came from Hawaii to visit the waters of Puuloa (Pearl Harbor) desirous of securing human flesh," wrote Thomas G. Thrum. Kaahupahau, the Queen Shark of Oahu, who lived at Puuloa, hearing of Mikololou, caused him to be netted near Waipahu. His body was thrown on the beach. It wasted away until "only the tongue remained, when a dog from the distant shore came along and seeing it, ate it." Finishing the "morsel the dog leaped into the water to return to its shore, whereupon it was transformed into Mikololou's living shark-form and returned" to Hawaii. Returning with a fleet of man-eating sharks, Mikololou led them against Queen Kaahupahau's Non-Man-Eating Sharks of Pearl Harbor, who "slaughtered the intruders and but few escaped. Hence the open thoroughfare of Puuloa is the guarded highway of Kaahupahau, whereby the Sea of Puuloa is safe and peaceful through her law that sharks shall not attack man."

"It happened to Kaahupahau, an ordinary native woman," wrote W. D. Alexander in his "Legend of Pearl River:" The Shark, greatly venerated and feared for his power said to her from the seething sea-foam:

"O Kaahupahau, why do you sleep, when the eastern sky is crimson, and the mountain-tops are red with the rising sun? Bring me soothing *awa,* for I am very weary. I am in my hole beyond Kekaa, where you have often seen me. Come, and fear me not."

Kaahupahau did as she was bid. Carrying *awa* to him



The "Chant of Kahahana"

she poured it down his throat without fear of the terrible teeth.

"Bring me *awa* again, tomorrow, O my daughter," commanded the Shark. Day after day the woman carried *awa* to the shark, who became stronger and stronger.

Kahunas, Papio the grandmother of Kaahupahau, Princess Aiole of Manana, now enter into the story. The Princess became displeased with Papio and threatened her life. The shark was appealed to by Papio and out of gratitude saved Papio by killing the Princess.

The Shark grateful to Papio destroyed Princess Aiole

Mokuumeume, or Ford Island, is full of traditional and legendary interest. There was a large cave in the center of Mokuumeume. One night the native in charge of the island was awakened by some person calling him by name. Looking up he was much terrified on beholding the pale form of the late King Paleioholani before him. Now Paleioholani was the son of Kualii (Moi of Oahu who died at an advanced age about 1770) and Kalanikahimakeialii.

"Go to the cave where you will find my bones with the bones of several great chiefs," commanded the ghostly king. "Take them from thence and convey them to a place of safety, out of reach of Chief Kaleioku who will come tomorrow with a party to search the Islands for the bones of the King and Chiefs with which to make points for their arrows to shoot rats with." The ancient Hawaiians believed there was a charm in human bones, and never in any other sort, for this purpose.

"The next day, according to the prediction, the Chief came and searched the Island," related Peter Corney who had it from Don Francisco de Paulo, or Don Marin, the owner of the Island, in 1818. The Chief took several bundles of bones with him, though not those of the King and Chiefs.

Kaleioku departed, and on the ensuing night the deceased King and Many Chiefs appeared to the man, and thanked him for what he had done.

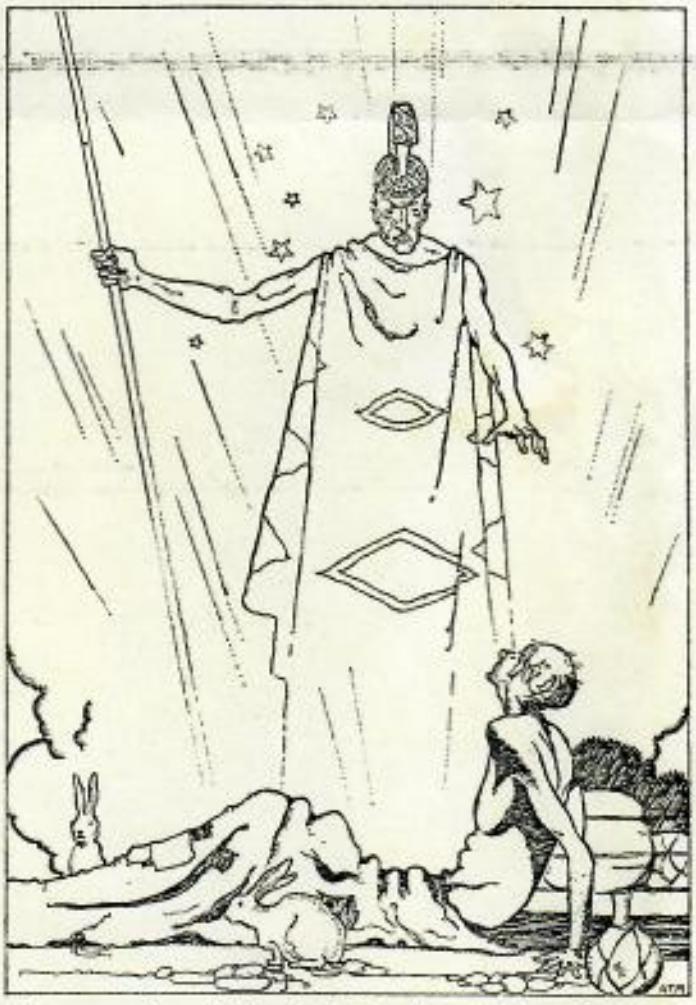
"Mr. Manning (Don Marin) was as superstituous as the natives," explained Corney, "and declared he had heard many instances of similiar nature." Shortly after this Corney and Marin went to the sleeping house where the women were. Mr. Manning went out to walk about. In a few minutes he returned in a terrible fright and perspiration.

"What is the matter?" asked Corney. Don Marin did not reply at once but after he got more composed told Corney very seriously that as he was walking by the prickly pear-trees, saying his prayers and counting his beads, he saw Chief Kaleioku, who had died about a month since, walking before him, attended by a number of people dressed in white.

"I laughed heartily at this relation and tried to persuade him it was all imagination; but he still persisted in having seen the spirits," said Corney.

"The next morning I went round the Island, which seems as though it had been kept for a burial place," related Corney, "for I saw hundreds of bundles of bones, wrapped carefully up in cloth, and laid in crevices of the rocks. We then left this spot, and Mr. Manning had the King's bones actually conveyed privately to his own house, where he still keeps them." There are islands in Pearl Harbor other than Ford Island but it is believed that it was Ford Island on which all this occured.

Invasions of Oahu often passed over the Pearl Harbor waters. About the fourteenth century three high chiefs of Hawaii (Hilo-a-Lakapu, Hilo-a-Hilo-Kapuhi, and Punaluu), together with Lunkoa, Chief of Maui, invaded Oahu during the reign of Mailikukahi, Moi of Oahu. The landing was made at Waikiki. From there the invaders proceeded up the Ewa Lagoon (Pearl Harbor) and marched inland. The bloody battle ended in their defeat in the Kipapa Gulch or Ravine, which "is said to have been literally paved with the corpses of the slain and received its name Kipapa from this circumstance."



"He was much terrified on beholding the pale form of the late King Paleioholani."

The Marine Advisory Program Newsletter

MAKAI

"Toward the Sea"

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Sharks in Hawaii: Nuisance or Bonanza

by Karl Samples,
MAP Marine Economist

Ask fishermen in Hawaii about sharks, and you will quickly learn that these fascinating animals are a source of constant aggravation and increased fishing costs. You will probably hear tales of sharks harassing boats and viciously destroying costly fishing gear and captured fish. Experiences such as these lead to a general regard for sharks as dangerous nuisances to be avoided whenever possible.

But the time is coming when more fishermen will intentionally seek out these stubborn troublemakers as a source of fishing profits.

It is no secret that Hawaiian waters support sizable populations of sharks. The abundance of sharks is evident in several ways. For example, open-water species such as white-tipped, blue, and mako sharks comprise 25 to 35 percent of the total annual longline billfish catch in Hawaii's Fishery Conservation Zone. In some years, the incidental longline harvest of sharks has amounted to over a million pounds. Furthermore, several nearshore shark species such as sandbar, gray reef, and tiger sharks exist in significant numbers in Hawaii's coastal waters.

Some biologists believe that catches of nearshore varieties could be as great as 20 percent of the total annual bottomfish harvest in the Hawaiian Archipelago. According to the *Hawaii Fisheries Development Plan*, the combined annual catch of sharks in Hawaiian waters could be as high as 2,360,000 pounds on a sustained basis.

Removal of several million pounds of sharks would undoubtedly be greeted with pleasure by harassed commercial and sport fishermen. Unfortunately, a shark fishery cannot be expected to develop until capturing sharks is shown to be profitable. By and large, the economic feasibility of shark fishing depends on two crucial factors: (1) whether suitable markets can be found for shark meat or other shark products; and (2) whether fishermen are willing to learn improved shark handling techniques to insure consistently high product quality.

Among the shark products—meat, fins, hides, and teeth—high quality meat currently has the greatest economic growth potential.

(Continued on page 5)

Sharks are often incidental sport catches.
—Art Reed photo

What Is So Good About Shark Meat?

Besides being low in calories and high in protein, shark meat is a "chef's dream." Shark meat's bland flavor combines with many sauces, herbs and spices, and other flavorings to please most palates. The taste of shark has been variously compared with tuna, mahimahi, codfish, lobster, and even chicken.

Here are some shark recipes from *Ono Hawaiian Shark Recipes*, a brochure published by the University of Hawaii Sea Grant College Program. Enjoy.

MAYONNAISE-BAKED MANO

by Brigette Campbell

1 - 1-1/2 lbs mano (shark) in one piece
1/4 t salt
1/4 t black pepper
2 T vegetable oil
1/4 C mayonnaise
1-1/2 t paprika

Sprinkle shark with salt and pepper to taste and place in a lightly-greased pan. Spread mayonnaise over fish and sprinkle with paprika. Place in oven and bake at 350°F for 30 to 35 minutes.

Serving sauce
1/2 ounce fresh ginger
2 cloves garlic, finely chopped
1/3 C soy sauce

Mix ginger, garlic, and soy sauce. Serve with the fish. If you like it hot, add two chili peppers or a dash of tobasco sauce.

SHARK STEAKS IN WINE-HERB SAUCE

by Les Dunman

4 shark steaks (1/3 - 1/2 lb each)
2 T butter
1/2 C white wine
1 lemon (1/2 of lemon for juice; 1/2 for wedges)
1/4 t crushed basil leaves
1/4 t oregano
Salt, pepper, paprika

Quick-fry steaks on both sides in butter. Turn heat down. Add wine and lemon juice. Sprinkle basil leaves and oregano on steaks. Cover and simmer for 10 minutes. Salt and pepper to taste. Garnish with paprika and lemon wedges.

GRILLED SHARK STEAK WITH "SECRET SAUCE"

by Les Dunman

4 shark steaks (1/3 - 1/2 lb each)

Sauce
1/2 C white wine
1/2 C black bean sauce
2 T butter, melted
1/4 t garlic powder
1/2 t parsley flakes

Combine ingredients for sauce. Dip steaks in sauce and slow cook on barbeque grill.

CRISPY SHARK WITH SWEET-SOUR SAUCE

1 lb shark, cut in 1-1/2" cubes

Batter
1/4 C flour
1/4 C cornstarch
1/2 C water
1/2 t salt

Dip shark cubes into batter and deep fry in oil at 350°F.

Sweet-sour sauce
1/4 C packed brown sugar
2 t cornstarch, approximately
3 T lemon juice (or vinegar)
1-1/2 t soy sauce
1/2 t MSG (monosodium glutamate)
1-1/2 t salt
1 t sesame oil
1/2 C water
1 ginger, 1" length, crushed
1 clove garlic, crushed

Boil ingredients until sauce thickens. Taste and add more sugar or salt as desired. Pour sauce over shark cubes and serve.

FILLET OF SHARK

by Randy Uyehara

1-1/2 lbs shark meat
3 eggs
1/4 C milk
Flour
Margarine or butter
Pepper
Garlic salt
Lemon juice

Slice shark meat across the grain into 1/4" fillets; then pound lightly until 1/8" thick. Make a batter of the eggs and milk. Dip fillets into batter; then lightly flour on both sides. Heat enough butter (or margarine) to cover bottom of pan till sizzling. Sauté fillets until golden brown (approximately 3 to 4 minutes on each side). Season generously with pepper and garlic salt (to taste) while still in pan. Sprinkle with lemon juice just before serving. May be served with tartar, bernaise, or veloute sauce. □

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Sharks in Hawaii *(Continued from page 1)*

A number of markets for shark meat already exist around the world. In Southeast Asia, shark is regularly sold in salted and dried form.

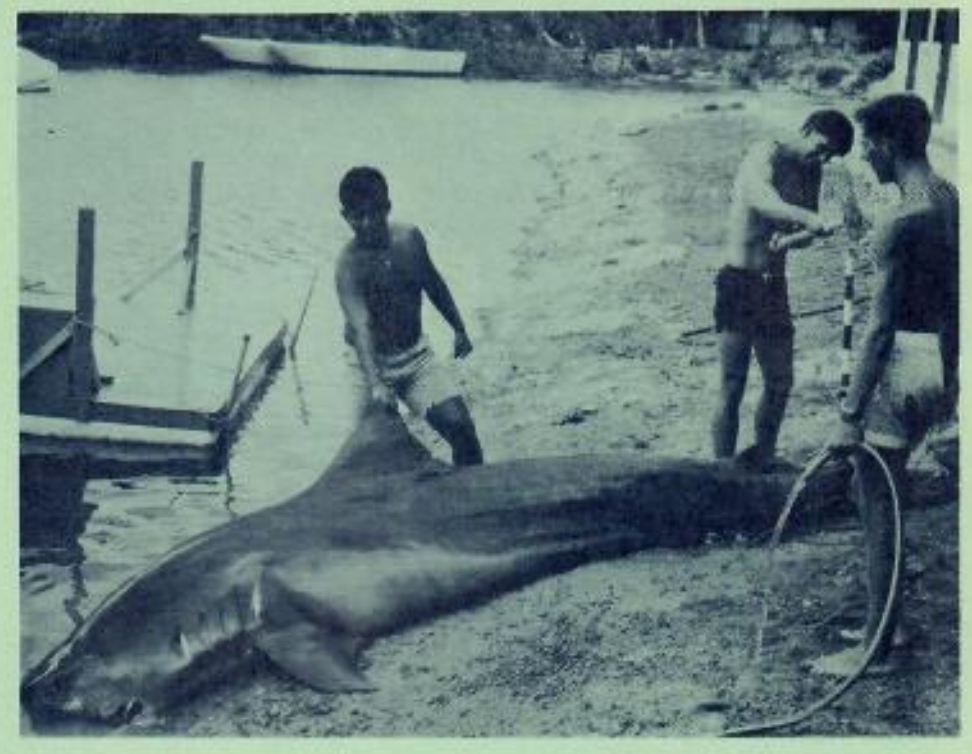
Australian commercial fishermen land over 13 million pounds of shark annually to supply an insatiable domestic market for "flake," a popular shark product. Shark is also in heavy demand in Europe where, for example, it is eaten either as fish and chips (United Kingdom) or smoked (Germany and France). The Japanese consider shark flesh to be an excellent ingredient for "hampen" and fish cakes.

Recently, a burgeoning market for fresh shark meat was developed in California. Innovative processors there currently purchase shark for 50 to 80 cents per pound. They process shark into steaks which have received high consumer acceptance. Presumably a similar market for shark steaks exists in Hawaii, although it is undeveloped at present.

One thing is certain: if Hawaii's shark harvest is to be successfully marketed, sharks must be properly handled to insure top product quality. Shark flesh can, if mishandled, develop a strong ammonia smell and unpleasant taste. These undesirable effects of improper handling are one reason why sharks have long been considered inedible by U.S. fish consumers.

Nevertheless, a high quality product can be obtained from sharks which have been correctly bled, properly iced, and carefully handled to minimize bruising. These steps seem to be the secret to product quality achieved by Australian and Californian shark fishermen.

The University of Hawaii Sea Grant College Marine Advisory Program is developing a program to train fishermen in shark handling. Readers are encouraged to contact their local MAP agent for more information on shark fishing and product quality control. □



Shark displayed on beach at Coconut Island. —Art Reed photo

Got Your Signals Straight?

The Coast Guard is now enforcing requirements which became effective on January 1 that boats carry visual distress signals.

The legislation, 33CFR175, applies to all boats for hire carrying six or fewer passengers, along with all recreational boats 16 feet and longer. These must be equipped day and night with visual distress signals. Boats under 16 feet must carry visual distress signals when operating at night on coastal waters.

The following types of boats need not comply with the requirements:

- Boats competing in any organized marine parade, regatta, or similar event;
- Manually propelled boats; or
- Sailboats of completely open construction under 26 feet long, not equipped with propulsion machinery.

However, boats under these exceptions must have onboard visual distress signals suitable for night use in the required number.

For information about acceptable visual distress signals and their storage and serviceability, write to Commander, 14th Coast Guard District, 300 Ala Moana Blvd., Room 8112, Honolulu, Hawaii 96850 or call 546-5575. □

Water Safety Newsletter Goes Statewide

Kahu o Ke Kai (guardian of the sea), a Marine Advisory Program water safety newsletter, is being published to address statewide water safety needs.

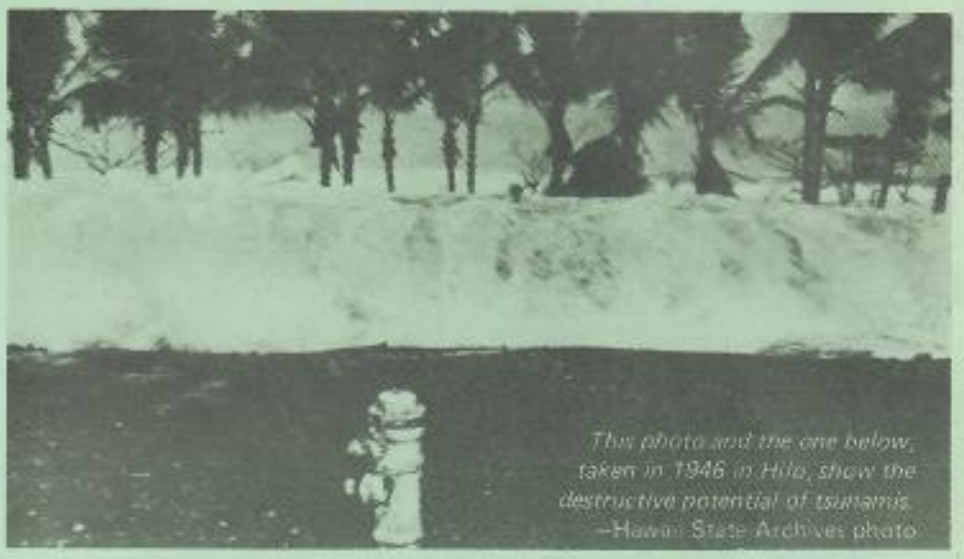
The newsletter was originally developed by MAP agent Jeremy Harris to serve the people of Kauai. Beginning with the January issue, *Kahu o Ke Kai* is being published monthly for statewide distribution.

Under the editorial direction of Pete Hendricks, MAP agent for West Hawaii, the newsletter is intended to enhance safety programs of federal, state, and county governments, as well as those of private industry.

Readers interested in receiving *Kahu o Ke Kai* may write to Martha Coleman, Aquatics, Health, and Safety Assistant, Marine Advisory Program, 2540 Maile Way, 252B Spalding Hall, Honolulu, HI 96822. □

WIND STUDIES MAY AID IN TSUNAMI "PROOFING"

by Ray Tabata,
MAP Environment Agent



This photo and the one below, taken in 1946 in Hilo, show the destructive potential of tsunamis.
–Hawaii State Archives photo

Wind studies conducted in the Hawaii Kai area of Oahu and on the island of Hawaii are providing new information which may help better define tsunami inundation areas and prevent future disasters.

Dr. Charles L. Bretschneider of the University of Hawaii's Department of Ocean Engineering has been studying the effects of "terrain roughness" on tsunami run-up and inundation by analyzing how various types of natural terrain affect winds. He is assisted by Frederick Casciano, Eiji Nakazaki, and Hans-Jurgen Krock of the J.K.K. Look Laboratory of Oceanographic Engineering.

Like wind tunnel studies, Bretschneider's experiments attempt to pinpoint how areas strewn with large boulders might differ in "roughness," or "friction," compared with, say, a golf course or grassy field. In theory, the "roughness" of these types of land can be measured and used to determine how it would affect an actual tsunami wave moving over the land.

The accurate prediction of tsunami run-up is critical to forecasting for warning and evacuation purposes. It is also important for zoning and design standards.

In the past, little research was focused on what happened to a tsunami wave once it hit a coastline and flowed over land. In an urban area, new parks or other open space can reduce "roughness" of terrain and therefore increase the extent of tsunami run-up and flooding.

The ability to predict such changes could be greatly improved through Bretschneider's wind studies, funded in part through the Sea Grant College Program at the University of Hawaii. With improved prediction, disastrous consequences of such tsunamis as those which hit Hilo, Hawaii in 1946 and 1960 might be lessened and considerable life and property saved.

Bretschneider's experiments are being conducted in the Hawaii Kai area on three types of terrain: a golf course; a boulder-strewn field at Queen's Beach; and a grassy field nearby. Wind measurements are being taken on 10-meter masts with five anemometers (to measure wind speed at different levels above the ground) and recording devices.

So far, as expected by the researchers, the rocky field with boulders two to three feet in diameter has the highest "friction," whereas the golf course with only a grassy surface has the lowest.

If an actual tsunami were to flow over such terrain, it could be expected to go farther inland over the grassed areas than over the rocky field, other variables being equal. The studies over natural terrain are, according to Bretschneider, the first to be conducted outside of river channels. Previous researchers focused on the roughness of artificial surfaces such as concrete, blacktop, and rubble mounds. The new information on "friction" of natural surfaces would help to better define areas likely to be affected by a tsunami.

Field studies are also planned for two areas on the Kona coast and Kolekole Beach Park on the island of Hawaii. After the field studies are completed, a user's manual will be written for publication.

The manual will include theory discussions, equations, charts, graphs, photographs of terrain types, and computer programs. Bretschneider says that the manual will be a very valuable document for potential users such as governmental agencies, engineers, tsunami researchers, civil defense planners, and coastal developers. □

SURVEY CATCHES IN NWHI MADE ON CROMWELL CRUISE

Catches indicating relatively good concentrations of commercially valuable fish such as red snapper and opelu and fair concentrations of caridean shrimps in the Northwestern Hawaiian Islands were reported by Paul M. Shiota, chief scientist on the first leg of a recent survey cruise aboard the NOAA ship *Townsend Cromwell*.

The cruise was part of a long-term effort to survey and assess the living terrestrial and marine resources in the Northwestern Hawaiian Islands. Cooperating agencies are the Honolulu Laboratory of the National Marine Fisheries Service, Hawaii Department of Land and Natural Resources, U.S. Fish and Wildlife Service, and University of Hawaii Sea Grant College Program.

Trolling lines, shrimp trawls, hydraulically operated handlines, kona crab nets, and lobster, fish, and shrimp traps were among the fishing gear used in the survey.

Night "jigging" for opelu and akule during dark moon phases was particularly effective at French Frigate Shoals, Shiota noted.

Richard N. Uchida, chief scientist for the cruise's return leg, reported excellent bottomfishing at Pogy Bank in the Nero Seamount complex about 40 miles southwest of Midway. Here, the catch rate of bottomfish, mostly red snapper and sea bass, reached 6.1 fish per line-hour.

While at the Nero Seamount complex, the *Cromwell* made some transects with an echo sounder to better define the bank's topography. The complex is poorly charted on existing maps, according to Uchida.

Shrimp trapping on the return leg revealed that caridean shrimps occur in varying densities at Gardner Pinnacles, Maro Reef, and St. Rogatien Bank. The catch rate, highest at Gardner Pinnacles, is only about one-third of that reached in trappings off Oahu several years ago, Uchida said.

Concentrations of caridean shrimps in the Northwestern Hawaiian Islands were first discovered at Necker Island, Laysan Island, Pioneer Bank, and French Frigate Shoals in 1973 during a cruise of the R/V *David Starr Jordan*. □

REEF FISH AND CIGUATERA TOXIN

Kahala (amberjack) and ulua (jackfish) have been implicated in 56 of 123 incidents in Hawaii of causing ciguatera food poisoning in humans since 1900. Other reef fish have also been implicated, but in no more than eight incidents per species.

Ciguatera toxin is produced by at least one kind of dinoflagellate (a microscopic marine organism). While reef fish eat these organisms without apparent harm, it is not clear what conditions make these fish harmful for humans to eat. Because little is known about dinoflagellates and environmental factors influencing their growth, the lack of seasonal patterns when poisoning incidents have occurred, and the mobile nature of most fish, predicting and controlling ciguatera food poisoning are difficult.

Deep-sea fish such as ahi and mahimahi are not affected because the toxin-producing organisms are shallow-water dwellers.

The 123 incidents include at least 600 people affected in Hawaii over the last 80 years. This compares with 2,795 cases of ciguatera poisoning reported in Tahiti during one year, 1966.

The preceding information and information about the symptoms of ciguatera poisoning, its treatment, and more are discussed in a pamphlet, *What You Should Know About Ciguatera Poisoning*. The pamphlet is available from the Health Education Office, Hawaii State Department of Health, 1250 Punchbowl Street, Honolulu, HI 96813. □

Governor Discusses Ocean-Related Projects

Legislators were urged to consider two proposals relating to the development of ocean resources by Governor George Ariyoshi in his State-of-the-State address.

In his remarks to the joint legislative session on January 29, Governor Ariyoshi proposed creating a corporation to direct development activities for the Aloha Tower Plaza Project.

The corporation would be responsible for supervising the development of an international trade center, the modernization of the area's facilities, and the beautification of the downtown waterfront, as well as for providing for public accessibility to the area.

Governor Ariyoshi told the legislators that as they review a feasibility study for Aloha Tower they will find Hawaii has a genuine opportunity to create a project that will transform underutilized and valuable Honolulu waterfront property into a showcase for international trade and public use activities.

Governor Ariyoshi also said he is proposing that an energy division be created in the state Department of Planning and Economic Development to provide greater support for alternate energy sources.

"I am happy to report that Hawaii has made considerable progress in developing electrical energy from several sources—biomass, direct solar, wind, ocean, as well as the earth's heat," Ariyoshi said.

"This has been due largely to your efforts and those of many state agencies including the University of Hawaii, the counties, and the private sector to come up with workable, economic solutions," he told the joint session.

"In other fields, Hawaii continues to be an innovator and a leader—especially in alternate energy, diversified agriculture, and aquaculture," the governor said. □

Sharks in Hawaii *(Continued from page 1)*

A number of markets for shark meat already exist around the world. In Southeast Asia, shark is regularly sold in salted and dried form.

Australian commercial fishermen land over 13 million pounds of shark annually to supply an insatiable domestic market for "flake," a popular shark product. Shark is also in heavy demand in Europe where, for example, it is eaten either as fish and chips (United Kingdom) or smoked (Germany and France). The Japanese consider shark flesh to be an excellent ingredient for "hampen" and fish cakes.

Recently, a burgeoning market for fresh shark meat was developed in California. Innovative processors there currently purchase shark for 50 to 80 cents per pound. They process shark into steaks which have received high consumer acceptance. Presumably a similar market for shark steaks exists in Hawaii, although it is undeveloped at present.

One thing is certain: if Hawaii's shark harvest is to be successfully marketed, sharks must be properly handled to insure top product quality. Shark flesh can, if mishandled, develop a strong ammonia smell and unpleasant taste. These undesirable effects of improper handling are one reason why sharks have long been considered inedible by U.S. fish consumers.

Nevertheless, a high quality product can be obtained from sharks which have been correctly bled, properly iced, and carefully handled to minimize bruising. These steps seem to be the secret to product quality achieved by Australian and Californian shark fishermen.

The University of Hawaii Sea Grant College Marine Advisory Program is developing a program to train fishermen in shark handling. Readers are encouraged to contact their local MAP agent for more information on shark fishing and product quality control. □

Shark displayed on beach at Coconut Island. —Art Reed photo

Got Your Signals Straight?

The Coast Guard is now enforcing requirements which became effective on January 1 that boats carry visual distress signals.

The legislation, 33CFR175, applies to all boats for hire carrying six or fewer passengers, along with all recreational boats 16 feet and longer. These must be equipped day and night with visual distress signals. Boats under 16 feet must carry visual distress signals when operating at night on coastal waters.

The following types of boats need not comply with the requirements:

- Boats competing in any organized marine parade, regatta, or similar event;
- Manually propelled boats; or
- Sailboats of completely open construction under 26 feet long, not equipped with propulsion machinery.

However, boats under these exceptions must have onboard visual distress signals suitable for night use in the required number.

For information about acceptable visual distress signals and their storage and serviceability, write to Commander, 14th Coast Guard District, 300 Ala Moana Blvd., Room 8112, Honolulu, Hawaii 96850 or call 546-5575. □

Water Safety Newsletter Goes Statewide

Kahu o Ke Kai (guardian of the sea), a Marine Advisory Program water safety newsletter, is being published to address statewide water safety needs.

The newsletter was originally developed by MAP agent Jeremy Harris to serve the people of Kauai. Beginning with the January issue, *Kahu o Ke Kai* is being published monthly for statewide distribution.

Under the editorial direction of Pete Hendricks, MAP agent for West Hawaii, the newsletter is intended to enhance safety programs of federal, state, and county governments, as well as those of private industry.

Readers interested in receiving *Kahu o Ke Kai* may write to Martha Coleman, Aquatics, Health, and Safety Assistant, Marine Advisory Program, 2540 Maile Way, 252B Spalding Hall, Honolulu, HI 96822. □

MARINE MISCELLANY

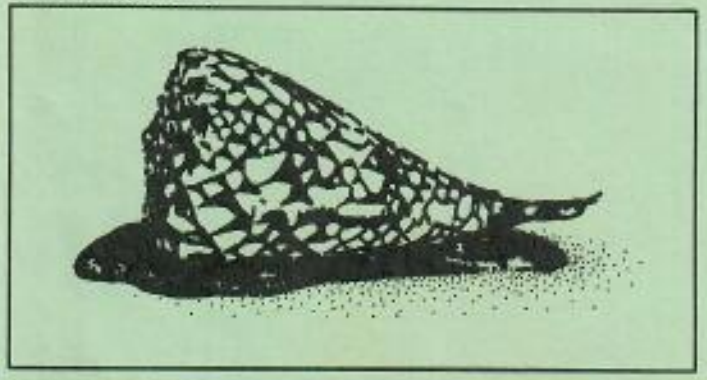
ALOHA TOWER LECTURES

The Aloha Tower Maritime Center continues to hold its commercial fishing lectures each Wednesday at noon, through February and March. Featured speakers for February are **Jed Inouye**, South Pacific International Seafood, Inc.; **Art Mersereau**, KEMS, Inc.; **Jim Sterling**, Pacific Marine; **Pete Hendricks**, UH Sea Grant College Program; and **Roy Yee**, KEMS, Inc.

For further information, call Nancy Preston at 548-5433.

SPRING LECTURE SERIES

The Spring Lecture Series continues in March featuring **Craig Harrison** on "Hawaiian Seabird Ecology" on March 4 and **Art Reed** on "Dangerous Marine Organisms of Hawaii" on March 18. These are the fourth and fifth in a series of eleven lectures scheduled every other Wednesday, 7:30 p.m., at the Waikiki Aquarium.



The series is sponsored by the Waikiki Aquarium, UH Sea Grant College Marine Advisory Program, and Society of Sigma Xi. The lectures are free although a donation of $1 is suggested.

For more information on the series, call the Waikiki Aquarium at 923-4725 or UH Sea Grant at 948-8191. Most speakers are also being featured at lunchtime lectures at the Aloha Tower on alternate Thursdays. Call Nancy Preston of the Aloha Tower Maritime Center at 548-5433 for more information.

LUCKY YOU LIVE HAWAII

Almost one-half of the people in Hawaii cite environmental factors such as climate, mountains, and beaches as what they like most about Hawaii.

Almost one-quarter valued people-related items.

These are some of the major findings of a poll taken of 1,431 Oahu households conducted by Public Affairs Advisory Services Inc. (PAAS) in November 1980.

The poll showed that climate was the most liked aspect of 38.6 percent of those interviewed. Nearly 17 percent selected people as the most liked aspect. Another 6 percent selected mountains and beaches.

The PAAS findings were similar to those published by the Marine Advisory Program in August 1979, following a poll of its readers.

In answer to the question, what is the most obvious difference between living in Hawaii and living on the mainland, 43 percent of the readers cited climate. Nearly 14 percent referred to the people and 32.2 percent referred to the ocean in the MAP poll.

COAST GUARD AUXILIARY BOATING COURSE

The Coast Guard Auxiliary will offer three classes during March for its Boating Skills and Seamanship course. Among the topics to be covered are boat handling, rules of the road, and legal requirements. The classes are scheduled to begin March 9 and 10.

For the March 9 class call **Clara Rodrigues**, Flotilla 11—Waianae, at 672-3654. For the two March 10 classes call either **Petie Vanderstok**, Flotilla 23—Hawaii Kai, at 395-3991 or **Mary Ebesu**, Flotilla 20—Kaimuki, at 845-6346. □

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GEORGE H. BALAZS
JR. MARINE BIOLOGIST
HIMB
COCONUT ISLAND

ander's admirable account of sorcery in his "Brief History of the Hawaiian People."

An inferior demon of the *Pele* family is the obscene *Kapo*, a conception of impurity too revolting to admit of description. She is continually employed by the *kahunas* as a messenger in their black arts, and is claimed by many as their *aumakua*.

In pleasing contrast with the above is the *pueo* [owl], perhaps the most beneficent to man of the lesser gods. As an *aumakua*, it was invoked as "*Pueo nui o Kona*" [the great owl of Kona], because so large a portion of the people of the district of Kona, on Hawaii, revered it as peculiarly their family god. The *pueo* gave its *kahus* and faithful worshippers timely warning of approaching danger. It aided the prisoner in untying the knotted cords with which he was bound and in making good his escape, and guided the fugitive, hiding him from his pursuers so that they might not find him.

The shark was perhaps the most universally worshipped of all the *aumakuas*, and, strange to say, was regarded as peculiarly the friend and protector of all his faithful worshippers. In the case of the *pueo*, all birds of that species were equally considered as representatives of the *aumakua* known as "*Pueo nui o Kona*." They were not worshipped as individual owls, and when one died the life of the *aumakua* was in no wise affected. Not so with sharks. Each several locality along the coast of the islands had its special patron shark, whose name, history, place of abode, and appearance, were well known to all frequenters of that coast. Each of these sharks, too, had its *kahu* [keeper], who was responsible for its care and

The sorcerer then had the owner of the soul in his power, and could levy blackmail on him as he pleased, for if he killed his *kakuola* he would go into a decline and soon die."—(Alexander's "Brief Hist. of Haw'n. People," pages 72–3.)

Apo leo was the art of depriving a person of the power of articulate speech. In order to do this, the *kahuna* prayed at night to *Uli* and *Hiiaka*, presenting them with the usual offerings of *awa*, etc. The next day he sought out his intended victim and entered into conversation with him, during which, as was believed, he caught and took away his voice, or paralyzed his vocal organs, so that he could never speak again. He might linger a long time in this wretched condition, or die in a few days if the sorcerer so willed.—(Ditto. Page 71.)

Hoomoko uhane. "The practices of the *kahuna hoomoko* strongly resembled those of modern spiritism. The medium was called the *kahu* or *ipu* of the spirit, which was often called a *makani* [wind]. Sometimes the spirit descended upon the *kahu*, and sometimes it spoke from the roof of the hut. Probably some of these *kahunas* were ventriloquists. The necromancer always demanded *awa* before commencing operations..... After drinking the *awa* the wind descended upon the *kahuna*, and showed him the cause of the sickness, whether the patient had been bewitched by a sorcerer, and by whom. The same practitioners were employed in cases of theft to recover stolen goods, and to detect the thief."—(Ditto. Page 68.)

worship. The office of *kahu* was hereditary in a particular family, and was handed down from parent to child for many generations, or until the family became extinct. The relation between a shark-god and its *kahu* was oftentimes of the most intimate and confidential nature. The shark enjoyed the caresses of its *kahu* as it came from time to time to receive a pig, a fowl, a piece of *awa*, a *malo*, or some other substantial token of its *kahu's* devotion. And in turn it was always ready to aid and assist the *kahu*, guarding him from any danger that threatened him. Should the *kahu* be upset in a canoe and be in serious peril, the faithful shark would appear just in time to take him on his friendly back in safety to the nearest shore. Such an experience, it is said, happened to Kaluahinenui, the *kahu* of a certain shark, while voyaging in the Alenuihaha channel. The schooner was overtaken by a severe storm and was lost with most on board. In her distress Kaluahinenui called upon her shark god, *Kamohoalii*, who quickly came to her rescue, taking her upon his back to the neighboring island of Kahoolawe.

This story of shark intervention and many similar to it are extensively believed at the present day. In Prof. Alexander's History[1], however, where the real facts of this case are carefully stated, no allusion is made to any aid rendered by a shark. His statement is as follows: "At noon on Sunday, the 10th of May, 1840, the schooner *Keola* foundered and sank a considerable distance west of Kohala Point. As there was a strong current running to the northward, the passengers and crew, seizing on oars, boards, etc., swam for Kahoolawe, then about thirty miles distant. A Mr. Thompson of Lahaina was drowned, but his wife and two young men reached Kahoolawe the next day. Mauae of Lahaina and his noble wife, Kaluahinenui, swam together, each with an empty bucket for a support, until Monday afternoon, when his strength failed. His wife then took his arms around her neck, holding them with one hand and swimming with the other, until she found that he was dead, and was obliged to let him go in order to save her own life. After sunset she reached the shore, where she was found and taken care of by some fishermen, having been thirty hours in the sea." It is interesting thus to learn the facts connected with this modern instance of a case illustrating the popular belief.

The largest and most celebrated of the Hawaiian shark-gods was

[1] Pages 230–1.

Kuhaimoana, a male whose mouth was said to be as large as an ordinary grass-house and could take in two or three common sharks with ease. Most of the channels around the islands of Maui and Oahu were too shallow for his huge bulk. More than once he had the misfortune to get aground, and to avoid this fate he spent most of his time in the deep waters off the island of Kaula.

Second to him in size and power was the shark called *Kamohoalii*, older brother of the goddess *Pele*. Like many of the other sharkgods, he was able at pleasure to assume the human form. In that form he dwelt in profound solitude in a most sacred spot called the *Pali Kapu o Kamohoalii* [the sacred precipice of *Kamohoalii*], overlooking the fires of the volcano of Mokuaweoweo.[n] Another *Pali Kapu o Kamohoalii*, with a like tradition, is similarly situated with reference to the crater of Kilauea. Even *Pele*, fiercest of gods, dared not allow the smoke from her furnaces to trespass on the awful sanctity of her brother's abode. He was also said to make his home in the highest cone in the crater of Haleakala. From time to time he walked among men, when he claimed the well-known prerogative of an Hawaiian god to discard his *malo*. In his shark form he is still said to roam at large in the deep waters about the island of Maui, and is claimed by many as their *aumakua*.

One reason for the affection shown to the shark *aumakuas* was the fact that so many of them claimed human parentage, and were related by ties of kinship to their *kahus*. Such was the case with *Kaahupahau* and her brother *Kahi'uká*, the two famous shark-gods of the Ewa Lagoon on this island. Their birth and childhood differed in no essential features from that of other Hawaiian children up to the time when, leaving the home of their parents, they wandered away one day and mysteriously disappeared. After a fruitless search, their parents were informed that they had been transformed into sharks. As such, they became the special objects of worship for the people of the districts of Ewa and Waianae, with whom they maintained the pleasantest relations, and were henceforth regarded as their friends and benefactors. After a time the man-eating shark, *Mikololou*, from the coast of the island of Maui, paid them a visit and enjoyed their hospitality until he reproached them for not providing him with his favorite human flesh. This they indignantly refused to give, whereupon, in spite of their protest, he made a raid

n The summit crater of Mauna Loa, on the Island of Hawaii.

on his own account upon the natives, and secured one or more of their number to satisfy his appetite. *Kaahupahau* and her brother promptly gave warning to their friends on shore of the character of this monster that had invaded their waters. To ensure his destruction they invited their unsuspecting guest to a feast made in his honor at their favorite resort up the Waipahu river. Here they fed him sumptuously, and at length stupified him with the unusual amount of *awa* with which they supplied him. While he was in this condition, their friends, who had come in great numbers from the surrounding country, were directed to close up the Waipahu river, which empties into the Ewa Lagoon, with their fish nets, brought for the purpose, while they attacked him in the rear. In his attempt to escape to the open sea he broke through one net after another, but was finally entangled and secured. His body was then dragged by the victorious people on shore and burned to ashes, but a certain dog got hold of his tongue, and, after eating a portion, dropped the remainder into the river. The spirit of the man-eater revived again, and, as a tongue, now restored and alive, made its way to the coasts of Maui and Hawaii, pleading with the sharks of those waters for vengeance upon the sharks of the Ewa Lagoon. They meantime secured the aid of *Kuhaimoana* and other notable sharks from the islands of Kaula, Niihau, Kauai, and Oahu. A grand sight it was to the numerous spectators on shore when these mighty hosts joined combat and began the great shark-war. It was a contest of gods and heroes whose exploits and deeds of valor have long been the theme of the bards of the Hawaiian Islands. We cannot enter into the details of this story, which, if wrought out, would be worthy of being called an epic. We will only say that in the first great battle the friends and allies of the cruel man-eater were routed by the superior force of their opponents, while the good *Kaahupahau* and her brother long continued to enjoy the affectionate worship of their grateful people. It is said that she is now dead, while her brother *Kahi'uká* still lives in his old cave in the sea, where he was visited from time to time by his faithful *kahu*, *Kimona*, now deceased. Sometimes *Kimona* missed his fish nets, when he was pretty sure to find that *Kahi'uká* had carried them to a place of safety, to preserve them from destruction by hostile sharks.

By some authorities *Kaahupahau* is represented as the mother of

Kahi'ukú, but as there is always an uncertainty in these matters of shark-relationship, I will not attempt to settle the point.

When we reflect on the amphibious habits of the Hawaiians and their familiarity with and exposure to the dangers of the sea, it is no longer a matter of surprise that they should propitiate certain sharks, and cultivate the pleasantest possible relations with them, as a defence against other sharks with whom they may not be on friendly terms.

The *leho* [cowry] is also a beneficent *aumakua*. It was over four hundred years ago, during the reign of Umi, on Hawaii, that the great value of its shell as a means of attracting and securing the *hee* [squid] was first discovered, and a lucky cowry is the squid catcher's greatest treasure, even to the present day. Like the shark, the *leho* helps its shipwrecked *kahu* to reach the shore. Should the *kahu* of a shark *aumakua* send him on an errand of mischief to one who has an *aumakua leho* [a cowry *aumakua*], the *leho* will outwit the shark, and, clinging to his eyes, will blind him so that he cannot do the intended ill.

The *opihi* [limpet], so common on our rocky coasts, is also an *aumakua* which defends its *kahu* against sharks in the same manner as the *leho*. It is of great service to fishermen, calming the raging surf and aiding them in bringing their canoes to land in safety. The *enuhe* [worm] is an *aumakua* of ill omen, worshipped under the name of *Kumuhea*, *he kanaka ino* [*Kumuhea*, a bad man]. The story is that *Kumuhea* was a monster living in a cave at the base of the hill called after him *Puu Enuhe* [Hill of the Worm], just north of the Hilea cane-fields in the district of Kau, on Hawaii. By day he carefully kept out of sight, hiding away in his cave. At night he paid attentions to a daughter of a prominent chief of the district, carefully concealing from her the fact that he was as much an *enuhe* as a man. When the fraud was discovered, her friends resolved upon his destruction. She was instructed to tie some *kapa* cloth about him, which would easily tear and leave the shreds upon the bushes as he returned to his cave. The artifice proved successful, and he was tracked to his den and slain the next day by the enraged friends of her family. From him sprang the hordes of *peluas* and other worms so destructive to vegetation, also the *loli* [sea-cucumber] and allied forms of marine life.

It is related of a certain Hawaiian King that as he was riding out at the head of a company of his followers, he spied one of these

creatures crossing his path, when he suddenly halted, and, with an expression of fear and horror on his countenance, pointed at the worm, uttering in a constrained voice the single word *enuhe!* Without any further remark or explanation the entire party at once turned back and gave up the trip for that day.

The following fishes, in addition to those already mentioned, were worshipped as *aumakuas*, namely, the *aawa*, the *oopukue*, the *ohua*, the *opae* [shrimp], the *uu*, addressed in prayer as *Uu kani po*, the *kokala*, addressed as *Kane i Kokala*, the *humuhumu-nuku-nuku-apuaa*, one of the forms in which the hog god, *Kamapuaa*, took to the sea when *Pele* made it too hot for him to remain on land, the *hee* [squid], addressed as *Haaluea*, the *paoo*, and the *puhi* [eel]. With them we may also mention the *wana* [echinus], and the *loli* [sea-cucumber], already referred to. I give this without claiming it to be a complete list.

The following birds received similar worship, viz., the *aa*, the *alae* [mud hen], the *amakihi*, the *elepaio*, the *iiwi*, the *io*, the *ou*, the *ua'u*, the *kolea* [plover], the *moa* [common fowl], addressed as *Kane-ulu-po*, the *nene* [wild goose], the *noio*, and the *pueo*, already mentioned. The *alae* is interesting for the part it played in the story of the discovery of the art of producing fire by friction, which it revealed to Maui, the Prometheus of Hawaiian mythology. "Its cry," as Alexander states in his history[a], "was an omen of death." The *elepaio* is the first of all the feathered race to welcome the dawn. When she utters the familiar cry *elepaio*, the night-labors of gods and heroes must cease, though broken off in the midst of an incompleted task. In this way she continually appears in the old legends. Among the gods of the canoe-makers, she held the position of inspector of all *koa* trees designed for that use. If, while inspecting a tree, she pecked it with her bill in a particular way, the tree had to be abandoned as unsound.

Three quadrupeds were included among the *aumakuas*, viz., the hog, dog and rat. The hog was the most powerful of all land animals known to the early Hawaiians. In the legend of *Kamapuaa*, we have for a hero a gigantic hog who was able for a time to defy the power of mighty *Pele*. Like so many of the demi-gods of Hawaiian mythology, this unruly hog was born of human parents and could appear as a handsome young man, a hog, a fish, or a tree, as

[a] Page 38.

suited his purpose. This power of changing his appearance led him into all sorts of mischievous pranks and deviltry, and added greatly to the complications in which he became involved. The legend requires sixteen hours to repeat, and is perhaps one of the best commentaries on the ineffable depths of impurity in which some heathen delight to wallow. In general, the more vile, obscene, and hateful the god, the more ready were the deluded people to render him worship.

While the hog-god embodies the idea of unbridled passion and mighty brute force, the dog-god is associated with faithful friendship to man and superhuman sagacity, as may be seen in the really beautiful story of the dog *Puapualenalena*, who flourished over four hundred years ago, in the time of King Liloa, on Hawaii. The Hawaiians throughout all the islands were passionately fond of their dogs, treating them with the same affection which they bestowed upon the other members of their families.

The rat [*iole*] shares with the owl the credit of being a most beneficent *aumakua*. Like the *pueo*, the *iole* is ever ready to assist its *kahu* when a captive, releasing him from his fetters and guiding him to a place of safety. When, according to the old mythology, the demi-god, *Makalii*, attempted to rob mankind of their food by putting all the taro, potatoes, yams, bananas, etc., into a net, which he hung up out of the reach of men to the *naulu*, ["a thick dense cloud" in the sky above Hanalei, on the island of Kauai], it was a rat, hidden away in the *Koko a Makalii* [net of *Makalii*] by the man *Puluena*, who bit a hole in the net and let all the food drop down to earth. For this important service, the *iole* was associated with *Kanepuaa*, the furrow-making god, as a god of agriculture. The *hei* [cat's cradle*] of *Koko a Makalii* still keeps fresh in mind the bold attempt of the robber, while the name Iole, given to a land in Kohala, on Hawaii, preserves the memory of the deliverer who saved mankind from hunger.

The following trees and plants were included among the *aumakuas*, or, speaking more strictly, served as the abodes of those *aumakuas* who manifested their power and presence through them,

* The ancient Hawaiians were exceedingly expert in this child's game, played like the familiar game of "cat's cradle" with a loop of string on the fingers. Usually the player worked the design on his own fingers, sometimes with the aid of his toes or teeth, unassisted by any other person. Many of these figures were supposed to represent some familiar mythological incident alluded to in the chant with which the play was generally accompanied.

namely, the *aheahea*, the *iliahi* [sandal-wood], the *ipu awaawa* [gourd], the *oa*, the *ohia ku makua*, the *olomea*, used in producing fire by friction, the *pilo*, the *kauila*, the *ko* [sugar cane], the *koa*, the *kakalaioa* [bramble], the *ki*, the *lama*, the *maia* [banana], the *manono*, and the *niu* [cocoanut]. All the wooden charms and fetiches, still so common among the Hawaiians, are made of the various woods included in the above list.

The *aumakua* in the water was addressed as *Kane i ka wai e ola*, and that in the stone as *Kane pohakaa*, a god often invoked in certain forms of sorcery. The worshipper of *Kane pohakaa* was forbidden to sit on a stone and was debarred from various of its uses.

The disgusting worship of *Nuu*, the *aumakua* in human waste, was associated with the treatment of the two diseases, *pupule* [insanity], and *hoounauna*, a chronic pain in some particular part of the body. In either case the disease was caused by an evil spirit sent by a *kahuna* to occupy the body of the afflicted person. The cure, always most difficult, required the exorcising of this spirit by a *kahuna*, who rubbed the patient with the substance most offensive to the spirit, and for that reason the most powerful of the remedial agents known in ancient Hawaiian medical practice. The *kahuna* who had *Nuu* for his *aumakua* could not burn this substance in the fire. If by any chance he should happen to do so, he became *hewa* [at fault], and must propitiate *Nuu* with a feast and with special prayer.

The *aumakua* in clouds was worshipped as *Nuu mea lani*, in rain as *Na kulu wai lani o Kulanihakoi*, in the lightning as *Lanioaka*, and in the thunder as *Kane wawahi lani*.

The *aumakua* in the sun, known as *Lanipipili*, also that in the moon as well, were chiefly invoked as detectives in cases of petty thieving. It is a strange comment on the intellectual and spiritual condition of these islanders that in their worship such an insignificant place should be given to the noblest of the heavenly bodies, while abject and slavish fear drove them to prostrate themselves before the foulest fiends.

Among stars, Sirius, called *Newe* or *Hoku kau opae*, determined the best time for catching shrimp by her rising or setting. *Newe* and *Keoe* were known as *Na-hoku-hookele-waa* [boat-steering stars]. The Milky way, or a portion of it, was called *Na ia* [the fishes], and the expression "*Ua huli na ia*" [the fishes are turned] indicated the near approach of morning. The Pleiades were called *Na huihui*, "the bunch," or *Na hiku*, "the seven." Venus was named *Hoku*

loa. The nebula of Andromeda, aptly described as having the appearance of a candle seen through horn and known to the Hawaiians as *Poloahilani*, also as *Hoku makapaa* [the star with a blind eye], and *Na kao* [Orion], complete the list of the star *aumakuas*.

The four greater gods, *Ku*, *Kane*, *Kanaloa*, and *Lono*[p], were sometimes regarded as *aumakuas*, particularly by the highest chiefs, while *Hina* the wife of *Ku*, so famous throughout Polynesia as the patron of *kapa* beaters, was also invoked as their *aumakua* by those who practiced that art here. According to one tradition, she led a secluded life on the summit of Hualalai, in the District of Kona, on Hawaii, with her son *Hiku*, who made the bold descent into the *Lua o Milu* [the pit of *Milu*[q]], and brought back the spirit of his beloved from the nether world. The cave in which she beat her *kapa* and the six *kahua hale* or raised foundations of the houses in which she lived, still mark the site of her ancient abode, while her body, long since turned to stone on the Kona coast near Hoopuloa, rests beside the huge *moo* for whose company she deserted her mountain-home. According to another tradition, she lived with her son *Maui* near Rainbow Falls in Hilo, on Hawaii, where she experienced great difficulty in drying her *kapa*, on account of which *Maui* sprang upon the sun and broke off some of his rays, so that he was thereafter

[p] It must not be supposed that in their worship these four deities were necessarily associated together as a group. The two brothers *Kane* and *Kanaloa* were represented as being much together, so that the worship of one of them generally involved the worship of the other. Not so, however, with *Ku* and *Lono*. Indeed, "Lono had a separate order of priests and temples of a lower grade, in which human sacrifices were never offered."—(Alexander's History, pages 36.)

[q] The *Lua o Milu* was the Hades of Hawaiian mythology. Its entrance, according to the usual account of the natives, was situated at the mouth of the great valley of Waipio, on the island of Hawaii, in a place called Keoni [the sands], where the sands have long since covered up and concealed from view this passage from the upper to the nether world. "The valley of Waipio is a place frequently celebrated in the songs and traditions of Hawaii, as having been the abode of *Akea* and *Milu*, the first kings of the island. .... Some said that all the souls of the departed went to the *Po* [place of night], and were annihilated or eaten by the gods there. Others said that some went to the regions of *Akea* and *Milu*. *Akea* (*Wakea*), they said, was the first king of Hawaii. At the expiration of his reign, which terminated with his life at Waipio, where we then were, he descended to a region far below, called *Kapapakuaumoku* [the island-bearing rock or stratum], and founded a kingdom there. *Milu*, who was his successor and reigned in Hamakua, descended when he died to Akea, and shared the government of the place with him. Their land is a place of darkness; their food lizards and butterflies. There are several streams of water of which they drink, and some said that there were large *kahilis* and wide spreading *kou* trees beneath which they reclined." Ellis' Polynesian Researches, London edition, 1853, pp. 305-7. For a further account of the *Lua o Milu* and of *Hiku's* descent into it, see "The Myth of *Hiku* and *Kaweku*," by the author, in Thrum's Hawaiian Almanac and Annual for 1883.

obliged to travel at a slower pace through the heavens and furnish a day of sufficient length for *kapa*-drying and other domestic cares.

Another tradition locates the home of *Hina* at Nanakuli in Waianae, on this island, where the cave in which she beat her *kapa* still exists. There, too, is the hill Heleakala on which her son *Maui* stood when he seized hold of the sun. The people of the Island of Maui, however, locate the scene of this seizure in their great extinct crater of Haleakala.

Each of the various crafts and professions had its *aumakua*, whose worship was an essential part of the business. The bird catchers had their *La'e*, a female. Some of the gods of the canoe makers are mentioned in the following fragment of an ancient prayer:

"O Kupulupulu,
O Kualanawao,
O Lea, o ka wahine noho mauna[r],
O Ku,
O Mokuhalii,
O Kupaaikee,
O Nohinohiana."

Mokuhalii was the chief of these, dwelling in the woods, and, like a king, doing nothing himself, while his sister *Lea* was his chief minister. *Kupaaikee* was the inventor of the bevel adze called by his name. He presided over the work of the interior of a canoe.

The fishermen retain more of the ancient superstitions than any other industrial class. Their chief *aumakua*, to whom they looked for abundant supplies of fish and other good things, was *Kuula*, whose worship extended throughout the islands. The following prayer to *Ku* and *Li* is quite charming for its simplicity and beauty:

"E Ku e Li,
E hee i kou honua aina nei e hua,
E hua i hea?
E hua i (Kalaeloa),
Hee ilaila,
Ulua ilaila,
Ke akule ilaila,

[r] This line may be rendered :—
"*Lea*, the woman that dwells on the mountains."
The other lines contain only the names of gods.

resided would often be quite confounded with the god itself. In this way, it would seem, the primary idea of ancestral worship has become greatly confused, if not sometimes quite lost sight of, so that it has become associated with the most odious and debasing form of fetich worship.

The friendly relations maintained between the Hawaiians and some of their *aumakuas* is in pleasing contrast with the dread with which the Tahitians regarded their *oromatuas*, who, as Ellis tells us in his "Polynesian Researches," "were never invoked but by wizards or sorcerers, who implored their aid for the destruction of an enemy, or the injury of some person whom they were hired to destroy. The *oromatuas* were the spirits of departed fathers, mothers, brothers, sisters, children, etc. The natives were greatly afraid of them, and presented offerings in order to avoid being cursed or destroyed, when they were employed by the sorcerers[v]."

Moses was divinely instructed to present the true God as a "jealous God" who would not tolerate the worship of another. Not so does the Hawaiian conceive of his deities. They willingly accept a worship in common with other gods, so long as they themselves are not entirely deserted, and left out in the cold. The term "*Akua pukuole*" used by the Hawaiians, and found in one of their old prayers, represents the deserted gods as hungering and starving for lack of worship and physical sustenance to be derived from the offerings which their neglectful worshippers failed longer to provide. The great need of the Hawaiians is to have clearly impressed upon them the fact of the absolute unity of the Godhead, a fact which they have never sufficiently appreciated and from which many of them have departed. The teaching of the Hawaiian *kahunas* is that the decay of the race is the result of the vengeance of their old time offended deities, fearful of being supplanted by the white man's God who, they claim, was brought from over the water in a book [the Bible]. This foreign God, according to the belief, came into the land as a weakling and a stranger, but by the worship [*hoomanamana*] paid him he has waxed mighty and destroyed the balance of power in the Hawaiian pantheon. Hence the revival of heathenism and the revolt against Christianity which has in a measure prevailed during the past few years.

[v] Ellis' Polynesian Researches, London edition, Vol. 1, pp. 334–5.

[To Rev. R. R. Hoes, Chaplain of the U. S. Flag-ship "San Francisco" and Librarian of the Hawaiian Historical Society, I am especially indebted for the careful reading of the proof, and for many valuable suggestions which have enabled me to make the paper clearer to readers in foreign countries.]

TRACES OF SPANISH INFLUENCE IN THE HAWAIIAN ISLANDS.

HON. C. R. BISHOP,

PRESIDENT OF THE HAWAIIAN HISTORICAL SOCIETY,

DEAR SIR:—The monograph by Prof. Alexander on the early relations of these Islands to Spanish enterprise and navigation in the Pacific is very interesting and suggestive. I may be pardoned for recounting a number of instances of the introduction of Mexican and South American ideas and habits amongst Hawaiians.

The use of adobe is perhaps one of the most prominent. People in these days can hardly realize how important an element that was in the early building up of Honolulu. House lots were enclosed in walls of adobe, built from the clayey soil of the yard itself, with *pili* grass stirred in. Great pits in the yards, afterwards used as rubbish holes, attested to the origin of these walls, which of course cost simply the labor of putting up. Crude boxes of boards served as moulds for the huge sun-dried bricks. Even important buildings had walls of this material, plastered with lime burnt from Hawaiian coral, and whitewashed inside and out. Notable among such was the early Mission School House, built, I think, about 1830, and the regular meeting place of the annual missionary gathering, known as the "General Meeting." This building still stands, south of Kawaiahao Church, at the foot of a lane, is still used as a schoolhouse by the Board of Education, and will, I trust, long be preserved. The great Kaumakapili Church, about 60x120 feet, if my recollection serves me right, had walls of this material; also all the early buildings of Punahou school, being 20 rooms built in single line around three sides of two open quadrangular courts, these courts too being a Spanish idea, followed also in the original Royal School, which stood on the site of the present barracks-building. I mean the school for young princes and chiefs taught so long by Mr. and Mrs. Cooke. It may also be queried whether the old Honolulu custom

THE LESSER HAWAIIAN GODS.

Read before the Hawaiian Historical Society, April 7, 1892, by J. S. Emerson, Esq., Vice-President of the Society.

THE subject of this paper is The Lesser Hawaiian Gods, especially those gods who have received the worship, and become the patrons, of individuals and of families, and have entered most intimately into their daily life. We shall treat of them under the two heads of *Unihipili* and *Aumakua*. It does not include several other classes like the *lapus* [ghosts], and that myriad of spooks, sprites, and elves, with which the Hawaiian imagination peopled earth, sea, air, and the nether as well as the upper world.

The battle of Kuamoo, fought about December 20, 1819, settled the fate of heathenism as the religion of the state in these islands. With the abolition of the tabus and of human sacrifices, the two most important features of the old regime forever passed away. Under the powerful leadership of Kaahumanu, many of the idols were destroyed, and in a remarkably brief period Christianity became the recognized religion of the land. But the ancient beliefs of the people, though greatly modified by the changed condition of the country, still continued to exert a powerful influence on their lives. There have always been those who have clung to the faith of their fathers, and who, in secret, have kept up the worship of their ancestral gods. From time to time the outward manifestations of heathen worship have cropped out. Especially from the year 1863, when Kamehameha V began his reign, up to the death of King Kalakaua in the latter part of the year 1890, has this tendency been more apparent. Under their royal favor and sanction, the heathen party took courage and publicly revived many of their ancient practices. Open encouragement throughout the land was given to the *kahunas*, so that they enjoyed an influence over the people unknown to them since the strong arm of Kaahumanu had guided the helm of state. In the mind of the average Hawaiian, the old gods still exist as living and active beings, even though he may defy their power and abhor their worship. In justice to the race, however, we may add that all history shows that the uplifting of an entire people out of a

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IN MEMORIAM

Albert Lewis Tester

1908–1974

The facts of Al Tester's life can be simply told. He was born in Toronto, Ontario, and raised in that city. After he obtained his baccalaureate degree from the University of Toronto, he was appointed by the Fisheries Research Board of Canada to a research position at its Biological Station at Nanaimo, British Columbia. In addition to his duties as a fishery biologist, he also continued his studies and obtained his doctorate in fisheries research from his parent university in 1936. He was the senior biologist at the Station in 1948 when we at the University of Hawaii offered him a professorship in our expanding program in marine biology. In 1955 he resigned from our staff to take the directorship of the Pacific Oceanic Fisheries Investigation of the United States Bureau of Commercial Fisheries. This appointment in turn led to his transfer in 1957 to the Bureau's Washington headquarters as Chief, Division of Biological Sciences. Not finding the life of a bureaucratic administrator in the capital to his liking, he returned to his old position at the University of Hawaii in 1958. He was serving, at the University's request, in a year's appointment past his normal retirement age when he was suddenly stricken in November 1974; he left his wife, Laura, two children, and six grandchildren.

Such a terse outline tells nothing of Al Tester as a teacher, as a scientist, and as an administrator. As a teacher, Al was known for presenting well-organized and coherent courses and for his patience with and understanding of his students; yet his demands upon them were such that they became thoroughly versed in the subject matter of the courses. He liked and was liked by his graduate students, whom he encouraged and with whom he spent many hours in supervision. In the section immediately following are the abstracts of the papers delivered by graduate students at the Albert L. Tester Memorial Symposium.

His research covered many fields, all with direct application to fishery problems, yet almost all with broad scientific importance. In Canada his work was done primarily upon the fluctuations in the stocks of the Pacific herring, research that led him into population biology and biometry. When he came to Hawaii, he first investigated aspects of the problem of baitfish for the tuna industry, a problem that led in turn to the study of the sensory perception and reaction to stimuli of the tuna itself. After his return from Washington, he studied for many years the sensory perception of sharks, aiding the United States Office of Naval Research in its attempts to develop an effective shark repellant. From his research, he published over 100 scientific papers and was accorded an international reputation as a thorough and careful scientist.

Although he did not especially like administrative work, he did not shirk this duty and would often find himself thrust into positions of authority. He was never other than competent and conscientious, and, above all, fair to all individuals without regard to their rank.

But, in the memories of those who knew him, his personal characteristics eclipse his fine professional qualities and performances. He was a man of great personal integrity, but one without pretense and pomposity, a man who gave to those he

knew a warm friendship, with compassion and personal help in their times of adversity. He is to be remembered as well for his bubbling humor that would so often break forth unexpectedly.

It is an honor to be able to dedicate this issue of *Pacific Science* to my good friend of so many years, Al Tester, and to his tradition of encouraging the individual research efforts of his graduate students.

15 September 1976

Albert H. Banner
Professor of Zoology

Albert Lewis Tester

U.S. DEPARTMENT OF COMMERCE
National Technical Information Service

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PRELIMINARY INVESTIGATIONS OF SHARK PREDATION ON THE HAWAIIAN MONK SEAL AT PEARL AND HERMES REEF AND FRENCH FRIGATE SHOALS

Leighton R. Taylor & Gary Naftel

Easy Rider Corporation
Honolulu, Hawaii

September 1978

Report No. MMC-77/07

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ABSTRACT

Longline fishing at Pearl and Hermes Reef and French Frigate Shoals in the Northwest Hawaiian Islands in April, May and June, 1977 resulted in a catch of 79 sharks representing 8 species. Eighteen longline sets totalling 388 hooks were made. The species most frequently caught was the tiger shark (Galeocerdo cuvier); 39 specimens ranging in total length from 198 cm to 432 cm (X = 295) were landed. Catch per unit effort for all species ranged from 6.3 - 51.6 sharks/100 hooks at Pearl and Hermes Reef; at French Frigate Shoals the range was from 4.0 - 37.5 sharks/100 hooks. Qualitative analysis of gut contents was focused on tiger sharks and revealed that they take a varied selection of apparently living prey including spiny and slipper lobsters, fish, sea birds, green sea turtles, spinner porpoise, and monk seals. Seal remains were found in three tiger sharks at French Frigate Shoals; no seal remains were found in tiger sharks caught at Pearl and Hermes Reef or in other shark species.

Sonic tagging of a large (approx. 4 m total length) female tiger shark at French Frigate Shoals permitted continuous tracking for 48 hours. The shark followed similar, roughly circular paths approximately 85 kms in extent during two consecutive 24 hour periods. Swimming depth ranged from approx. 5 m to greater than 175 m and changes in depth were often abrupt. Swimming speed averaged approx. 3.5 km/h; maximum speed during tracking was estimated at 6.4 km/h.

No direct observations of shark-seal interactions were made but large tiger sharks were observed in shallow water within 50 m of seals basking on East Island, French Frigate Shoals. Underwater observations of monk seals indicate the possibility of behavior designed to avoid shark attack. Storage of exhalation bubbles in the ceiling poskets of submarine caves and crevices may allow the extension of breath-holding time by seals. Analysis of trapped gas revealed high partial pressures of CO_2 (10 mm Hg) and low partial pressures of O_2 (120 mm Hg). One swimming seal was observed to exhale into a cave and two resting seals were seen to repeatedly inhale gas from cailing bubbles.

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SUMMARY

Shark predation has been suggested as an important factor in preventing population increase in the Hawaiian monk seal. However, little information is available about the shark populations in the Hawaiian Leeward Islands, the area to which the monk seal is limited. This study was designed to provide preliminary data on the kinds and relative abundance of sharks present in the area, and a qualitative analysis of their diets. In addition, an individual of the largest shark species in the area (the tiger shark, Galeocerdo cuvier) was sonic-tagged and tracked continuously for 48 hours in order to see whether such large individuals were limited in range and hence more vulnerable to a fishing/abatement program.

Fishing effort was restricted to two islands: Pearl & Hermes Reef, where seal numbers are believed to be declining; and French Frigate Shoals, where numbers may be increasing. A total of 79 sharks representing 8 species were caught using longline methods. All species are potential predators on seals; only three contained seal remains. Although precise population estimates are not possible, catch per unit effort figures indicate that shark populations are relatively larger in the two study areas than in locations near Maui, Oahu, and Hawaii.

Seal remains were found only in the stomach contents of three tiger sharks from French Frigate Shoals. No seal parts were found in sharks of other species or from tiger sharks at Pearl & Hermes. Reef spiny lobsters were found to occur in a majority of tiger shark stomachs examined; monk seals are also reported to feed on lobsters and it is possible that sharks and seals are exploiting a common food resource. More data are needed on the feeding habits of both seals and tiger sharks to ascertain if feeding interactions could be reduced by added human exploitation of lobsters.

A large (+3m) female tiger shark was tagged with a sonic transmitter and tracked continuously for 48 hours. It was found to traverse large areas (approx. 85 km/day) and a wide depth range (5-140 m). Such wide-ranging may not be typical of all individuals of the species, but suggests that some tiger sharks may be more likely to encounter seals and may be more difficult to fish out than sharks with a more restricted range.

Seals were observed by SCUBA divers in submarine caves which contained reservoirs of gas trapped in the ceiling. Gas analysis revealed elevated levels of CO_2 (approx. 7 mm Hg) and lowered levels of O_2 (approx. 120 mm). Seals were seen to inhale the contents of these bubbles and to exhale into caves after an inhalation at the sea surface. We hypothesize that seals may store air reserves in underwater caves in order to extend breath-hold time while resting or seeking shelter from shark attack.

It has been suggested that intensive fishing programs might be conducted in the Leeward Islands in order to reduce the numbers of sharks and hence reduce mortality on monk seals. While we agree that such fishing effort would indeed reduce the numbers of large shark species, there is evidence from other programs that the smaller species may increase in number.

While seal remains have now been found in tiger shark stomachs, we cannot determine whether this represents shark predation or scavenging of dead animals. It is possible that sub-adult and adult seals have behavioral mechanisms protecting them from fatalities due to shark attacks. The reduction of predation on pups may be tied to availability of nursery areas and perhaps is independent of shark numbers. The rise in seal numbers and the observation of puppings at Necker Island (where shark numbers are probably high) may confirm this. It is our opinion that, given limited resources, effort should be expended on research on monk seal biology and not on shark abatement programs.

5 w/turtle N=16 stomachs examined (with food)

TABLE 3 - Tiger Sharks Caught at French Frigate Shoals with Catch Data, Size (cm) & Gut Contents

Shark No. (#23)	Sex	TL	PCL	Set No.	Date	Gut Contents
35	F	219	160	7	5-17-77	L, F
37	F	412	318	7	5-17-77	6 Tiger shark, coral rock
38	M	244	181	7		L, F, Ray
39	F	362	280	7	5-17-77	L, B, MS
44	F	329	250	7	5-17-77	L, B, F, Dolphin
45	F	269	194	7	5-17-77	L, SL, F
48	M	223	158	8	5-18-77	L
49	head only			8	5-18-77	
51	F	226	161	8	5-18-77	R - E
52	M	357	277	8	5-18-77	L
53	M	198-	139	9	5-19-77	Belly bitten out
54	M	280	208	9	5-19-77	L, T, MS, F
55	F	231	165	9	5-19-77	L, B
56	F	403	313	9	5-19-77	L, T, MS, B, F, Trawl net
66	F	359	275	11	5-20-77	L, T, B
67	F	386	323	11	5-20-77	B, crab pincer
68	F	362	272	11	5-20-77	R
71	F	347	262	12	5-20-77	L, SL, T,
80	F	380	296	14	6-24-77	T
80A	F			14	6-24-77	Sonic tagged and released
82	F	218+	177	15	6-27-77	L, SL, F
86	M	278	203	17	6-28-77	E
86A	F	270est.		18	6-30-77	Fins clipped and released

Abbreviations: TL = total length; PCL = Precaudal length; T = turtle; MS = Monk Seal L = Spiny lobster; SL = Slipper Lobster; B = Sea bird; F = fish; R = Regurgitated; E = Empty

TABLE 4 - Tiger Sharks Caught at Pearl and Hermes Reef with Catch Data, Size And Gut Contents

Shark No.	Sex	TL	PCL	Set No.	Date	Gut Contents
4	F	374	288	1	4-20-77	T, B, Kona Crab
5	F	222	161	1	4-20-77	L, SL, F
7	head only			1	4-20-77	
16	M	288	207	1	4-20-77	T (also contained shark 16A)
16A	in shark #16's stomach					L, F
17	F	226	161	1	4-20-77	L, B, F
18	F	261	188	1	4-20-77	F, octopus, crustacean
20	M	368	277	2	4-21-77	L, T, B
21	F	229	167	2	4-21-77	F
22	M	198-	145	3	4-22-77	F
25	M	266	192	3	4-22-77	E
27	F	340	271	3	4-22-77	R
28	F	267	192	5	4-23-77	R
29	M	235	167	4	4-23-77	E (bait)
30	F	432-	336	4	4-23-77	L, T, B, F, Ray
31	M	314	233	6	4-24-77	L, F

Abbreviations as in Table 3

ANALYSIS OF GUT CONTENTS OF SHARKS
Materials and Methods

The major objective of this part of the study was to determine qualitatively those food items on which sharks were feeding. Gut contents of all species caught were recorded but only data on tiger sharks are reported here because seal remains were only found in this species and it is the largest shark species in the area and thus presumably presents the greatest threat of predation.

Quantitative analysis of shark diet was precluded by three major factors: 1) set line catches are probably biased toward actively feeding sharks, and satiated individuals are underrepresented; 2) hooked sharks occasionally regurgitate food items, as evidenced by everted stomachs and tooth marks in the stomach lining apparently caused as a result of eversion; and 3) hard parts of certain food items, such as turtle shell and lobster carapaces are retained longer than faster digesting items such as fish flesh. Turtle parts, for example, may be retained in the gut from several feeding bouts whereas fish remains may only represent more recent feeding actions. Therefore only the presence of a food item was noted and the estimated amount was recorded anecdotally.

Hooked sharks were hauled onto the deck. Gut contents and reproductive condition were recorded after a standard series of morphometric data (Bigelow & Schroeder, 1948) was taken. Large sharks were pulled up head first to avoid the loss of gut contents which occurs if the specimen is lifted by the tail.

Gut contents were carefully inspected and recorded to the lowest identifiable taxon. In some cases gut contents afforded data for cooperating investigators. Mr. G. H. Balazs was able to obtain stomach samples from a 42 cm green sea turtle specimen removed from a hooked tiger shark.

Although it is probable that all food items present were taken by the shark as living prey, it is not possible to document this. It is possible that some food items such as monk seal, spinner porpoise (Stenella longirostris), and sea birds may represent feeding activity on animals whose death was not the result of shark predation. Live capture was assumed to be very likely when intact specimens (e.g. turtles) were found.

Results

Figures 4 and 5 display food items found in tiger sharks caught at Pearl and Hermes Reef and French Frigate Shoals. Only major groups are listed in figures; complete taxonomic data are recorded on the field sheets. At the former locality, 5 of the total of 15 sharks had regurgitated their gut contents prior to capture or while on the hook; at the latter location, 8 of 23 had empty guts. Monk seal parts were found in 3 sharks from French Frigate Shoals. Although other workers have reported shark predation on the Hawaiian monk seal (Kenyon, 1973; E. Kridler, in. litt., 1974; Johnson & Johnson, 1978; R. DeLong, pers. comm., 1978), these reports are based on the presence of wounds on moribund animals or scars on living animals and not on shark gut contents. To our knowledge, this study is the first to document the ingestion of Hawaiian

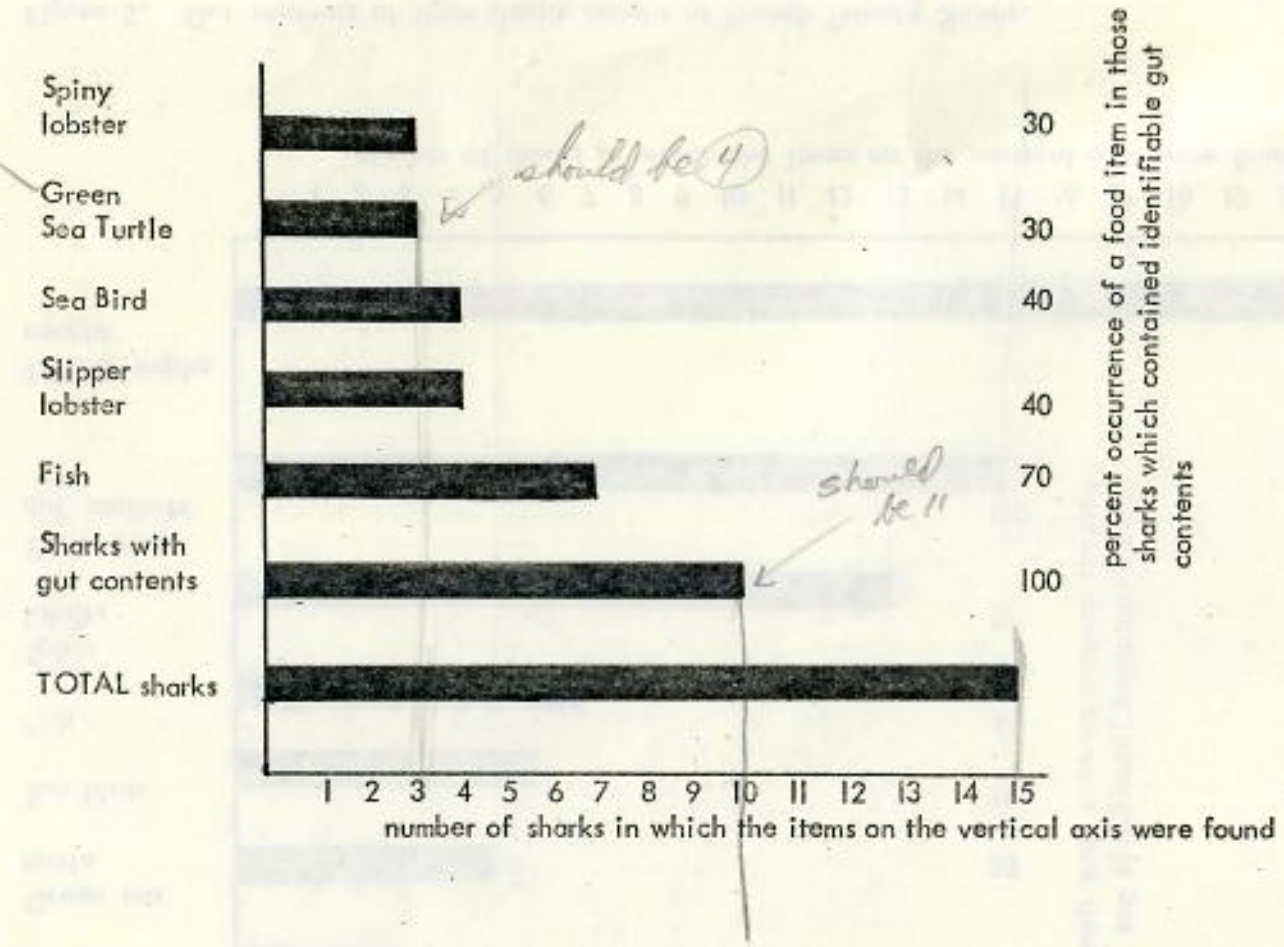

Figure 4. Gut contents of tiger sharks caught at Pearl and Hermes Reef

PH from table 4/11

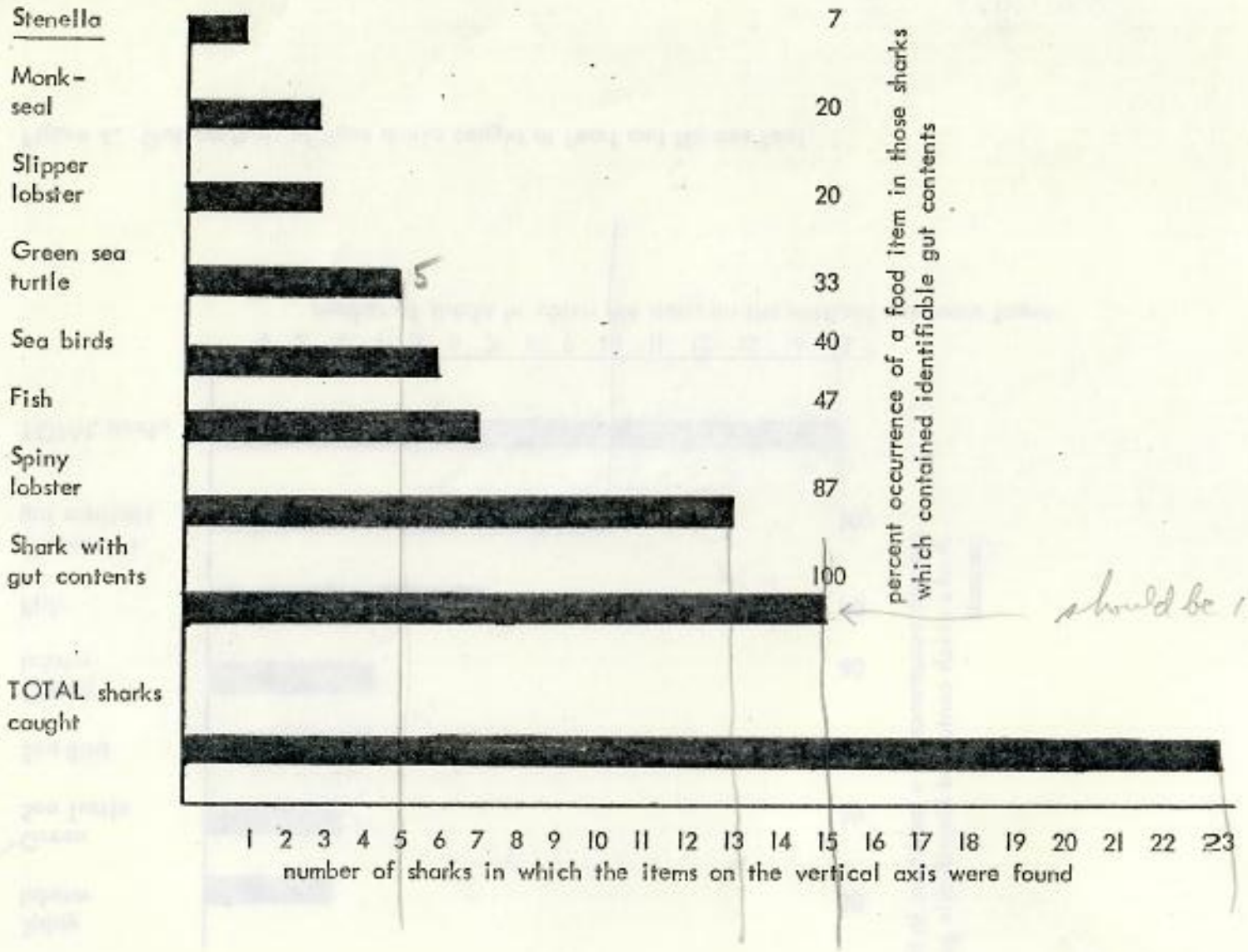

Figure 5. Gut contents of tiger sharks caught at French Frigate Shoals.

from Table – 5/16

TABLE 5 - Catch Data for Tiger Sharks Specimens Whose Gut Contents Included Monk Seal Remains

Shark No.	Set No.	Date Caught	Sex	Reprod. Condition	Co-occurring food items
39	7	5-17-77	F	Pregnant w/ 29 pups	lobster, shearwater
54	9	5-19-77	M	Mature	lobster, turtle, fish
56	9	5-19-77	F	Mature Ovaries w/ large eggs	lobsters, turtles, fish, sea birds, remains of trawl net

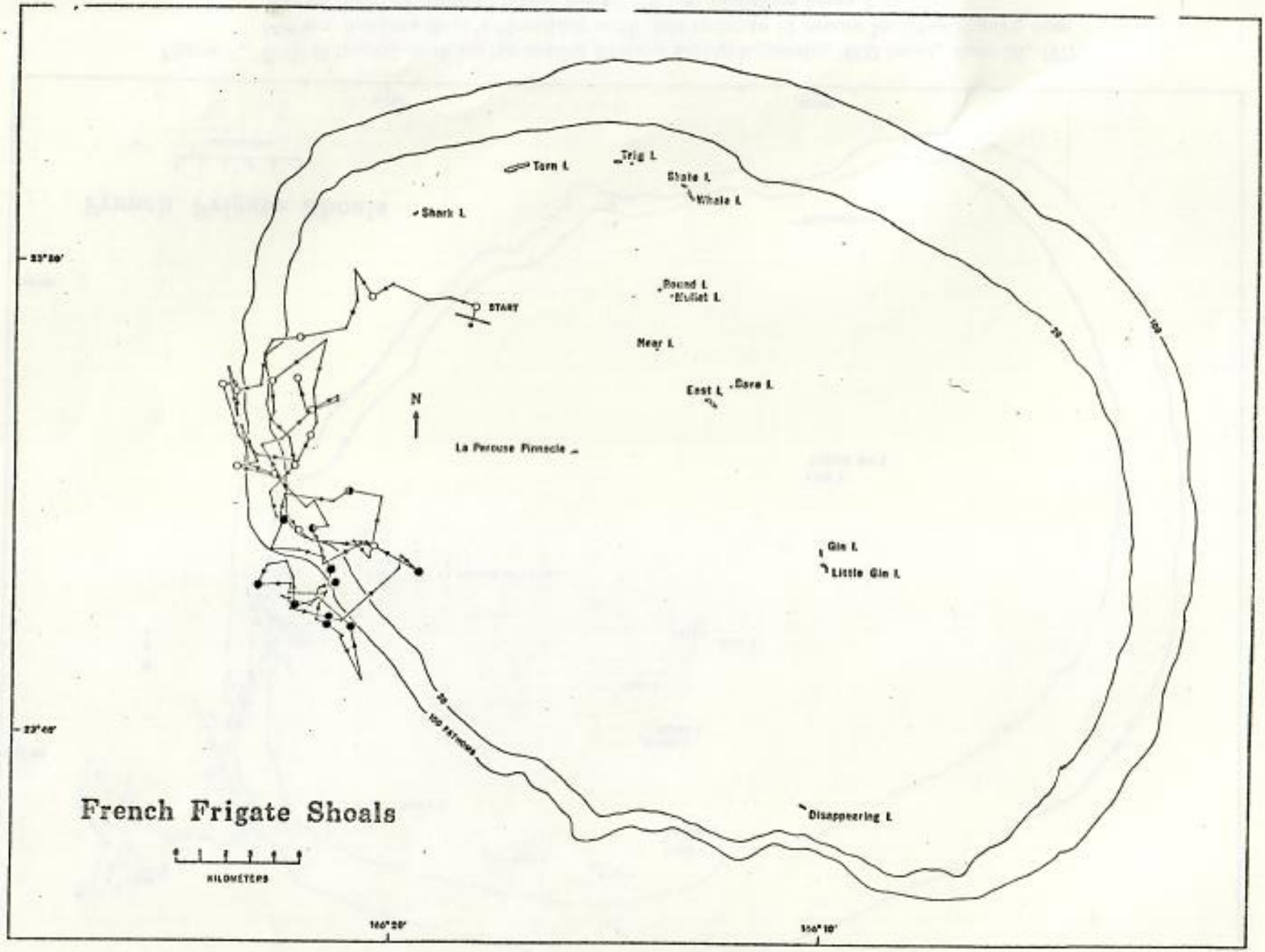

Figure 6. Path of tagged tiger shark during first 24-hour period beginning 1000 hours, June 25, 1977. (Arrows indicate shark's direction; small dots indicate 15 minute location checks; open circles indicate daylight hours; closed circles, nighttime hours.)

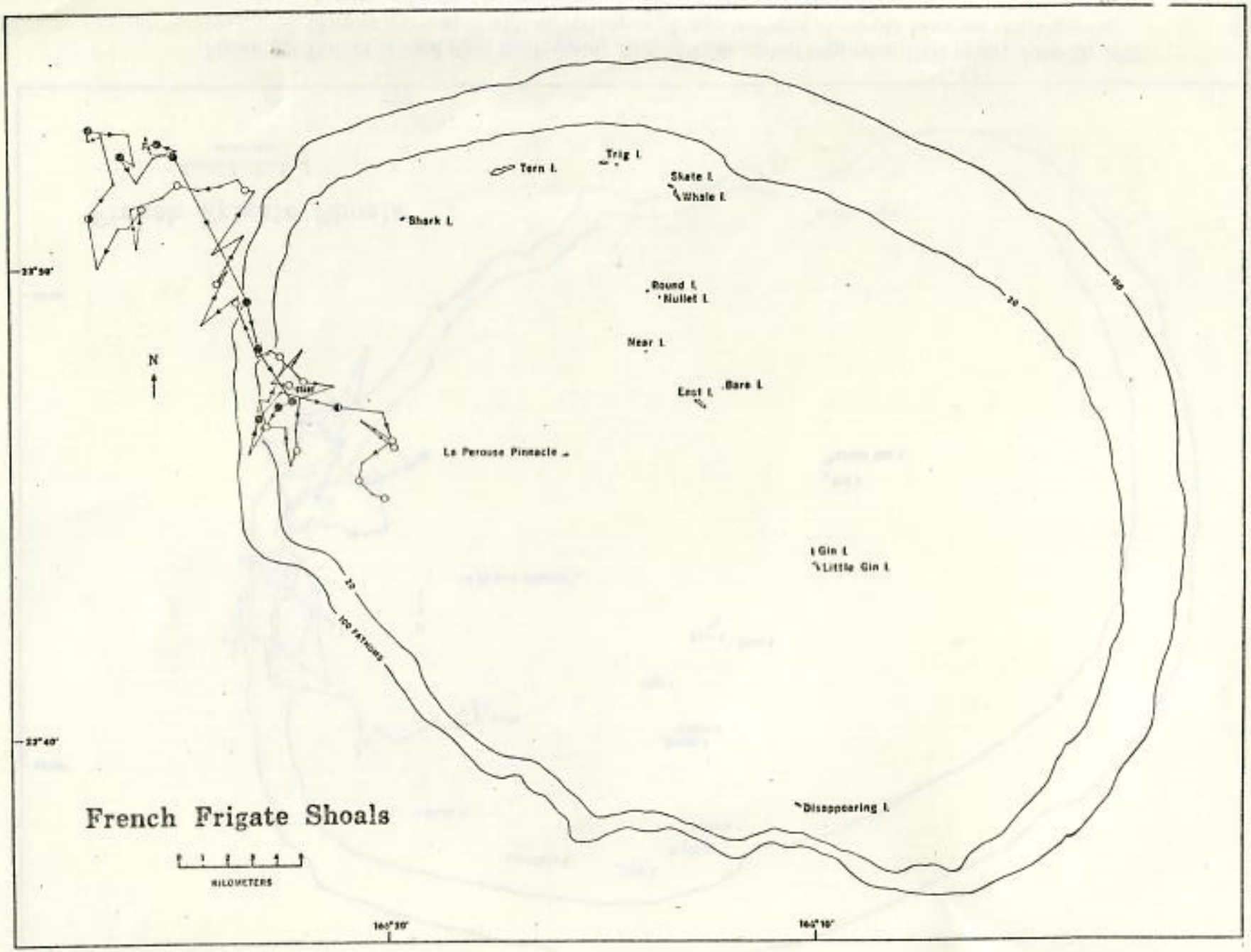

Figure 7. Path of tagged shark during second 24-hour period beginning 1000 hours, June 26, 1977. (Arrows indicate shark's direction; small dots indicate 15 minute location checks; open circles indicate daylight hours; closed circles, nighttime hours.)

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Shark Control and the Hawaiian Monk Seal

Ron S. Nolan

Ocean Research Consulting and Analysis, Limited
Honolulu, Hawaii

May 1981

U.S. DEPARTMENT OF COMMERCE
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SHARK CONTROL AND THE HAWAIIAN MONK SEAL

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Sharks are known to feed upon seals and there is some evidence that sharks in the Northwestern Hawaiian Islands may feed upon Hawaiian monk seals. A shark fishery/control program might prove beneficial to the survivorship of monk seals, however, the magnitude of shark predation on monk seals and the effect of a shark control program on monk seals, associated marine food webs, and sharks themselves is not known. This report summarizes past studies of shark fisheries and shark control programs in order to provide background information on the effectiveness of such programs and their impact on shark populations, and the environment. Generally, shark populations are very susceptible to overfishing. In some instances, shark fisheries and control programs have had subtle, long-term negative impacts on food webs and shark abundance. A controlled, experimental program would provide valuable data--and might be used to temporarily reduce shark predation on localized populations of monk seals.

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INTRODUCTION

Many monk seals carry fresh and/or healed scars suggestive of shark attack. Balazs and Whittow (1979) observed sharks feeding on the carcass of a monk seal and Le Beouf et al (MS) document shark mortality on California pinnipeds. Taylor and Naftel (1978) found monk seal remains in the stomachs of tiger sharks (Galeocerdo cuvier). However there have been no direct observations of sharks killing or eating monk seals. Kenyon (1959) and Kramer (1971) report many observations of monk seals and sharks swimming together without obvious interaction. More research needs to be done before the magnitude of shark predation on monk seals is known.

> "It has been hypothesized that the observed decline of monk seals on Kure Atoll may be caused by sharks preying upon newly weaned pups and that a shark control program in the vicinity of Kure Atoll and, perhaps, elsewhere in the Northwest Hawaiian Islands, might facilitate the recovery of the Hawaiian monk seal. It also has been hypothesized that a shark control program could adversely affect other components of the marine communities from which the sharks would be taken, as well as the shark populations themselves. Therefore, while a shark control program might benefit monk seals, the benefit might be at the expense of other community components, including sharks. There is a need, therefore, to determine, as possible, how a shark control program might affect monk seals, sharks, and other components of nearshore communities in the Northwest Hawaiian Islands." (excerpted from the contract scope of work).

It has been suggested by members of the Monk Seal Recovery Team that a shark fishery around one or more of the Northwest Hawaiian Islands (NWHI) might enhance the survivorship of monk seals. The purpose of this manuscript is to assemble and evaluate information on shark fisheries and control programs throughout the world including:

> An introduction identifying the nature of the program and the purpose of the study; a brief summary of available information concerning the structure and dynamics of nearshore marine communities in the Northwest Hawaiian Islands; a description of past and on-going shark fisheries and shark control programs in Hawaii and elsewhere including, as possible, the locations, dates, and

purposes of the fisheries/control programs, the value and cost of the programs and the technologies used, the number, species, size, ages and sexes of sharks taken and any related information concerning changes in the structure and dynamics of the shark populations and associated species; a discussion of the data with respect to apparent harvest-related changes in shark behavior and in the distribution, size, age/sex composition or productivity of the shark populations and species found in association with them; an assessment as to how a shark control program might affect shark populations and populations of other species in the vicinity of Kure Atoll or elsewhere in the Northwest Hawaiian Islands; an annotated bibliography of relevant published and unpublished reports. (from contract scope of work).

Holden (1977) states that the classical theories of fish population dynamics developed by Beverton and Holt (1957) and Ricker (1958) do not apply to shark fisheries. This is because:

1. Elasmobranchs cannot be easily aged.
2. Elasmobranchs bear few young, therefore, stock and recruitment are closely related.
3. There are few large fisheries from which population data may be gathered.

A review of shark control programs and fisheries for Scotland-Norway, U.S.A., the Indian Ocean, Australia, South Africa and Hawaii follow. The NWHI environment will then be discussed in the context of a monk seal related shark fishery.

A TIGER SHARK

The tiger shark is an indiscriminating destroyer of life in the seas, for it does not scruple to bite big pieces out of other sharks in addition to devouring prey of remoter kin. Turtles, crabs, rays, and porpoises, among other creatures, fall victims to its voracity. Even sea-birds alighting on the waves are not immune to its attack. Among the disgorgings of the shark shown in the picture were numerous feathers, the indigestible finery of some plumaged visitant of the ocean

WHAT SHARKS REALLY EAT*

BY

JOHN T. NICHOLS†

FOREWORD: Popularly all sharks are "man eaters." As a matter of fact, very few are guilty of such misbehavior,—not that sharks seem to have any deep-rooted aversion to man as an article of food, although Doctor Coles thinks that they are somewhat particular as to their diet, but it would appear that in many if not most cases where man has fallen a victim to their voracity, it has been because he happened to be handy. What sharks really eat is set down by Mr. Nichols, who has recorded the observations of Doctor Coles and Mr. Bell.

The illustrations accompanying this article are from photographs kindly supplied by Dr. E. W. Gudger. The hammerhead depicted was harpooned in the harbor of Beaufort, N. C.; the tiger and the nurse sharks were taken at Tortugas, Fla., at the Marine Laboratory of the Carnegie Institution of Washington.—F. A. LUCAS.

SEAS all over the world have their sharks, as they doubtless have had since far back in geologic time, but these marauders are not nearly so numerous in high latitudes or temperate regions as along the sun-baked shores of the tropics. As we go south along our own eastern seaboard, they become abundant at the capes of the Carolinas, where the Gulf Stream hugs the shore for the last time before spreading out to the east across the Atlantic, and here, at Morehead City, North Carolina, near Cape Lookout, Mr. J. C. Bell, of the American Museum's department of preparation, spent some weeks last summer obtaining plaster molds for reproducing sharks for our exhibition series. He was the guest of the Ocean Leather Company, which furnished specimens for and aid in casting. Dr. Russell J. Coles, who was instrumental in arranging for Mr. Bell's trip and who was himself "sharking" off Cape Lookout, also provided specimens. It was Doctor Coles, it may be remembered, who secured the great devil fish or *Manta* which hangs above the fish exhibit in the north corridor of the American Museum. Some excellent material was obtained which will, in due course, be placed on exhibition. More than that, thanks to Mr. Bell, exceedingly interesting observations bearing on the habits of sharks were made.

The tiger shark (*Galeocerdo tigrinus*) is a large species found in all warm seas, and whether considered from the point of looks or habits, the name is most appropriate. It has a blunt head and heavy shoulders. The body tapers back to a long, slender tail, and its sides are marked with dark stripes and spots. This marking is quite distinct in the young, but as the shark grows it becomes less well defined, like a pattern in watered silk, and, it is said, finally disappears altogether. The tiger shark's maximum length is thirty feet, but specimens of the largest size are seldom seen. Its mouth is very large, and is armed with a row of big, flat, cutting teeth quite different in outline from those of any other shark. Each tooth is roughly sickle-shaped with a fluted edge suggesting a patent bread knife and a triangular point at the summit projecting obliquely outward.

This is one of the sharks most dreaded in the West Indies, and, indeed, it seems quite capable of living up to the evil reputation of being a man-eater, although we know of no authentic evidence that it is such. Dr. Coles has written of it in the following words:[1]

"There can be little doubt that the tiger shark regularly preys on other sharks to a considerable extent. During the few weeks that I was watching the fishery at Cape Lookout I examined the stomachs of three young tiger sharks, and in all three I found cleanly bitten pieces of freshly eaten shark meat with skin attached, just as if the chunk of meat had been cut from the side of a

[1] Coles, Russell J., "The Large Sharks of Cape Lookout," *Copeia*, No. 69. 1919.

† Associate Curator of Recent Fishes, American Museum.

The tiger shark has the evil reputation of being a man-eater. Even if its alleged propensity as such be exaggerated, its capacious jaws would have no difficulty in encircling a human victim, a small boy being a particularly manageable morsel

shark. In the largest example, 7 ft. 9 in., in length, caught in my nets June 25, there were eleven of these chunks of shark meat of from one to five pounds each in weight, and they represented *hammerhead*, *sharp-nosed*, and *ground sharks*.

"Additional observations made during the first week of August on three more tiger sharks, each in excess of twelve feet in length, confirm my former observations as to the varied character of their food. In one of them I found a freshly eaten loggerhead turtle, approximating 100 lbs. in weight, which had been bitten through both shells, in three places and the pieces of shell much crushed, yet all parts of the turtle were present.

"Probably tiger sharks will use as food, when hungry, any creature which they find moving in the water, for which reason they must be dangerous as man-eaters; but I do not regard them as nearly so dangerous as a white shark which has once acquired the habit of eating human flesh. While it is not fastidious, I have no evidence as yet that even the tiger shark will eat unclean food, and in my opinion, the sharks which eat garbage or putrid matter are exceptional individuals, which, through some accident, have acquired the habit."

Speaking of a 12½ foot individual, he says: "Stomach contained most varied assortment of food that I have ever found in any shark, consisting of parts of three very large stone crabs, one bird, the small diver called locally water witch, and various unidentified substances."

Mr. Bell examined the stomach contents of more than thirty individual tiger sharks, mostly from nine to twelve feet in length. Of these sharks 56 per cent had been eating such large creatures as sea turtles, other sharks, and large rays and porpoises; 38 per cent had consumed a variety of smaller creatures (crabs, horseshoe crabs, mackerel, shad, and other fish, and in one case a water bird); 6 per cent had swallowed the bones of domestic animals, probably in their rôle of scavenger. That is, it was found that one individual contained among other material beef bones and hair, and a second, landed on the dock still alive, vomited several small mammal bones, among which the leg bones of three sheep have been identified.

Other sharks constituted the largest single item of diet for the tiger sharks examined. The stomach of an individual 11 ft. 3 in. long contained a large piece from the side of the head and gills of an eleven foot hammerhead taken in the net with it. In the stomachs of four tiger sharks taken on July 13

were found black-tip sharks (*Carcharhinus limbatus*) bitten in large pieces, some about in half. An individual 12 ft. 2 in. long had swallowed a large shark of 8 or 9 ft. bitten into seven or eight pieces. An eleven foot individual contained a small hammerhead of about 3½ ft. intact and several parts of other sharks. In most cases, at least, the sharks consumed appear to have been caught in the nets and so to have fallen an easy prey. It is doubtful if so many of them could have been captured in the open, although the evil tiger doubtless carries always with it the will to consume its weaker brethren.

It is more than doubtful if the tiger shark is ever quick enough to capture porpoises in the open, but it must be a very serious enemy to the rather sluggish loggerhead turtles, through the tough shells of which it bites with comparative ease. Several of those which Mr. Bell examined had pieces of big turtle in their "innards," and one large female contained a loggerhead intact. Mr. Bell's observations attest to the ravenous appetite of this shark and the variety of its food. In this particular case, owing to the fact that other sharks were being taken in the nets in large numbers, these made up much of its diet. Ordinarily loggerhead turtles and valuable food fish are probably consumed in quantity.

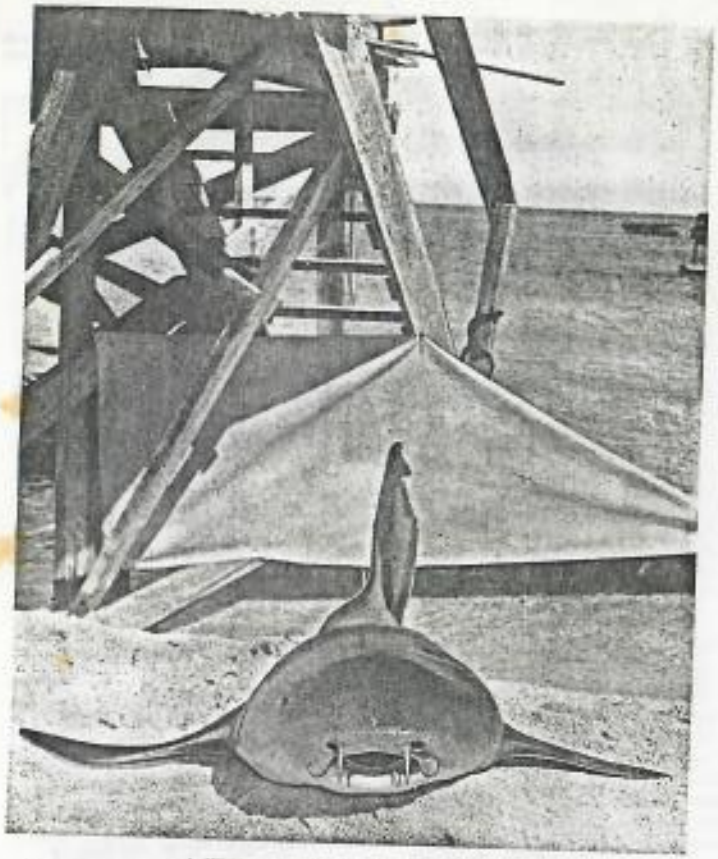
From the stomach of one of these sharks was taken the tail spine—more than a foot long—of a big horseshoe crab; why a shark should eat creatures about as nutritious as a basket of shavings is a puzzle—a still greater puzzle is why the long and sharp spine did not pierce the walls of the stomach.

A comparatively small series of large cub sharks (*Carcharhinus commersonii*) were examined. Making allowance for their somewhat smaller size, these showed a very similar range of food to that of the tigers—including smaller sharks, rays, the fin of a porpoise, shad, mackerel, and crabs.

Among the formidable and voracious denizens of tropical and subtropical seas is the hammerhead shark. The eyes of the shark are located at the extremities of the mallet-like prolongations. The object of this peculiar head structure is apparently to function as a bow rudder

Thus it appears that while sharks have an evil reputation, they are far more dangerous to one another than they are to man, and while from man's point of view cannibalism is not considered good form, yet among sharks it may be tolerated as tending to lessen their numbers. And now that man has begun utilizing sharks for food, leather and fertilizer, our sympathies are largely with the sharks.

The nurse shark (*Ginglymostoma cirratum*) is a creature of different make-up from the species we have been discussing. It is a rather slow-moving animal with a

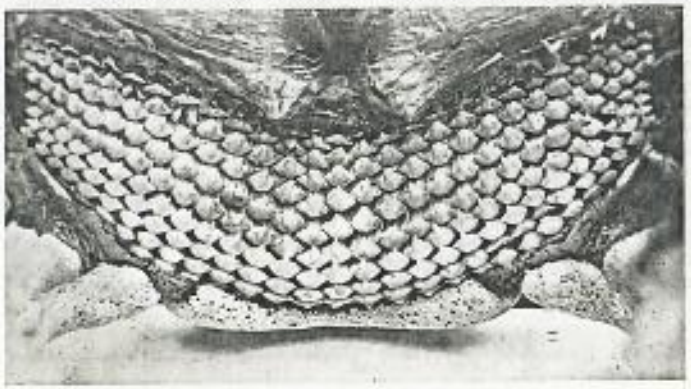


A HEAD-ON VIEW OF A NURSE SHARK

More slow-moving than many other species, this shark must nevertheless be the equivalent of a "do not trespass" sign to many of the smaller swimmers. Its eight or nine feet of length and three hundred to four hundred pounds of weight require many a squid or inkfish for proper maintenance

small, thick-lipped mouth. Its teeth also are small, although each one is sharply pointed, and they are arranged in a sort of pavement, with their points directed backward, all or most of the rows functioning at the same time. In the tiger shark or in the numerically abundant ground shark group to which the cub belongs, only a single anterior row of big, cutting teeth is erect and functional, numerous other rows lying superimposed out of the way behind it, in turn to become erect and functional as the preceding row is worn out and discarded. The nurse shark has an exceedingly tough, resistant hide, so heavily armed with minute bony points as to be difficult of penetration by a harpoon. This hide may furnish some protection against its fierce relatives, at any rate, they do not appear to prey on it, although it is too sluggish to get out of their way. Two nurse sharks between eight and nine feet in length, each weighing between three and four hundred pounds, had been feeding on squid or inkfish, and one of them also contained a little, partly digested shrimp.

One of these nurse sharks was a female, containing twenty-eight eggs,

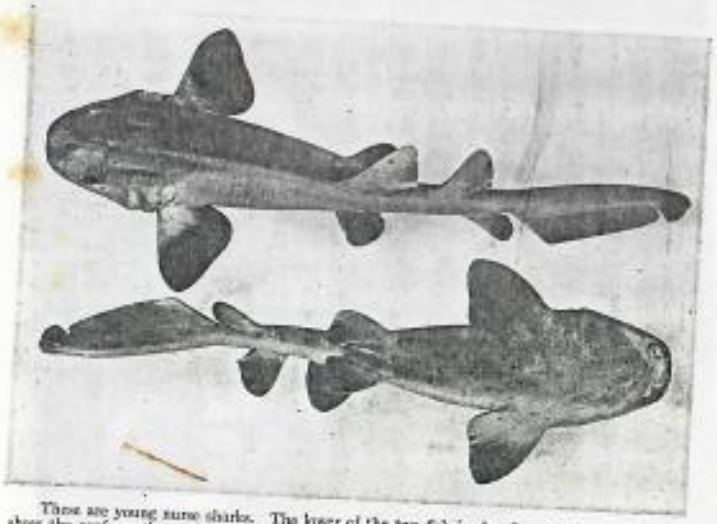


Equipped with row upon row of sharply pointed teeth, all or most of which function at the same time, the expanded jaws of the nurse shark spell peril for any small creature that is luckless enough to attract the hungry gaze of this shark

each about as large as a goose's egg and with a delicate, horny shell. They suggested the tougher-shelled eggs of skates, which are washed up along our shores in great abundance and are called "sharks' eggs" or "devil's pocketbooks" by seaside visitors. Above these there were a large number of smaller eggs ranging from the size of a pea to that of a large-sized marble.

Present-day sharks differ little from those which swam the seas in early geologic time, the first and simplest form of true fishes, and yet it is among the sharks and rays (which are no more than flattened sharks) that we find the most highly developed systems of reproduction in the fish world. In most modern sharks the young attain considerable size within the body of the mother, and the egg and helpless stages, in passing through which other young fishes must face so many dangers in the ocean, are thus protected. This is true of all our eastern, coast-wise species, with the possible exception of the nurse shark. In other parts of the world there are sharks which lay large eggs with tough shells like skates' eggs.

Dr. E. W. Gudger has for years been especially interested in the case of the nurse shark. He believes that the egg of that species, although it has a shell, is never deposited and that its young also are born alive. If this can be proved, we have in *Gingly mostoma* an extremely interesting transition form, for an egg-shell would not be formed unless this genus or its immediate ancestors deposited their eggs.



These are young nurse sharks. The lower of the two fish is placed on its back in order to show the conformation and markings of the under surface. In a still earlier stage numerous spots are found also on the upper surface

FISH AS MOSQUITO DESTROYERS[1]

AN ACCOUNT OF THE PART THEY PLAYED IN THE CONTROL OF YELLOW FEVER AT GUAYAQUIL, ECUADOR

BY

MICHAEL EDWARD CONNOR, M. D.

GUAYAQUIL, Ecuador, one of the oldest cities of the Western Hemisphere, has at no time been noted for the salubrity of its climate. Don Antonio de Ulloa, who visited it toward the middle of the eighteenth century, reported that even then fevers were very common there and, knowing as we do to-day that certain insects are responsible for the transmission of certain diseases, his further comment has especial interest. "Though all these hot and moist countries swarm with an infinite variety of volatile insects," writes the Spaniard, "yet the inhabitants are nowhere so greatly incommoded as at Guayaquil." Writing as recently as 1912 the Right Hon. James Bryce refers to Guayaquil as the pesthouse of South America, the last stronghold on the continent (if one excepts the banks of the Amazon) of the deadly yellow fever.

Today, less than a decade after the denunciation just cited was written, Guayaquil is a city redeemed from the yellow fever peril, which, first recorded in that community in 1740, maintained its hold until May, 1919, when the last case was officially reported. All Ecuador, and not merely Guayaquil, is enabled to take a forward stride as the result of this accomplishment, for the isolation imposed upon the chief port of the country has been an important factor in retarding the development of the wonderful resources of the republic.

How was this improvement in sanitation brought about? The reader familiar with the achievements of our government in controlling disease-carrying mosquitoes at Panama and elsewhere will not unnaturally assume that fumigation, oiling, screening, and the inspection of mosquito-producing containers were the methods resorted to. In Guayaquil, however, partial reliance was placed upon an animal ally of man—a fish so indefatigable in the destruction of the larvæ of the dangerous *Stegomyia* mosquito that through its agency the breeding of this insect in small containers has been reduced from 100 per cent. to less than 2 per cent., a figure not far from complete extermination.

The yellow fever mosquito breeds by preference in fresh-water containers in or near human habitations, and is rarely ever found in pools of water on the surface of the ground and never in the fields or swamps. It is a domestic mosquito and clings to inhabited buildings with tenacity. It does not fly any considerable distance and avoids direct sunlight. The female deposits between one hundred and one hundred fifty eggs at a time. These eggs are deposited on the surface of the water, always in a barrel, tank, tin can, flower vase, broken bottle, or some other receptacle holding fresh water. From each egg there comes a wriggler or larva, which after several molts finally reaches the adult stage and, if it be a female, starts at once to secure a victim from whom to suck blood. Should this victim be ill with yellow fever in the early stages, the mosquito will take up in the blood germs of the disease, which after a period of about twelve days in its body will be injected into the next victim that the mosquito bites.

The water supply of Guayaquil pe-

[1] At about the time that Dr. Connor was engaged in yellow fever control, the Rockefeller Foundation, under whose auspices his work was conducted, also became interested in the rôle played by fish in malaria control. The latter demonstration was conducted by Dr. W. H. Howard (Director for the West Indies of the International Health Board) in Rich County, Mississippi, from 1918 to 1920. A report of this work is found in Document No. 1286 of the International Health Board, entitled, *Use of Fish Minnows (Gambusia Affinis) as an Agent in Mosquito Control.*—THE EDITOR

G.W.
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JOB COMPLETION REPORT

INVESTIGATIONS PROJECTS

State of Hawaii

Name Reef and Inshore Game Fish Management Research

Project No. F-5-R-8

Job No. 12

Title Shark Predation Studies

Period Covered: July 1, 1959 to June 30, 1960
(Includes field data obtained during the previous segment for presentation of a comprehensive report)

Abstract:

Using set lines specially designed for shark fishing, 824 sharks comprised of 9 different species were taken over a 2-year period. Sand sharks (Eulamia menisorrah), tiger sharks (Galeocerdo cuvieri), and small black-tipped sharks (Carcharhinus limbatus) made up 95 percent of the total shark catch.

Shark predation on food and game fishes appeared negligible, however, substantial predation on lobsters and octopi seems to be taking place. Of the 657 stomachs examined, 51.7 percent were empty.

The relative abundance of sharks, as measured by the number of sharks caught per unit of gear set, showed a noticeable decline after a year of steady fishing.

From scanty information obtained on the reproductive habits of the sharks, it is hypothesized that the probable gestation periods of both the sand and tiger sharks are about 16 or 17 months, while that of the small black tipped shark is approximately 10 months.

Special deep water sets revealed that the six-gilled sharks (Hexanchus sp.) may be abundant at depths greater than 80 fathoms. Cooke's shark (Echinorhinus sp.) were caught also at these depths.

Objectives:

1). To determine the predatory effects of sharks on reef and inshore fishes.

2). To develop a method of estimating shark abundance.

3). To collect biological information on the sharks.

Techniques Used:

The method utilized in sampling for sharks has been described in the F-5-R-7 Job No. 12 Completion Report. In brief, a complete unit of sharking gear consisted of a specially designed set line, the main line of which measured about one-half mile in length to which 24 hooks were suspended. Details of the sharking gear are illustrated in Figure 1.

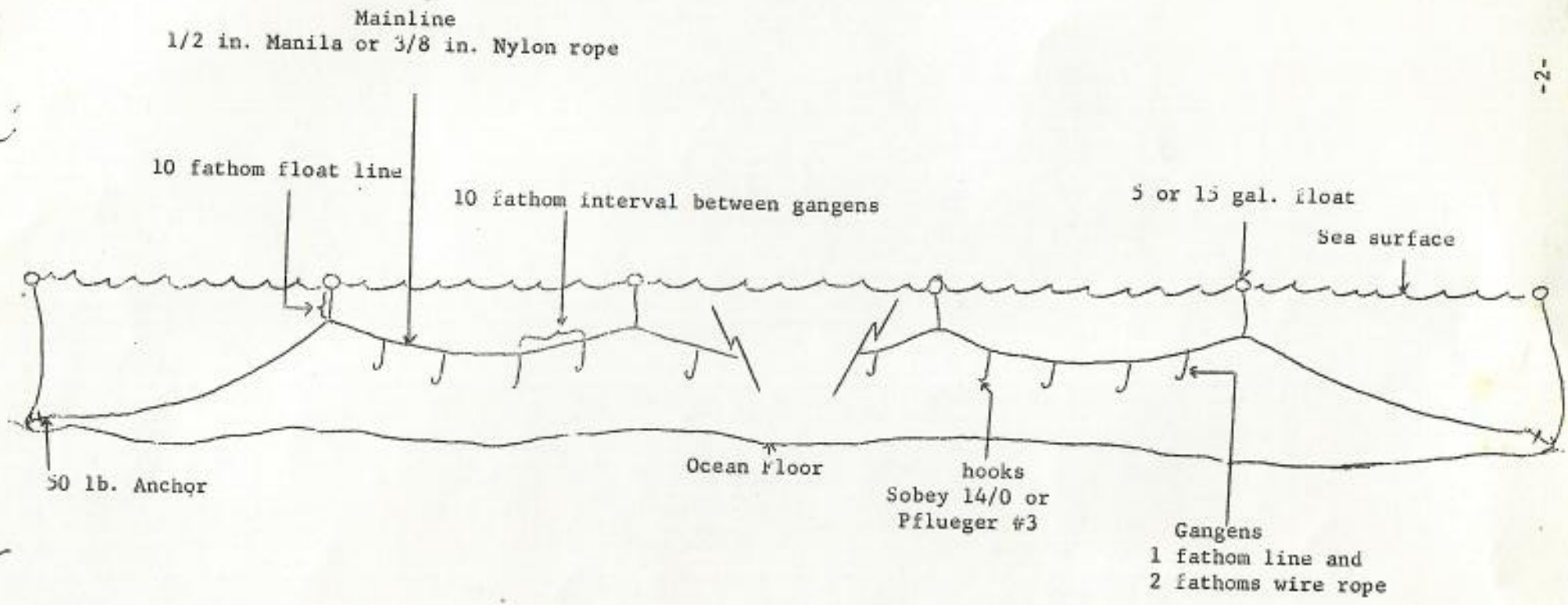


FIGURE 1 - Arrangement Of A Unit Of The 24-hook Shark Gear Showing Anchors, Floats, Mainline and Gangens.

The gear was usually set with the main line parallel to the shoreline. One to three units of the gear were fished during each sharking operation. The hooks were baited with either porpoise flesh or skipjack. A substantial quantity of skipjack bait were obtained without charge from the Honolulu Biological Laboratory of the U. S. Fish and Wildlife Service.

The vessels used to fish for the sharks were the M.V. MAKUA, a 65-foot Army T-49 wood hull cargo boat converted into a research and patrol vessel by the Division of Fish and Game and the HOLOKAHANA I, a 48-foot tuna fishing sampan chartered for the "Billy Weaver Shark Research and Control Program." 1/

The data collected of each captured shark consisted of the following: species identification, sex, length measurements, weights (whenever possible), contents of stomach, and gonadal condition.

Findings:

In order to present a comprehensive report of all information on sharks uncovered to date by this agency, data collected aboard the M.V. MAKUA from June, 1958 to February, 1959 as well as data gathered aboard the HOLOKAHANA I from April, 1959 to March, 1960 are included in this report.

Throughout this paper, the common names of the various species of sharks are used. These names and scientific equivalents are as follows:

Sand shark	Eulamia menisorrah
Tiger shark	Galeocerdo cuvieri
Small black tipped shark	Carcharhinus limbatus
Hammerhead shark	Sphyrna lewini
Mako shark	Isurus glaucus
Great blue shark	Prionace glauca
Great white shark	Carcharodon carcharias
Six-gilled shark	Hexanchus sp.
Cooke's shark	Echinorhinus sp.

There is a possibility that some error may have been committed in properly identifying the sand shark. Some suspicion exists that a species of shark very closely resembling the sand shark but, as yet, not recognized as being taxonomically discrete may have been identified as E. menisorrah. This possible discrepancy came to light just prior to the termination of the shark sampling phase; therefore, it was not possible to resolve or investigate the matter further.

1/ This research and control program was initiated after a teen-aged surfer was fatally attacked by a shark off Lanikai, Oahu. Funds to carry out the program was obtained through public contribution and from the Governor's contingent fund.

Stomach Content Studies

Sand Shark

Of the 469 sand shark stomachs examined, 182 or 39 percent contained ingested material. As shown in Table 1, fish and cephalopods composed the primary food item. Much of the ingested material were in the advanced stages of digestion; thus, it was not possible to identify all of the fish remains even grossly to fish families. Of the 12 fish families identified, it appeared that the eels, goat fish, lizard fish, parrot fish and trigger fish were preyed upon most frequently. Although a few fast swimming fishes were eaten by the sand shark, the bulk of the fish found in the stomachs appeared to be comparatively slow swimmers or bottom living forms which have the habit of remaining motionless at times on the substrate.

Tiger Shark

Unlike the sand shark, a much higher percentage of the tiger shark stomachs contained ingested material for of the 117 stomachs examined, 92 or 79 percent contained food items. Fish, crustacea and cephalopods, in that order, appeared to be the main sustenance of the tiger shark. This shark appears to be an indiscriminate and opportunistic feeder to a greater degree than other selachians examined for some of the ingested materials found in the tiger shark stomachs were birds, turtles, garbage (mammal bones, grapefruit rinds, and vegetables) and trash such as pie plates, pieces of corrugated fibre board cartons, shoes, slippers, etc. Judging from the frequency of shark flesh found in tiger shark stomachs, cannibalism appears to be more pronounced in this species than among the others. In most instances of cannibalism, it appears to have occurred on sharks which were caught on a hook. As with the sand sharks, the majority of live organisms fed upon by the tiger sharks were of the slow swimming or bottom dwelling forms.

Small Black-Tipped Shark

Of the 71 small black-tipped shark stomachs examined, 43 or 61 percent contained food items. Octopi appeared to be the most important dietary item followed by various species of fish. Of the 8 fish family identified from the stomach of the small black-tipped sharks, the eels and a species of surgeon fish were the most commonly occurring forms.

Other Shark Species

The stomachs of most of the other species of sharks were empty. Of the 11 hammerhead shark stomachs examined, 9 were empty while of the remaining two stomachs, one contained an octopus and the other a belonid. In the stomach of the great blue shark an unidentified mammalian bone was found. No ingested material was found in the great white shark stomach and of the 8 six-gilled shark stomachs examined, only one contained the remains of an octopus while the rest were empty. Examination made of one Cooke's shark stomach disclosed the remains of a shark and a badly digested fish.

TABLE 1 - Check-list Of Food Items Found In:
182 Stomachs of Sand Sharks
92 Stomachs of Tiger Sharks
43 Stomachs of Small Black-tipped Sharks

Food Items	SAND SHARK			TIGER SHARK			SMALL BLACK-TIPPED			TOTAL		
	No of Organism	Stomachs containing Food Items		No. of Organism	Stomachs containing Food Items		No. of Organism	Stomachs containing Food Items		No. of Organism	Stomachs containing Food Items	
		No.	%		No.	%		No.	%		No.	%
Crustacea:	(13)	(11)	(2.3)	(37)	(24)	(20.5)				(50)	(35)	(5.3)
Spiny lobster (Panulirus sp.)	3	3	0.6	26	17	14.5				29	20	3.0
Kona Crab (Ranina serrata)	2	2	0.4	4	4	3.4				6	6	0.9
White Crab (Portunus sanguinolentus)	2	2	0.4	1	1	0.9				3	3	0.5
Unidentified Crabs	2	2	0.4	5	4	3.4				7	6	0.9
Crab megalops	2	1	0.2							2	1	0.2
Stomatopods	2	1	0.2							2	1	0.2
Isopods				1	1	0.9				1	1	0.2
Cephalopods:	(73)	(69)	(14.7)	(24)	(23)	(19.7)	(24)	(23)	(32.4)	(121)	(115)	(17.5)
Octopus (Polypus sp.)	68	65	13.9	20	20	17.1	24	23	32.4	112	108	16.4
Squids	3	3	0.6	3	2	1.7				6	5	0.8
Unidentified Cephalopods				1	1	0.9				1	1	0.2
Fish:	(129)	(110)	(23.5)	(62)	(43)	(36.8)	(28)	(21)	(29.6)	(219)	(174)	(26.5)
Parrot fish (Scaridae)	6	6	1.3	1	1	0.9	1	1	1.4	8	8	1.2
Spiny puffers (Diodontidae)	2	2	0.4	2	2	1.7				4	4	0.6
Unidentified puffers	3	3	0.6	20	14	12.0	1	1	1.4	24	18	2.7
White eel (Congridae)	3	3	0.6							3	3	0.5
Moray eel (Muraenidae)				2	1	0.9				2	1	0.2
Unidentified eels	13	13	2.8	4	4	3.4	5	5	7.0	22	22	3.3
Goat fish (Mullidae)	12	12	2.6	3	3	2.6	2	2	2.8	17	17	2.6
Lizard fish (Synodontidae)	12	12	2.6				1	1	1.4	13	13	2.0
Flying fish (Exocoetidae)	2	2	0.4							2	2	0.3
Trigger fish (Balistidae)	6	6	1.3							6	6	0.9
Needle fish (Belonidae)				7	1	0.9				7	1	0.2
Trumpet fish (Aulostomidae)	1	1	0.2	2	2	1.7				3	3	0.5
Big-eyed Scad (Trachurops crumenopthalmus)	1	1	0.2							1	1	0.2
Opelu (Decapterus pinnulatus)	18	4	0.9							18	4	0.6

(Continued)

TABLE 1 (Continued)

	SAND SHARK			TIGER SHARK			SMALL BLACK-TIPPED			TOTAL		
	No. of Organism	Stomachs containing Food Items		No. of Organism	Stomachs containing Food Items		No. of Organism	Stomachs containing Food Items		No. of Organism	Stomachs containing Food Items	
		No.	%		No.	%		No.	%		No.	%
Fish: (Continued)												
Amberjack (Seriola dumerilii)				3	3	2.6				3	3	0.5
Jack (Caranx sp.)				1	1	0.9				1	1	0.2
Bonefish (Albula vulpes)	5	5	1.1	2	2	1.7	1	1	1.4	8	8	1.2
Leatherback (Scamberoides sancti-petri)	1	1	0.2							1	1	0.2
Kala (Naso sp.)	1	1	0.2	1	1	0.9	5	5	7.0	7	7	1.1
Aawa (Bodianus bilunulatus)							1	1	1.4	1	1	0.2
Paleni (Acanthurus dussumieri)				1	1	0.9				1	1	0.2
Scorpion fish (Scorpaenopsis sp.)	1	1	0.2							1	1	0.2
Unidentified fish	40+	40	8.5	13	13	11.1	9	9	12.7	62+	62	9.4
Sting ray (Dasyatidae)	4	4	0.9	2	2	1.7				6	6	0.9
Shark remains		8	1.7		27	23.1		2	2.8		37	5.6
Coral, Shell & Sea weeds		5	1.1		1	0.9					6	0.9
Turtles				10	10	8.5					10	1.5
Birds	3	3	0.6	13	13	11.1				16	16	2.4
Mammal remains		7	1.5		9	7.7					16	2.4
Garbage		14	3.0		11	9.4		1	1.4		26	4.0
Coconut leaf				2	2	1.7					2	0.3
TOTALS:												
Number of stomachs containing food items		182	38.8		92	78.6		43	60.6		317	48.2
Number of empty stomachs		287	61.2		25	21.4		28	39.4		340	51.7
NUMBER OF STOMACHS EXAMINED		469			117			71			657	

From the above data it appears that total shark predation on the reef and inshore food and game fishes is of minor consequence. However, predation on octopi and spiney lobsters which are important resources from the commercial as well as recreational standpoints may be substantial in nature. The octopus appears to be one of the most common food items of nearly all of the sharks examined and the spiney lobsters appear to be frequently ingested by the tiger sharks.

Effects Of Fishing Pressure On the Population Of Sharks

During the one year that the HOLOKAHANA I was chartered to conduct sharking operations, the vessel was able to complete four fishing circuits around the island of Oahu. In terms of number of sharks caught per unit of gear set, the availability of sharks showed a marked decrease with the completion of each circuit. This decline in catch is shown in Table 2. The results obtained strongly indicate that species of sharks such as the sand, tiger and small black-tipped sharks are highly vulnerable to continued fishing pressure and that their population can be controlled through the application of judicious fishing pressure.

TABLE 2

Effects Of Continued Fishing Pressure On Shark Availability

Fishing Period	No. of Units Set	SHARK CATCH: Sand		Tiger		Small-black tipped		Others		Total	
		No.	Catch/Unit	No.	Catch/Unit	No.	Catch/Unit	No.	Catch/Unit	No.	Catch/Unit
First Circuit (5/18/59 to 8/14/59)	82	168	2.05	33	0.40	15	0.18	3	0.04	219	2.67
Second Circuit (8/19/59 to 10/25/59)	113 2/3	112	0.99	29	0.26	34	0.30	3	0.03	178	1.57
Third Circuit (10/26/59 to 2/4/60)	108	77	0.71	11	0.10	13	0.12	6	0.06	107	0.99
Fourth Circuit (2/5/60 to 3/22/60)	96	38	0.40	9	0.09	8	0.08	3	0.03	58	0.60
Total		395		82		70		15		562	

Miscellaneous Observations

The species composition in terms of number and percentage of the total shark catch made during the course of this investigation and the size ranges in total length of the sharks were as follows:

Species	Number	Percentage	Size Range
sand shark	564	68.4%	3'3" - 9'10½"
tiger shark	140	17.0%	4'0" - 14'8"
Small black-tipped	82	10.0%	4'6" - 7'8"
hammerhead shark	18	2.2%	1'10" - 10'6"
six-gilled shark	11	1.3%	9'5" - 10'10"
great white shark	3	0.4%	10'10" - 11'5"
Cooke's shark	3	0.4%	7'5" - 10'10"
great blue shark	1	0.1%	7'6"
mako shark	1	0.1%	11'8"
unidentified shark	1	0.1%	

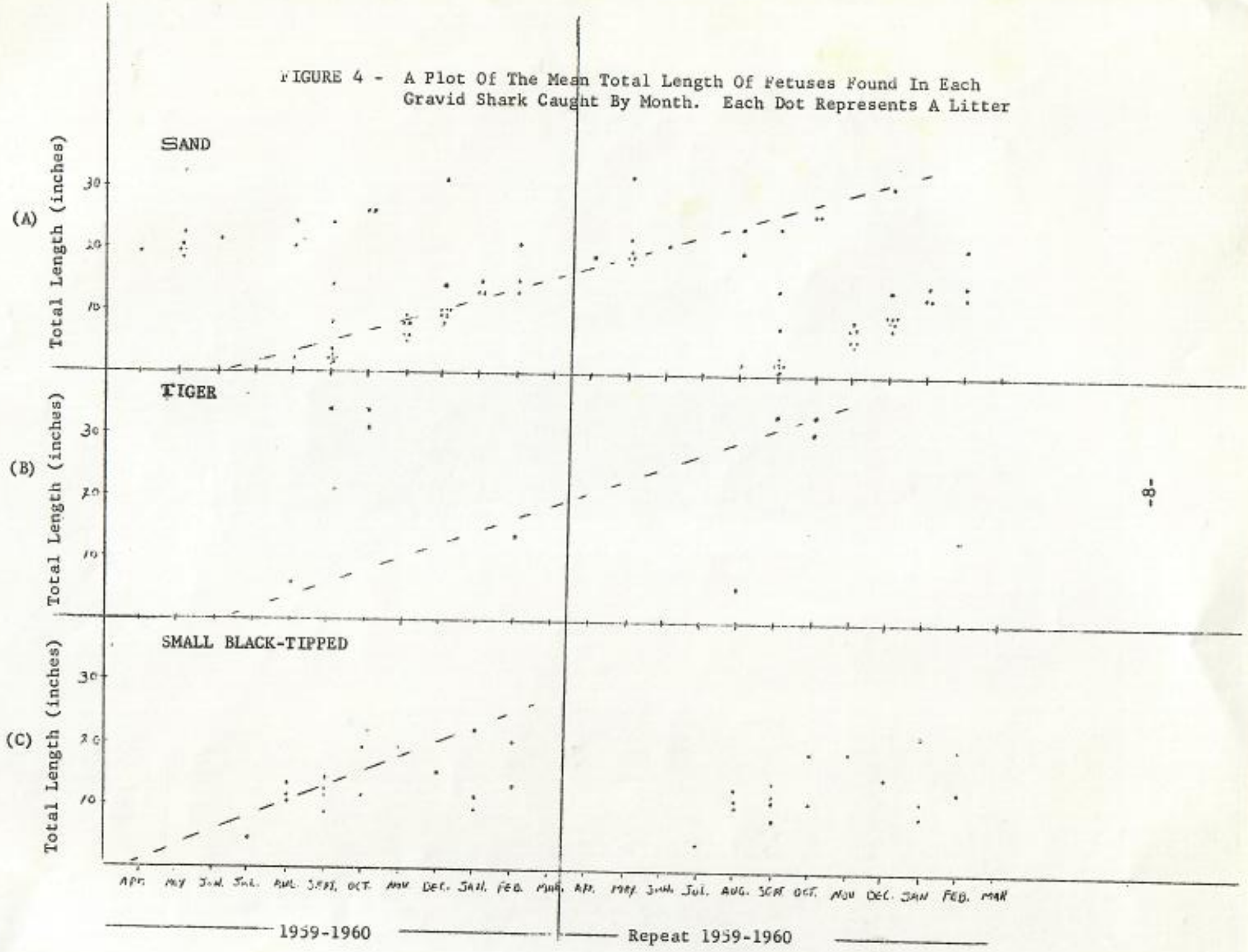
Over the two years of shark fishing, the number of gravid females captured amounted to only 58 sand sharks, 7 tiger sharks and 17 small black-tipped sharks.

The smallest gravid sand shark measured five feet and the largest was 9 feet 3 inches in total length. The 58 females carried a total of 348 fetuses, with a mean number per gravid female of six. The smallest fetus measured one inch and the largest was 32 inches in length. The five feet female carried only three fetuses while the 9 feet 3 inch female carried eight. An 8 feet 2 inch female was found with only two fetuses, the smallest number observed for the sand shark. The greatest number of fetus found was nine. These were observed from individuals ranging in size from 5 feet 6½ inches to 8 feet 7 inches in total length.

To determine the approximate gestation period, the mean total lengths of 43 litters of sand sharks were plotted by months in Figure 4-A. Examination of the distribution of the "points" shows that there are two separate "populations" of mean fetus sizes. Fetuses were found throughout the year but the one and two inch size fetus appear in August and September only. During the same months, females with fetuses as large as 24 inches in total length are found. The manner in which the points fall on the graph indicate the existence of a regression line. By fitting in the best straight line by eye, the line intersects the base line or point of origin in June. Thus, it is surmised that June is the midpoint of the mating season. The embryos then keep developing until they reach a total length of approximately 31 inches by late fall or early winter. Using November as the midpoint of the termination of the gestation period, it is hypothesized that the total gestation cycle takes 17 months. A litter, each with mean length of 32 and 14 inches were found in May and September, respectively. It is believed that these were aberrant samples and as mentioned earlier, due to possible error made in species identification.

The smallest gravid tiger shark caught measured 9 feet 2 inches and the largest 14 feet 1 inch. The range in the number of fetus found was 9 to 57. These 7 females contained a total of 202 fetuses. One female caught was observed giving birth to pups after she was tied to the bow of the vessel. Ten pups were still in the uterus when cut open, and 6 were observed following the vessel. These were netted, measured, tagged and released. Others which may not have been seen may have been expelled by

FIGURE 4 - A Plot Of The Mean Total Length Of Fetuses Found In Each Gravid Shark Caught By Month. Each Dot Represents A Litter



the female. These pups measured 32 to 35 inches in total length and appeared to be full term pups. Not including the female which gave birth to the pups, the mean number per litter of the other 6 females is 31 fetuses. The smallest gravid female (9 feet 2 inches) carried the least number of fetuses (9), while a 13 feet 8 inch female carried the largest number of pups (57).

Although only 5 mean total lengths of litters of tiger sharks are available, these were plotted in figure 4-B because of the present dearth of information available on the reproductive habits of the tiger shark. Following the same procedure utilized for the sand shark, the "best line" fit in the tiger shark intersects the base line in June. This coincides very closely with field observation for a female with what appeared to be ripe eggs in both uteri was observed in June. In addition, two females with near-term pups were observed in October and, thus, taking October as the midpoint of the pupping season, it is hypothesized that the gestation period for the tiger shark is approximately 16 months.

The smallest gravid small black-tipped shark measured 5 feet, 8 inches and the largest was 7 feet, 8 inches in total length. The range in the number of fetuses was from 3 to 7 per litter. The mean number per litter was 5.2 fetuses per gravid female. The female bearing the 3 embryo litter measured 6 feet 4 inches and that bearing the 7 embryo litter measured 7 feet 1 inch.

As shown in Figure 4-C, the mean total length plots of each litter does not appear to be distributed into 2 separate groups as does the plots for the sand or the tiger shark. The best straight line drawn by eye intersects the base line in April which is assumed to be the midpoint of the mating season. Fetus of about 23 inch size examined in February possessed all the attributes of near-term pups. Therefore, if February is assumed to be the midpoint of the pupping season, the gestation period of the small black-tipped shark is estimated at approximately 10 months.

Special sets of the shark line were attempted during the course of the shark sampling period primarily to determine the vertical distribution of the sand, tiger, and small black-tipped shark and secondarily for exploratory purposes. Lines were successfully set at 7, 16 and 27 fathom depths, but great difficulty was encountered in setting the lines on the bottom at the 50, 67 and 82 fathom depths. This was due to the acute slope of the bottom which rapidly angled down from about the 50 fathom depth. Two successful sets in which hooks were fishing at depths ranging from approximately 60 fathoms to 175 fathoms were completed. The one set attempted where the hooks were fishing on the bottom in depth ranging from 250 to 300 fathoms was lost due to the mainline fouling on the substrate.

Results indicate that the optimum depth of fishing for the sand, tiger and small black-tipped sharks is approximately at 27 fathoms. Due to difficulty in retrieving the gear and having lost parts of the set, the results from the 50, 67 and 82 fathom depths were not conclusive; however, judging from the partial results, it appears unlikely that catches from the deeper sets would produce results surpassing catches from the 27 fathom depth.

The results of the two successful deep water sets indicate that six-gilled and Cooke's shark may be abundant in depths greater than 80 fathoms. One six-gilled shark, a deep water sting ray and a gravid Cooke's shark were sent to Dr. Schultz of the U. S. National Museum, Smithsonian Institute, for further identification and also for preservation. One of the gravid Cooke's shark contained a total of 114 pups of approximately 24 inches in total length.

RECOMMENDATIONS:

The primary objective of this study was the determination of the predatory effects of sharks on reef and inshore fishes. Since much of the desired information was obtained, it is recommended that this job be terminated.

Prepared by Isaac I. Ikehara
ISAAC I. IKEHARA
Aquatic Biologist

Approved by Kenji Ego
KENJI EGO, Chief
Bureau of Fisheries

Date October 31, 1960

Approved by Michio Takata
MICHIO TAKATA, Director
Division of Fish and Game

11/4/60
cy

copy/correspondence from OI folder of Tester Shark program

THE OCEANIC FOUNDATION

March 15, 1967

Mr. Laurance S. Rockefeller
Room 5600
30 Rockefeller Plaza
New York, New York 10020

Dear Mr. Rockefeller:

Thank you very much for your letter of March 7 endorsing our Shark Study Program for 1967 and for the $24,000 in securities to support this work. The securities have been turned over to our Business Manager, Mr. William Potter, who informs me that he signed and returned to Mr. Raymond H. Wilkens the copy of the letter certifying the receipt of the securities.

I was on the U. S. mainland at the time your letter and the securities arrived. Because my return to Honolulu was so imminent, it was agreed that this letter of acknowledgment and thanks would be written on this, my first day back at the office.

The first fishing period off Kawaihae will begin on Monday, March 20th. Further Kawaihae fishing will take place in approximately June, September, and December. As ship time is scheduled, I will keep your office informed. If it should happen that you are in the islands at an appropriate time, we would be very happy to have you go along on one of the morning collection trips--I think you might find it most interesting.

With best regards and many thanks for your continued interest and support.

Yours sincerely,

JRH

John R. Hendrickson
Director

JRH/aml
CC: T. A. Pryor
W. E. Potter
R. H. Wilkens
BCC: Dr. Al Tester

Dear Al: This will establish the fact that we are now fully operative for our part of this project. All that remains is to arrange for the actual transfer of funds. When can we get together? J.R.H.

THE OCEANIC FOUNDATION

SEA LIFE PARK | OCEANIC INSTITUTE | MAKAI RANGE

June 30, 1967

MEMO TO: Dr. Albert L. Tester
University of Hawaii

FROM: John R. Hendrickson
Director, Oceanic Institute JRH

SUBJECT: CETACEAN FLESH

I have written to Japan, inquiring about the possibility of purchasing frozen porpoise flesh for shark bait. I have had no answer as yet.

In the 1965-66 Market News Service Summary of California Fisheries I note that a stock of 1,800,000 pounds of frozen whale meat has a valuation of $144,000 (8¢ per pound). The publication mentioned, authored by L. A. Keilman, Room 205, Post Office Building, San Pedro, California, 90731, is a Bureau of Commercial Fisheries publication. If you wanted to explore this further, I should think that our local Bureau of Commercial Fisheries people could be of some assistance.

JRH/aml

MAKAPUU POINT · WAIMANALO · OAHU · HAWAII 96795
CABLE: OCEANFOUND · TELEX: MAKAI 7430188 · PHONE: HONOLULU 257-951

August 25, 1967

Dr. John Hendrickson
The Oceanic Institute
Makapuu Point, Waimanalo
Oahu, Hawaii 96795

Dear John:

As agreed at our staff meeting of the Cooperative Shark Research and Control Program, August 25, 1967, we accept your offer to serve as our agent in procuring 200 lbs. of porpoise meat and 200 pounds of whale meat, in 3 x 3 x 3 inch pieces, from your contacts in Japan. The bait will be used in experimental fishing for sharks.

If it is consigned to us, we will arrange for pick-up when it arrives.

We understand the cost, including freight, will be about 0.25¢ per pound, or a total cost of about $100.00. We can reimburse you for this cost when O.I. contributed funds are transferred to the University.

Thank you for this service to our cooperative project.

Sincerely yours,

A. L. Tester
Senior Professor of Zoology

cc: Bill Coops, Research Corporation

ALT/cja

October 25, 1967

Mr. Teruo Tobayama
Ito Aquarium
Yukawa, Ito City
Shizuoka-Pref., Japan

Dear Mr. Tobayama:

Thank you very much for your good letter of October 20th. I sincerely appreciate your doing us the favor of investigating supplies of porpoise and whale meat. At the next meeting of our Shark Committee, I shall tell them that the shipping costs for 200 pounds of meat would be the same as for one ton of meat. I cannot say at this point whether the Committee will agree to allocate the necessary extra money or not. As soon as I have any definite information for you, I shall write to you again. In the meantime, let us simply postpone any further action.

Let me say again how much I appreciate your excellent help in this matter. I hope it will eventually be possible to find some way to go ahead with our plans for test fishing using porpoise and whale meat. With best regards and many thanks,

Yours sincerely,

JRH

John R. Hendrickson
Director

JRH/aml
CC: Dr. A. L. Tester

— the ref. to "Committee" all the time is a deliberate ploy useful in such a case as this. A.L.

Al -- What do you want to do now? J.R.H.

October 17, 1969

Dr. Kenneth Norris, Director
The Oceanic Institute
Makapuu Pt., Waimanalo,
Oahu, Hawaii 96795

Dear Ken:

As promised to Steve Keil yesterday, enclosed is a draft copy of the "final" report on the Cooperative Shark Research and Control Program 1967-69. It is complete except for two figures (photographs) and three tables (data forms). Your critical review with comments and suggestions will be welcome.

The Oceanic Institute's contribution to the program was to be publically one of general support to avoid undue publicity about Kawaihae fishing. Hence I have not attempted to isolate any research directly attributable to O.I. funds. Specifically, by agreement we were to undertake 8 trips (3-4 fishing days each) to Kawaihae and the adjacent Kona coast and 8 trips to Niihau (3-4 fishing days each). Our first trip to Kona should have been made in March, 1967, to maintain the continuity of fishing started on a quarterly basis by O.I. in January, 1966. Since our ship could not be chartered until June, 1967, the trip was made, as in previous trips, by the Imua, and the cost was deducted from our grant. The agreement with Dr. Hendrickson was that he should participate in the planning of the Kona and Niihau trips, accompany the trips when possible and have access to all resulting data so that he could prepare reports and further proposals to Mr. Rockerfeller. In reciprocation, I have received reports from Dr. Randall regarding the earlier O.I. fishing in 1966, and copies of Dr. Hendrickson's reports and proposals to Mr. Rockerfeller (marked confidential). I have not received any data on the March, 1967, the Makua, paid for out of our grant, but don't really need these data.

We had sort of a gentlemen's agreement that joint publications might arise from the Kona and Niihau work.

In the meantime the history of the Kawaihae fishing is of considerable interest to Mr. Rockerfeller, to Dr. Hendrickson, to me and to the general public as an excellent example of control of shark abundance. Hence, I would like your permission to include the discussion of the Kawaihae fishing history, based on earlier data collected by O.I. and later data collected during our joint venture. Only the latter data are presented in the detailed tables. I refer to the footnote on p. 26 and Fig. 11, p. 28, Dr. Hendrickson approved a general discussion of the situation in our report for 1967-68 (p. 9), a copy of which is enclosed. Of course, the results would not be formally published without collaboration with Dr. Hendrickson, Dr. Randall or someone else whom O.I. might disignate as

having proprietary rights to the early data. Our joint data are made available to all in Table 19 (p. A-23).

The Niihau-Kauai fishing was successful in catching and tagging only 14 viable tigers (in which Dr. Hendrickson was particularly interested) at Niihau and 9 tigers off Kauai (Table 20). Of these, two were recovered from the same area of tagging at Niihau and none were recovered off Kauai (Table 21). Of course the Niihau-Kauai trips did provide much valuable information other than that related to the tagging of large sharks, including bait preference tests, in which Dr. Hendrickson was particularly interested, depth distribution studies and life history studies of all species, but particularly the gray reef shark.

The contract with Alika Cooper to fish on a daily basis for sharks at Kawaihae was strictly on a Hendrickson-Cooper basis, although I was consulted and gave advice on the design of the experiment and the simplified data forms which were to be completed and submitted periodically to O. I. As I indicated to Steve, I would be happy to assist in any way with analysis of these data, if you have them.

I will also be available to meet with you at some mutually agreed time for any discussions you may wish about the contents of this letter, your Rockerfeller report, etc.

Sincerely yours,

Albert L. Tester
Senior Professor of Zoology

ALT/cja

OCEANIC INSTITUTE

November 19, 1969

Dr. Albert L. Tester
Senior Professor of Zoology
University of Hawaii
Department of Zoology
Honolulu, Hawaii

Dear Al:

Thanks for the copy of your report. I have asked my secretary to send you a copy of our confidential report to the Rockefeller interests, specifically concerning the Mauna Kea-Kawaihae project. Renewal was applied for but a decision has been postponed for a year because of funding problems.

In general, your publication plans seem okay as to authorship. If we have done any major part of the work, I would like to attach an OI contribution number and order 1500 copies. The Kawaihae results must remain confidential until we have a written release from Rockefeller's office. They, rightly, consider this proprietary information and may not wish to release it because of public relation problems. I'll inquire.

Sincerely,

Kenneth S. Norris
Director

KSN/emr

Nov. 26, 1969 - Phone call from Steve Kid says he had looked to NY Rockefeller people and it was OK to publish the memos reserv as written (there is no reference to Rockefeller & no reference to the hotel) - Art.

MAKAPUU OCEANIC CENTER · MAKAPUU POINT · WAIMANALO · HAWAII 96795
CABLE: OCEANFOUND · TELEX: MAKAI 7430188 · PHONE: HONOLULU 259-7951

(from Test Shark data cartons

February 16, 1960

Cruise Plan No. 30 - Holokahana I

The Holokahana I will depart Pier 17 at 1000 hours on Tuesday, February 16, 1960, to continue the fourth circuit of routine shark fishing around Oahu.

The first day's fishing will be conducted in the Makua-Kaena Point Area. On subsequent days the gear will be fished as follows: February 17 - Kaena Point; February 18 - Kaena Point - Kawaihapai; February 19 - Kawaihapai - Mokuleia; February 20 - Waialee - Kahuku Point; February 21 - Waimea-Waialee; February 22 - Kawailoa-Waimea; February 23 - Mokuleia-Kawailoa; February 24 - Diamond Head-Ala Moana.

Whenever possible, porpoise will be harpooned and used as shark bait. In the event that porpoise flesh are used, the hooks will be alternately baited with porpoise and aku flesh.

Small and lively sharks caught will be tagged, measured and released.

ETA Pier 17 will be 1200 hours, February 25, 1960.

The Field Party Chief will make every effort to contact a Bureau personnel by telephone at least once a day during the cruise.

Field Party Chief: F. J. Inouye

Personnel assigned to vessel: Captain - F. J. Inouye
Crewmen - J. Johnson, S. Kaaihue, J. Costa

MICHIO TAKATA, Director
Division of Fish and Game

MT/II:dla
cc: W. L. Collins, Dr. Tester,
V. E. Brock, Kewalo office,
K. Ego and Bureau of Patrol

WILLIAM F. QUINN
Governor

ADMINISTRATION
FORESTRY
PARKS

ENTOMOLOGY AND MARKETING
ANIMAL INDUSTRY
FISH AND GAME

TERRITORY OF HAWAII

BOARD OF COMMISSIONERS OF AGRICULTURE AND FORESTRY

C. ERIC REPPUN, President
RICHARD H. TOYOSHIBA, Executive Secretary

Division of Fish and Game
MICHIO TAKATA, Director

HONOLULU 14, HAWAII

May 14, 1959

Cruise Plan No. 5, HOLOKAHANA I

The HOLOKAHANA I will catch night bait in Honolulu Harbor the morning of May 14, 1959 and depart Honolulu Harbor at 0600. The objective of this cruise is to hunt for porpoise and aku which are to be used as bait for the coming shark fishing trip. The scouting areas will be from Diamond Head to Waianae. Estimated time of return to Pier 17 will be May 14, 1959 at 1700.

Field Party Chief:

Fred J. Inouye, Captain

Personnel Assigned to Vessel:

Ship's Crew: Fred J. Inouye, Captain and Crew men Katsumi Munitake, Herbert Lenchanko, James Kubota and Charles White.

Fish and Game Personnel: Fred J. Inouye will represent the Division of Fish and Game

MICHIO TAKATA, Director
Division of Fish and Game

KE/MT:nz
cc: C.E.Reppun
Dr. Tester
V.E.Brock
Bureau of Patrol
Kewalo Basin

WILLIAM F. QUINN
Governor

ENTOMOLOGY AND MARKETING
FORESTRY

ANIMAL INDUSTRY
FISH AND GAME

STATE OF HAWAII

DEPARTMENT OF AGRICULTURE AND CONSERVATION

HONOLULU 14, HAWAII

February 26, 1960

Cruise Plan No. 31 - Holokahana I

The Holokahana I will depart Pier 17 at 1200 hours on Tuesday, March 1, 1960, to continue the fourth circuit of routine shark fishing on the Windward side of Oahu.

The three sections of shark gear will be fished each evening as follows: March 1 - Ka oio Point to Kapapa Island; March 2 - Kahuku Point to Laie Point; March 3 - Laie Point to Punaluu; March 4 - Punaluu to Ka oio Point; March 5 - Northwest Kaneohe Bay; March 6 - Southwest Kaneohe Bay; March 7 - Mokumanu Island to Mokulua Island; March 8 - Mokulua Island to Rabbit Island; March 9 - Mokapuu Point to Hanauma Bay.

Whenever possible, porpoise will be harpooned and used as shark bait. In the event that porpoise flesh are used, the hooks will be alternately baited with aku and porpoise flesh.

ETA Pier 17 will be 1600 hours on Friday, March 11, 1960.

The Field Party Chief will make every effort to contact a Bureau personnel by telephone at least once a day during the cruise.

Field Party Chief: F. J. Inouye

Personnel assigned to vessel: Captain - F. J. Inouye
Crewmen - J. Johnson, S. Kaaihue, J. Costa

MICHIO TAKATA, Director
Division of Fish and Game

MT/II:dla
cc: W. L. Collins, Dr. Tester,
V. E. Brock, Kewalo office,
K. Ego and Bureau of Patrol

Leighton - East Is, FFS 1945
I.D. please - ? Mahalo - George Balazs

Well, he's not
Vic Fanfman
That's for sure.

Homo sapiens ♂ adult
subspecies melange (hawaiiensis x philippensis x? moderae)

probably Carcharhinus galapagensis based on trailing margin of D1 (almost vertical) and long P1 -

other (less likely) possibility C. limbatus.

need to see teeth to be about certain (p ≤ .05)

8:1 C. galap

Moku-o-hua. Gulch, Ka-malō qd., south Moloka'i.

Moku-o-Kaha'ilani. Rock island (0.9 acres, 40 feet elevation), Ho'ōpū-loa qd., Hawai'i. *Lit.*, island of Kaha'ilani (a chief).

Moku-o-Kau. Islet (0.18 acres, 40 feet elevation), Ha'i-kū qd., Maui.

Moku-ola. Old name for Coconut Island, Hilo Bay, Hawai'i. *Lit.*, healing island. (People came here for spring water believed to have healing qualities; umbilical cords of infants were hidden here under a flat stone known as Papa-a-Hina [stratum of Hina] to protect them from rats. In another explanation, Moku-ola was a son of 'Ulu; see Wai-ākea. A sea pool to the right of the landing on the island was called Pua'a-kāheka; see Kaula'i-nā-iwi; Appendix 8.1 for a saying; li 171.)

Moku-o-Lo'e. Old name for Coconut Island, Kāne-'ohe Bay, O'ahu. *Lit.*, island of Lo'e (Kahoe's sister who is said to have lived on the island; see Pu'u-ke-ahi-a-Kahoe).

Moku-one. Valley, Wai-mea district, Kaua'i. Street, Hawai'i-kai, Honolulu. *Lit.*, sand island.

Moku-'opihi. See 'Opihi.

Moku-pala. Islet (0.18 acres, 40 feet elevation), Ki-pahulu qd., Maui. *Lit.*, rotten island (probably referring to *limu*).

Moku-papa. Gulch and point, Ha'i-kū qd., Maui. *Lit.*, flat island.

Moku-papapa. Islet (0.72 acres, 50 feet elevation), Hālawa qd., Moloka'i. On her first journey from Kahiki, Pele left her brother, Kānemilo-hai, there to build up land (PH X). *Lit.*, flat island.

Moku-pe'a. Gulch, Honolua qd., Maui. *Lit.*, cross district.

Moku-pipi. Islet (1.08 acres, 80 feet elevation), Hāna qd., Maui. *Lit.*, pearl oyster island.

Moku-puku. Islet (1.50 acres, 40 feet elevation), Wai-pi'o qd., Hawai'i. *Lit.*, contracted island.

Moku-pūpū. Point, East Maui. *Lit.*, shell island.

Moku-'ume'ume. Old name for Ford Island, Pearl Harbor, O'ahu. Water was brought for melons raised here. *Lit.*, *'ume* game island (famous for this sexual game).

Mōlehu. Land area, southeast Kaua'i. Drive, Foster Village subdivision, Hālawa, O'ahu. Name suggested by Mary Kawena Pukui in 1956. *Lit.*, twilight.

Moleka. Stream, Makiki, Honolulu.

Mō-li'i. Fishpond, Haki-pu'u, O'ahu. *Lit.*, small section (*mō-* is short for *moku*, section).

Mōli-lele. Cliff inland of Wai-o-'Ahukini, Hawai'i. *Lit.*, leaping albatross.

Molo-a'a. Land division, bay, volcanic cone, stream, and forest reserve, Hanalei and Ka-wai-hau districts, northeast Kaua'i. *Lit.*, matted roots (said to be of the paper mulberry growing here).

Moloka'i. Island, 38 miles long, 10 miles wide, 261 square miles in area, and having a 1970 population of 5,261. District, forest reserve, lighthouse, high school, airport, and hospital. Poetic names are *Moloka'i nui a Hina* (great Moloka'i, child of Hina) and *Moloka'i pule o'o* (Moloka'i, powerful prayer). In legends Hina was the mother of Moloka'i. The island was noted for sorcery and sports. (Elbert and Mahoe 78–79.)

Moloka'i-nui-a-Hina. Gulch, Hālawa qd., south Moloka'i. See Ke-ana-o-Hina. *Lit.*, great Moloka'i, [child] of Hina.

Molo-kini. Islet (150 feet elevation) between Ka-ho'olawe and Maui. When Lohi'au (Pele's dream lover) lived at Mā'alaea, Maui, he took to wife a *mo'o*, Pu'u-o-inaina (hill of wrath). Pele in anger bisected her; her tail became Pu'u-ō-la'i Hill, Mākena, Maui, and her head Molo-kini Islet. see Pu'u-ō-la'i. (For. 5:514–521; HM 189; PH 75.) *Lit.*, many ties.

Mololani. Crater, Mō-kapu peninsula, O'ahu. Here, the god Kāne drew a figure of the first man on the earth, and Kū and Lono caught a spirit of the air and made the drawing live. Kāne tore a woman from the man's side. (HM 47–48; for a song, see Elbert and Mahoe 61.) *Lit.*, well cared for; also the name of a rain.

***Momoualoa.** Land division and gulch, Wai-pi'o qd., Hawai'i. (For. Sel. 190.)

Mona. Street, 'Āina-Haina, Honolulu, named for Mona Hind Holmes, daughter of Senator Robert Hind. (TM.)

Monsarrat. Avenue near the Diamond Head end of Wai-kiki, probably named for Marcus Cumming Monsarrat, who came to Hawai'i from Ireland and Canada in 1850 and was at one time collector of customs. He died in 1871. His wife was Elizabeth Dowsett. The avenue may have been named for his son, Judge James Melville Monsarrat (1854–1943), a legal adviser of Hawaiian monarchs.

Montague Hall. Music school building, Puna-hou School, Honolulu, built in 1937, donated by the Atherton family in memory of Juliette Montague Cooke and her daughter, Juliette Montague Cooke Atherton. Both were interested in music.

Monte. Street, Ka-lihi Uka, Honolulu, leading to a small Catholic church where a statue of the Portuguese Lady of the Mount stands in a grotto. *Lit.*, mountain (a Portuguese loanword).

Monte Cooke. Place near the Bishop Museum named for Dr. Charles Montague Cooke, Jr., who was a trustee of the museum 1929–1948, president of the board of trustees 1941–1948, and curator of malacology 1946–1948.

Monterey. Drive and place, Wilhelmina Rise, Honolulu, named for a Matson steamer. (TM.)

Mo'oheau. Park, Hilo waterfront, Hawai'i, named for Chief Ka-'ai-'awa'awa-i-Mo'oheau (the bitter food of Mo'oheau), the son of Ho'olulu, who is said to have hidden Ka-mehameha's bones. Avenue, Ka-pahulu section, Honolulu, named by Auhea Crowningburg, through whose land the street ran, for Chief Mo'oheau, an ancestor. (TM.)

Mo'o-helāia. Unknown place, famous in chants, said to be near the summit of Mauna Loa, Moloka'i. *Noho ana Laka i ke'a uluwehiwehi, kū ana i luna i Mo'o-helāia, 'ōhi'a kū i luna o Mauna Loa* (UL 33). Laka lives in the verdure, stands at Mo'o-helāia, *'ohi'a* trees stand on Mauna Loa.

Mo'o-kapu-o-Hāloa. Main ridge of Kāne-hoa-lani at Kua-loa, O'ahu. *Lit.*, sacred section of Hā-loa (a son of Wā-kea, the first man).

Mo'o-kini. *Heiau*, Kohala qd., Hawai'i, attributed to Pā'ao, a priest from Tahiti. In building the *heiau*, stones were passed hand to hand

for 9 miles from the seacoast. Stones near here were called Pā'ao's canoe, paddles, and fishhooks, and the fields he cultivated were called *nā mau'u o Pā'ao* (Pā'ao's grasses) and left untouched for fear of storms. (HM 370–371.) A stone east of the *heiau* was called Pōhaku-holehole-kānaka (stone [for] stripping human [flesh]). The flesh was removed from human sacrificial victims and the bones were made into fishhooks and other objects. Pahu-kini *heiau* at Kai-lua, O'ahu, was also called Mo'o-kini. *Lit.*, many *mo'o or* many lineages.

M

Mo'o-loa. Land section and falls, Ka-malō qd., south Moloka'i. *Lit.*, long lizard *or* long ridge.

Mo'o-moku. Land division, Lahaina qd., Maui. *Lit.*, severed ridge.

Mo'omomi. Beach and land area, Airport qd., Moloka'i.

Mo'o-muku. Place, Kuli-'ou'ou, Honolulu. (TM.) *Lit.*, cut-off land section.

Moore Hall. Building, Mānoa campus, University of Hawai'i, Honolulu, completed in 1969 and named for Charles Moore (1901–1967), professor of philosophy.

Mōpua. Village, Olowalu qd., Maui. *Lit.*, melodious (said to be the name of a legendary character).

Moreira. Street, Papa-kōlea, Honolulu, named for Benjamin Moreira, who built the first house on this street. (TM.)

Mormon Temple. The Church of Jesus Christ of Latter-day Saints was established in Lā-'ie, O'ahu in 1850; in 1920 the temple was dedicated—the first ever built outside Salt Lake City.

Morris. Lane, Ka-pā-lama section, Honolulu, named for a part-Hawaiian carpenter family who in 1890 owned property there. (TM.)

Mother Waldron. Park, Kaka'ako, Honolulu, named for Mrs. Margaret Waldron (1873–1939), teacher at Pohukaina School, and founder and director of the playground for 24 years.

Mott-Smith. Drive, Makiki, Honolulu, named for E.A. Mott-Smith, a lawyer who was a trustee of the Lunalilo Estate in 1926 when the Luna-lilo Home was moved from Makiki to Mauna-lua. (TM.)

Mott-Smith Building. Brick structure, downtown Honolulu, constructed in 1897 and named for Dr. John Mott-Smith, Honolulu dentist.

Mount Ball. See Pa'upa'u.

Mount Olympus. Mountain, Ko'olau Range between Mānoa Valley and Wai-mānalo, O'ahu. See Tantalus.

Mountain View. Village and elementary school, Hilo qd., Hawai'i, named for the Mountain View House, built in 1891 as a half-way house stop on the way to the volcano from Hilo (Olson 75). See Mauna-hu'ihu'i.

Muliwai. Land section and land division, Wai-pi'o qd., Hawai'i. Land section, Kau-pō qd., Maui. Lane, downtown Honolulu, named for Nu'u-anu Stream (TM). *Lit.*, river.

Muliwai-'ōlena. Stream, Wai-mānalo, O'ahu. *Lit.*, turmeric river *or* yellow river.

Mu'o-lau-lani. Site of the Queen Lili'u-o-ka-lani Children's Center, Ka-pā-lama section, Honolulu. Lili'u-o-ka-lani had a home here. *Lit.*, innumerable royal buds.

Mū'olea. Point, village, and land section, Kī-pahulu qd., Maui. See PE, *lima-make-o-Hāna.*

Murray. Drive, Ālia-manu, Honolulu, named for a military officer. (TM.)

M

SEA GRANT

UNIVERSITY OF HAWAII

ONO HAWAIIAN
SHARK RECIPES

Alvin Tachibana, editor

UNIHI-SEAGRANT-AB-77-03
May 1977

University of Hawaii
Sea Grant College Program
Marine Advisory Program

A NOTE FROM THE EDITOR

These recipes reflect many ethnic cooking styles which are popular in Hawaii today. They capture the cooking versatility of shark meat and demonstrate how its texture and taste can be varied in innummerable ways to suit the individual.

We hope that you will not only try out these recipes, but also experiment using shark in your own recipes. By doing so, you will not only have a nutritious fish on your table but also fewer sharks in the ocean. How can you lose?

Alvin Tachibana, Editor

ONO HAWAIIAN SHARK RECIPES

Alvin Tachibana, editor

Sea Grant Advisory Brochure
UNIHI-SEAGRANT-AB-77-01

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RECIPES

THIS "NEW" FOOD ITEM CALLED SHARK

In Hawaii shark meat was an overlooked and underrated protein source until recently. More and more island people are now discovering this "new" local food item. Of course, there is nothing new about eating shark. Centuries, ago, people in the Orient, Europe, Africa, Mexico, and Polynesia were consuming this seafood. In Japan, Great Britain, and Australia, shark meat was and still is a favorite item. It is even the main ingredient in "fish and chips" dishes served along the mainland seaboard.

Mano (Hawaiian for shark) has an interesting history. It was the family *aumakua*, or personal god and guardian, for some ancient Hawaiian fishermen. Eating shark was *kapu* (forbidden) to them and their families. For other people, however, eating this fish was acceptable.

Today, shark gods and goddesses exist mostly in Hawaiian legends, but some people still believe in them.

Shark meat was one of the ingredients used to make kamaboko (Japanese-style fishcake) in Hawaii after World War II until the 1950s. When local consumers started to question what went into the fishcake, manufacturers began to avoid using shark. Then when the US Food and Drug Administration required food processors to label product contents, the fishcakemakers switched completely to using other types of fish. Local folks, the fishcakemakers reasoned, would not eat kamaboko or any other food product that they knew contained shark.

But market acceptance of shark meat was never tested until recently.

In 1976, in an effort to test market acceptance of shark meat, the State Department of Planning and Economic Development, the United Fishing Agency, the Office of the Marine Affairs Coordinator, and the University of Hawaii Sea Grant College Program developed a program to study the feasibility of a shark fishery in Hawaii. The activities included: (1) several shark-catching expeditions by the fishing vessel *Easy Rider* which caught sharks around the Hawaiian Islands and brought them to the market for the first time in years; (2) a shark "pupu" party which was held at the Waikiki Aquarium; and (3) statewide shark workshops with *Easy Rider* Captain "Skip" Naftel and Waikiki Aquarium Director Leighton Taylor as the guest speakers. The workshops, which were organized by the University of Hawaii Sea Grant Marine Advisory Program, made people curious about tasting shark. And, to the surprise of many, shark sales have been successful in the markets.

Currently, several fishing vessels are catching shark regularly, and it is often found in local supermarkets. Charcoal-broiled, barbequed, or baked, shark meat is hard to beat. Today, people are looking to the sea to meet the protein needs of an ever-expanding population, and shark meat is turning into a good buy.

WHAT'S SO GOOD ABOUT SHARK?

Shark meat is high in protein and contains almost no fat or cholesterol. One-third pound of raw shark meat yields about four ounces of lean, cooked fish, with more than 20 grams of high-quality protein and only about 100 calories.

From a culinary standpoint, shark has been called a "chef's dream." The shark meat's bland flavor allows it to conform readily to many tastes, with the use of sauces, herbs and spices, and

flavorings. The boneless, all-meat fillets turn perfectly white when cooked, and this fish cooks easily and quickly. It should not be overcooked, however, for the texture will become firmer and drier as it cooks, due to the lack of oil or fat in the meat.

What does shark taste like? Shark fillets at the market look like swordfish, and some people compare the two in taste and texture. Others have likened shark meat to tuna, mahimahi, codfish, lobster, and even chicken.

WHAT TYPES OF SHARK MAY BE FOUND IN THE MARKET?

Shark meat sold at the market comes from three main types of shark, yet all are simply labeled "shark" or "shark steak." The meat is similar in appearance and texture, yet each has its own distinctive characteristics.

Tiger shark is the most common. The meat is relatively bland, with distinct, white, circular bands visible on the steaks. Its firm texture can be tenderized by pounding, soaking in milk, or marinating in a sauce.

Sandbar shark tends to have a finer grain and soaks up sauce more quickly, according to *Easy Rider* chef, Les Duman. It has a tender texture.

Mako, a deep water species caught by long-line fishing boats, is one of the tastier sharks.

The size of the shark seems to have more bearing on texture than the species. The larger the shark, the coarser the grain and the thicker the tendon rings, resulting in tougher meat. Shark pups or small sharks from one to three feet are extremely tender.

All shark meat on the market is processed by soaking in brine water to remove the urea, which, although harmless, decomposes into ammonia. Untreated shark meat can give off an unpleasant taste and smell.

To insure good flavor, a quarter teaspoon of vinegar or lemon juice per pound of shark meat may be added to any recipe during cooking to eliminate any residual ammonia.

THE PEOPLE BEHIND THE RECIPES

The imaginative recipes of this unique collection were contributed by the following people:

LES DUMAN, cook and crew member of the fishing vessel, *Easy Rider*

RANDY UYEHARA, former executive chef of the Second Floor Restaurant, Kailua, Oahu

BRIGETTE CAMPBELL, food instructor at Kapiolani Community College and the University of Hawaii

APINYA "SAM" THUMRONGKUL, senior in Food and Nutritional Science, University of Hawaii

EARLINE WEDDLE and her fall 1976 Meal Management students: Constance Arikawa, Laura Boyd, Carol Chatterley, Valerie Chun, Elizabeth Dye, Ella Kawamoto, Bertha Kawauchi, Theresa Lee, Dorothy Livermore, Tin Rin Lo, Adele Sora, Ruth Ann Suzuki, Naomi Yamada, and Y. Ada Chong Yeung. Recipes without credit lines were contributed by this class.

A special mahalo to Earline Weddle for acting as advisor and recipe editor and contributing so much of her time to this project.

Recipes compiled and edited by Alvin Tachibana, graduate in Food and Nutritional Science, University of Hawaii.

RECIPES

SHARK TERIYAKI

1 lb. shark meat
1 T oil

Teriyaki sauce

2 T shoyu sauce
1 clove garlic
1/2 t ginger
1 T brown sugar
1 T cornstarch
1/4 C water
2 T sherry

Cut shark into bite-size pieces. Stir-fry in oil until cooked (flesh will be somewhat white in appearance). Pour the prepared teriyaki sauce over the fish and let stand for 15 minutes or longer depending on the size of the pieces. Reheat. Serve as appetizers.

SHARK STEAKS IN WINE-HERB SAUCE

by Les Duman

4 shark steaks (1/3 - 1/2 lb. each)
1/2 C white wine
1 lemon (1/2 of lemon for juice; 1/2 for wedges)
2 T butter
1/4 t crushed basil leaves
1/4 t oregano
Salt, pepper, paprika

Quick-fry steaks on both sides in butter. Turn heat down. Add wine and lemon juice. Sprinkle basil leaves and oregano on steaks. Cover and simmer for 10 minutes. Salt and pepper to taste. Garnish with paprika and lemon wedges.

GRILLED SHARK STEAK WITH "SECRET SAUCE"

by Les Duman

4 shark steaks (1/3 - 1/2 lb. each)

Sauce

1/2 C white wine
1/2 C black bean sauce
2 T butter, melted
1/4 t garlic powder
1/2 t parsley flakes

Combine ingredients for sauce. Dip steaks in sauce and slow cook on barbeque grill.

CRISPY SHARK WITH SWEET-SOUR SAUCE

1 lb. shark, cut in 1-1/2" cubes

Batter

1/4 C flour
1/4 C cornstarch
1/2 C water
1/2 t salt

Dip shark cubes into batter and deep fry in oil at 350°F.

Sweet-sour sauce

1/4 C packed brown sugar
2 t cornstarch, approximately
3 T lemon juice (or vinegar)
1-1/2 t shoyu
1/2 t MSG (monosodium glutamate)
1-1/2 t salt
1 t sesame oil
1/2 C water
1 ginger, 1" length, crushed
1 clove garlic, crushed

Boil ingredients until sauce thickens. Taste and add more sugar or salt, as desired. Pour sauce over shark cubes and serve.

MAYONNAISE-BAKED MANO

by Brigette Campbell

1 - 1-1/2 lbs. mano (shark) in one piece
2 T vegetable oil
1/4 t salt
1/4 C mayonnaise
1-1/2 t paprika
1/4 t black pepper

Sprinkle shark with salt and pepper to taste and place in a lightly-greased pan. Spread mayonnaise over fish and sprinkle with paprika. Place in oven and bake at 350°F for 30 to 35 minutes.

Serving sauce

2 cloves garlic, finely chopped
1/2 ounce fresh ginger
1/3 C soy sauce

Mix ginger, garlic, and soy sauce. Serve with the fish. If you like it hot, add two chili peppers or a dash of tabasco sauce.

BARBEQUE SHARK--KOREAN STYLE

by Alvin Tachibana

1-1/2 - 2 lbs. shark meat

Sauce

1/3 C shoyu
3 T sesame oil or vegetable oil or in any combination
2 T brown or white sugar
2 T green onion, finely chopped
1/2 C onion, diced
1/2 t garlic, grated
1/2 t ginger, grated
1/2 t MSG (monosodium glutamate)
1/4 t pepper
2 T sesame seeds

Lightly brown sesame seeds in an ungreased frying pan. Be careful because they burn easily. Crush in a bowl until powdery. Combine well with rest of sauce ingredients.

Slice shark meat into steaks (1/4" - 1/2" thick) or cut into 3/4" - 1" cubes. Marinate in sauce for several hours in refrigerator. Turn occasionally to soak evenly. Place steaks under broiler or on hibachi for several minutes on each side, or until done. Do not overcook, unless a chewier meat is desired. If cubes are used, skewer onto Bar-B-Q sticks and cook as above, turning over once.

Variation

Shark Pupu Kabobs. Cut Bar-B-Q sticks in half with wire cutters. Secure shark cubes, onions, tomatoes, and bell peppers on skewers for individual pupus.

SPICY SHARK CURRY--BENGAL STYLE

1 lb. shark
1 t paprika
1/8 t turmeric salt
3 T vegetable oil
3 large onions, finely chopped
2 cloves garlic, crushed
1/4 t chili powder
1/4 t cumin
1/2 C yogurt
1/4 t mustard seeds
1/8 t ground cinnamon
1/8 t ground cloves
1/8 t ground cardamon
1/8 t ground turmeric
3 large fresh tomatoes, chopped, (or 1 1-lb. can tomatoes cut into small pieces)
1 T coriander leaves, chopped (optional)
1/4 C water
1-1/2 t salt

Cut shark into serving pieces. Rub with paprika and turmeric salt; salt lightly. Heat oil and brown the fish lightly. Remove from frying pan and set aside. Fry onions and garlic until lightly brown, adding more oil if necessary. Add chili powder, cumin, mustard seeds, cinnamon, cloves, cardamon, and turmeric. Fry for a minute or two. Add tomatoes, coriander leaves, and water. Simmer until tomatoes are tender. Add salt and yogurt. Add fish. Cover and simmer for about 10 minutes, watching carefully.

SHARK LAU LAU

1/2 lb. shark
1/4 lb. salted butterfish (or smoked salted salmon)
1/4 lb. pork butt
16 - 20 luau leaves (taro, large)
16 ti leaves, large
Coarse Hawaiian salt
Liquid smoke

Cut butterfish (or salmon) into 8 small pieces and soak in water for 1 to 1-1/2 hours. Cut pork butt into 8 pieces. Cut shark into 8 generous size pieces. Wash ti leaves and remove tough center ribs. Crisscross 2 or 3 ti leaves. Place 4 or 5 luau leaves in center. Place 2 pieces each of lean and fat pork, 2 pieces of butterfish or salmon, a couple drops of liquid smoke, and 2 pieces of shark on luau leaf. Sprinkle Hawaiian salt over fish and meat. Fold luau leaves over meat and fish to form a bundle. Tie up ends of ti leaves with twine if desired; leave 4" of stem for handle. Steam 3 to 4 hours or cook in pressure sauce pan at 15 pounds pressure for 45 minutes. Serve lau laus hot in ti leaves. Makes 4 lau laus.

SHARKBAIT FRITTERS

by Alvin Tachibana

1-1/2 - 2 C chopped or grated shark meat
1/2 C flour
2 eggs, beaten till foamy
1 small carrot, finely chopped
1/2 small onion, finely chopped
2 - 3 T green onion, finely chopped
Salt and pepper to taste, depending on whether or not a sauce is used and the type of sauce
Dash of MSG (monsodium glutamate)
1 - 2 drops of yellow food coloring, if desired

Optional

1/4 C of any combination of the following:
sliced Chinese peas or string beans
slivered gobo (burdock)
chopped water chestnuts
chopped Chinese parsley

Combine all ingredients. Batter should be stiff, but should drop easily from teaspoon. If not, add more flour or moisten with water as needed. Deep fry at 350°F till evenly browned. Drain on paper towel. Serve with tartar, tempura, or soy sauce.

TANGY SHARK CURRY

by Alvin Tachibana

1-1/2 lbs. shark meat chunks (about 1" size)
2 T butter or margarine
1 small onion, chopped
1 large stalk celery, sliced
1 piece ginger, 1" long, grated
1 large clove garlic, grated
2 T flour
1 C coconut milk
1 C chicken broth or bouillon
1 T curry powder
1 T lemon juice
Dash of sugar
Dash of MSG (monosodium glutamate)
Salt to taste

Using half the butter margarine, lightly sauté shark chunks in a skillet until meat turns completely white. Remove chunks and set aside.

Add rest of butter or margarine to skillet and sauté onion and sliced celery. Add ginger and garlic then cover and cook until onion is clear. Add flour and curry powder to mixture, blending well. Add rest of ingredients except shark and lemon juice. Mix well and taste. Add more curry powder or salt if desired and simmer about 10 minutes. Stir in cooked shark chunks, add lemon juice, and simmer just long enough to heat through. Serve hot with rice and condiments (chutney, green onions, raisins, grated coconut). Serves 4 to 6.

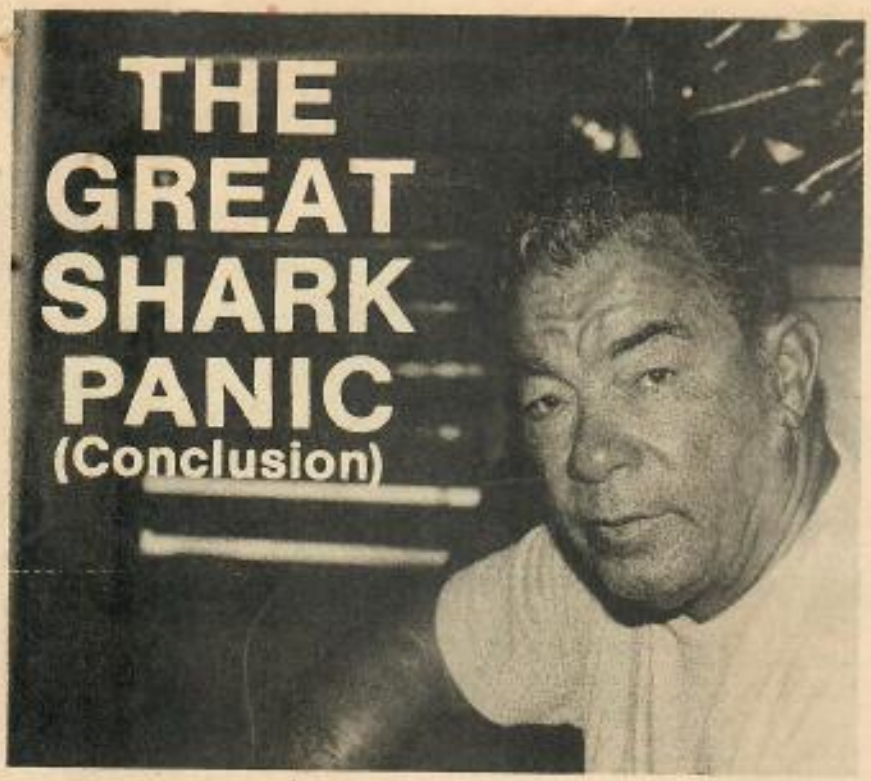
LACY SHARK TEMPURA

by Randy Uyehara

1 lb. shark meat
1 C flour
1 C cornstarch
1/4 t baking soda
1-2/3 C water
1 egg, beaten
1/4 t salt
1/8 t pepper
pinch of dillweed (optional)
Oil

Slice shark meat into 1/4" fillets; then pound lightly on both sides. Cut fillets into 1" x 3" strips, and pat dry. Sift flour, cornstarch, baking soda, and seasonings together. Combine egg and water, then add to dry ingredients. Mix thoroughly. Using fingers, sprinkle a little of the batter on top of the heated oil (approximately 365°F), repeating several times. This should be done rapidly as it will be the lacy background for the tempura. Dip shark strips in batter until thoroughly coated. Lay strips on the lacy batter in the oil. Then sprinkle more batter on top. Turn strips over after approximately 1 minute. Cook till lightly brown. Drain strips on paper towels. Serve hot with tartar or tempura sauce.

THE GREAT SHARK PANIC
(Conclusion)



Kona's **Danny Camacho** is a hired gun.

"I'm a professional fisherman," he says. "I guess I've caught every kind of fish in Hawaiian waters, including sharks, of course. And as a professional, I work on assignment, too. Sort of a hired gun."

Camacho has hunted, caught, killed and sometimes brought fish back alive for 21 years. He's captured porpoises for the University of Hawaii and the U.S.M.C. Kaneohe Undersea Warfare Center, who train them for military purposes. He was the man who caught **Ihunui,** the false killer whale which delighted audiences at *Sea Life Park* on Oahu for many years until its death late last year.

When the fisherman disappeared from Kailua Bay recently (his body was never found) and his swim fin and a pair of shredded swim trunks were later found, Danny went out with Capt. **Rick Rose** and his crew on the *Aerial IV* the next night and went after the shark. They got him. It was a tiger shark about 11'2" long weighing more than 700 pounds.

"I used a bang-stick," Camacho says. "It's a modified Magnum-type gun with power, big power. I shot this one several times. They are hard to stop, the Tigers."

Dr. **David Grobecker,** Scientific Director of *Pacific Gamefish Research Foundation* doesn't believe that shark-hunt fishing accomplishes much toward permanently eliminating possible shark problems. Does Camacho?

He grins and shrugs: "Probably not. There will always be others out there to take the place of any we kill." then he says, "But it felt good to get *THIS* one."

Camacho, incidentally, doesn't agree with the generally-accepted theory that the missing fisherman was probably dead when the shark attacked, if that's what did happen.

"It's possible that he was already dead," he says, "but if he was, it (the shark attack) had to have happened almost immediately after he died. My experience is that sharks will not touch spoiled meat. I think that the man was alive and struggling and that's why the one fin that was recovered came off him."

Camacho has no doubts whatsoever that there are plenty of sharks out there. He's seen them and he's caught them, and he knows that the predators like to congregate around the mouths of harbors and bays, where skippers and crews often tend to dump refuse.

"They'll eat *anything,*" he says. "Once we caught a 14 or 15-foot female shark. When we opened her up, we found three big turtles, shells on and everything, we counted about 75 humuhumu that hadn't been digested yet, and there was aluminum foil and a small glass fisherman's ball and a big piece of driftwood.

"And she'd somehow – don't ask me how – gotten ahold of a fighting cock! That was pretty well gone, but there were a lot of feathers still, and even the fighting gaff – the spur."

Over one three-night period shark fishing off the Kona coast, Capt. **Bobby Erickson** and his crew and Camacho caught (1) one 740-pound female tiger shark, (2) one nine-foot male tiger, and (3) had a third shark almost in when it snapped the line. "The biggest of the three by far," he says.

Camacho is very concerned about the safety of the 1,000-plus siwmmers in the *Ironman Triathlon* every year, so much so that he says he met with both Rep. **Virginia Isbell** and race founder **Valerie Silk** "a couple of years ago" and expressed his fears.

"I'm just plain scared," he says. "There are sharks out there, of that I'm positive, and it's simply a matter of time before there's a tragedy. You can't put more than a thousand thrashing bodies out there over an area that big for that long a time and not expect that sooner or later a shark or sharks will hit.

"It's just a matter of odds."

Camacho suggests that the swimming leg of the Ironman be held off Hapuna Beach in Kohala, citing the sandy bottom and relative shallowness of the water there, plus fairly calm seas.

"You know," he says, "I agree with all the experts who say that the odds are overwhelming that an individual won't get attacked, considering the huge number of swimmers and divers that go out in our waters compared to the relatively small number of shark attacks reported.

"But the thing is, sharks *are* dangerous. You can shave with a shark tooth taken right out of its jaw, did you know that? The males are most dangerous when they're older and hungry and can't compete with the younger more aggressive fish for food in deep water – so they come in and prowl the shallow water.

"The female is trouble when she's bearing pups. She's mean and she's so hungry she eats most of her own after dropping them. Maybe that's lucky for us, because she delivers 100 eggs or so. Maybe that's how nature keeps our waters from being crawling with sharks.

"But they still multiply. Fishcake from shark isn't in demand much for human consumption so long-liners don't bother to catch 'em."

Incidentally, Camacho believes that there have actually been more shark attacks than offical figures would lead us to believe. "No, I don't think they're fooling with the figures or anything," he says, "but I know that there have been a lot of boats, small and large, just abandoned at Kailua and Honokohau over the years.

"Harbor officials will come and ask around and say to other fishermen, 'Do you know the owner of this boat? Do you know so-and-so?' A lot of guys come in from California or someplace and stay pretty much to themselves so they aren't known much and other people don't really notice when they haven't been around for awhile.

"But even small boats are expensive. I can't see many people just takin' off and leaving their boat behind for the State to eventually confiscate as an abandoned vessel, which it does.

"So if they have been victims of shark attacks they aren't reported as such."

Camacho smiles, but his eyes show no mirth. "Just tell people to be careful out there. They may be right that being the victim of a shark is one chance in a million.

"But if *YOU'RE* the one, that's the hard t'ing."

KC

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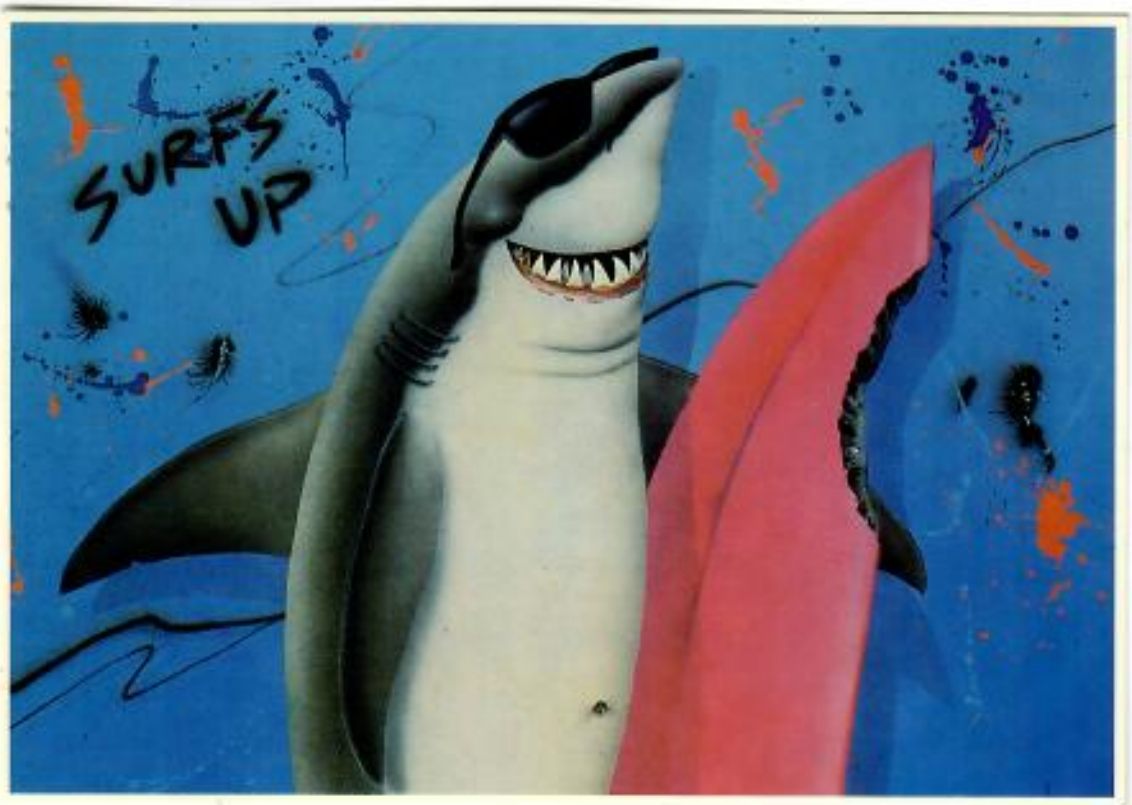

Potentials for Shark Meat as Food

ECONOMIC DEVELOPMENT DIVISION
DEPARTMENT OF PLANNING AND ECONOMIC DEVELOPMENT

1976

The theory which assumes that cerebral convolutions have their origin in a disproportion of the brain surface to the skull with a resulting reciprocal mechanical influence on various parts of the brain is too generalized for our purpose. The use of the term "mechano-functional" condition may be comprehensive but does not explain the developmental process. I have applied the Weber method, which Scammon used so successfully in the study of the early pancreas, to this problem. While I am not yet in a position to make a positive statement the evidence at hand seems to suggest that a definite growth process in the region of the fissures is a factor in their formation.

It would seem that cerebral anthropology is dependent for its ultimate development on functional localization in the cerebral cortex. Such localization involves so many different factors that we can not hope for a solution of the problem by any one method of research or by any one department, but only by a thorough weighing and assorting of all the evidence contributed by the investigators in all departments. Since anthropology will benefit so largely by the answer to this question her workers should contribute their share toward its solution.

UNIVERSITY OF NEBRASKA,
OMAHA, NEBRASKA

HAWAIIAN SHARK AUMAKUA

BY MARTHA WARREN BECKWITH

DURING a stay of some months in the district of Puna, Hawaii, two years ago, I came across instances of a belief in animal helpers, half god, half human, who utter their counsels through the lips of some medium, who becomes for the moment possessed with their spirit. Such gods are called *aumakua*. They are bound by obedience to their devotee, who becomes their keeper, and their worship, and consequent service, extends to his family and is handed down from generation to generation. Hawaiians are very unready to discuss this belief with foreigners, or even with those of their own race who mingle with foreigners. My interpreter, a part Hawaiian woman educated in foreign schools, told me that her grandmother, although believing devoutly in the phenomena of spirit possession, would never talk with her upon the subject.

On the coast, sharks are the particular object selected for veneration. In the village where I was staying, I quickly discovered that one family of two brothers named *Puhi* (eel) were much feared among their neighbors for their power to transmit disease to any who fell under their displeasure. Consumption was common in the village, and its victims were supposed to have fallen under the malign spell of the *Puhi*, or of the one other sorcerer they feared, the native pastor of the evangelical church. On one occasion the younger *Puhi* made a birthday feast for his son, but upon report that he had been at pains to secure a black animal without a white hair for the underground roasting, in spite of the popularity of such entertainments, not a man, woman or child outside the family, dared appear at the feast for fear of *Puhi*'s sorcery. The man had a wife subject to fits of insanity—a dark heavy-faced woman with some traces of beauty, and sister to two albinos, men of big frame, white skin, light reddish hair, and blue eyes. As

they quarreled with their brother-in-law, we never saw them at the coast. "They talk bad of my father," the son explained, who, handsome, bright-eyed and finely formed, nevertheless inherited his mother's mental flightiness.

Under these circumstances it was no great surprise to learn that the *Puhi* had a supernatural helper or *aumakua* who appeared in the form of a particular shark inhabiting the waters off Cape *Kumukahi*. My informant was the native clergyman in the adjoining village of *Kawelean*, named *Kaiwi*. Said he: "When the *Puhi* go fishing, the shark appears. The *aumakua* obeys the voice of man; name the kind of fish you want and it will bring it. The men give it some of the first catch, then it disappears, and they always come back with full nets. Only when the shark appears do they have luck (hence they recognize the god's intervention). Sometimes the *aumakua* tells them beforehand in a dream that it has gathered the fish together. Besides this, the *Puhi* family can never be drowned. If there is a storm and the boat capsizes, the shark appears and the man rides in on its back."

In answer to questions we drew from *Kaiwi* that this *aumakua* was a particular shark, light with yellow spots, called *Ke-au*. It originated when certain ancestors of *Puhi* had an abortive child.[1] They buried it in the ground, but the *aumakua* came in a dream and told them this was not right, so they threw it into the sea and it became this shark. "How can one tell that a shark is an *aumakua?*" we asked. *Kaiwi* said: "You can tell because when the mother goes in to bathe, the shark will come and jump at the breast as if to suckle; thus she knows it is her child, for it does this to no one else." As *Kaiwi* talked we heard his wife muttering in the back part of the house and presently she called him peremptorily from such dangerous gossip.

We asked the native clergyman of *Puhi*'s own village, a man of higher intelligence than *Kaiwi*, to explain to us more fully the idea of the *aumakua*. "How does the god come to have the shape of a shark?" we asked. "The *aumakua* has no form," he said, "It

[1] I am told that "Hawaiians suppose an abortive child to be the offspring of an *aumakua* and a human. If an *aumakua* finds the remains of such a child he adopts it, causing it to be like himself, another *aumakua*."

comes in the shape of a wish into the mother. When she is in trouble she prays and the object comes before her. After the one dearly loved passes away, he is worshiped, the dead one's spirit is fed with *awa* (the intoxicating drink of the Hawaiian). Or if a child comes before its time, unformed, lifeless, such a child is thrown away. The spirit comes back. The mother is then unlike herself—the face is the same but the thought is changed. She says: 'Have you any *awa*? Have you any food?' when such may be before her in the house. The friends will say 'Who are you?' The mother says, 'I am so-and-so'; then the people flock about her and ask the *aumakua* to help them."

The idea is a simple one. The presence of a spirit is indicated by a divine possession in which the person possessed speaks not as he is accustomed but in the character and with the words of the spirit whose medium he is. His utterances are not his own but are the means by which, together with dream and vision, the spirit of the *aumakua* counsels his protegé.[1] In order that the *aumakua* may be strong enough to act his part as helper, he must receive offerings of prayer, and of sacrifice in the shape of food and drink called "feeding the spirit." For example, a woman living near *Kealakekua* was seen each night to carry a pail from her house to the cliff and empty it over into the sea. It was found that the pail contained *awa* drink which was being fed to the household *aumakua*.

May any creature, plant, or object, then, become an *aumakua*? Logically, yes; but practically there are only certain ones which are regarded as possible god bodies. Mr. J. S. Emerson enumerates

[1] Miss Laura Green furnishes me with some notes as to this belief in spirit possession. When the *aumakua* comes into a home where illness or other trouble is present, it enters the body of some member of the family—by the head if a friendly, by the feet if an evil spirit. The person falls asleep, the *aumakua* taking the place of the spirit thus ejected. Such a medium is called a *kaka*, and the seance a *noho* (sitting). If a friendly spirit, it offers advice as to how to escape the illness or other troubles—what prayers to offer, fish to catch, herbs to gather. To test that *aumakua*, a member of the family throws a wreath of some special plant (*lai* or *laukaʻau*) about the neck of the *kaka*. If it is a friendly spirit, he will take it, if an evil spirit, he will spit, glare, tear his clothing, or even plunge naked into the bushes. Such insanity is relieved by a drink made from a coarse kind of grass. To keep out these evil spirits, house and yard are sprinkled with water to which salt and a bit of root similar to the ginger are added. This ceremony is also used in case of death.

these in his paper called "Lesser Hawaiian Gods" published among the papers of the Hawaiian Historical Society. The shark, cowry shell, limpet, squid, and eel are famous sea *aumakua*. The mud-hen, plover, chicken, wild-goose, frigate-bird, besides song birds, are important *aumakua*. The spider among insects (not mentioned by Emerson) and the lizard among reptiles are worshiped, and of quadrupeds the pig, dog, and rat.

Rocks, too, are often set up as *aumakua* and worshiped as transformed deities. Certain trees, sweet-scented flowers and phenomena of nature and the elements, the volcano, for example, are powerful *aumakua*.[1] In fact, the *aumakua* worship corresponds well with Polynesian utterances about the creation of the world in which earth, rocks, plants, and animals are imputed to sex birth and their race and lineage recorded. The singling out of special classes of objects perhaps signifies merely that to such names the *aumakua* of famous families of the past got attached and hence their descendants worship these inherited forms.

Are the *aumakua* friendly or evil spirits? Cases differ. Some, says Emerson, such as the shark and limpet, which calm the waves or provide food for their patron, are beneficent; some like the dreaded worm (*enuhe*) and the lizard (*moo*) are much to be feared. The dog is beneficent, but a great thief. The pig is a mischief-maker, symbol of lechery and filth. The rat is, like the owl, beneficent, from the classic tale of the rat-god who, when *Makalii* (Little Eyes—the Pleiades) tied up all the food of mankind in a net and hung it in the heavens, gnawed the ropes and let it tumble back again to earth. Emerson and Fornander[2] both point out the difference between Hawaiian and Tahitian feeling in this respect, the Tahitian *oromatua* being regarded as malevolent beings carefully to be propitiated. In general, the *aumakua* protects its own family, however inimical it may be to strangers.

Are the *aumakua* class or individual gods? In some cases,

[1] Miss Green says, however, that *Pele*, like the gods and goddesses, is not thought of in the *aumakua* class. Even the pig-god is a superior kind of *aumakua* because of his high lineage.

[2] *Polynesian Race*, vol. 1, page 127.

individuals are worshiped, in others all the species of a class. Emerson says:[1]

> In the case of the *pueo* (owl) all birds of that species were equally considered as representative of the *aumakua*, known as "*Pueo nui o kona*" (the great owl of *Kona* district, looked upon by a great portion of *Kona* people as their family god). They were not worshiped as individual owls, and when one died, the life of the *aumakua* was not affected.[2]

On the other hand,

> Each several locality along the coast of the islands had its special patron shark whose name, history, place of abode, and appearance were well known to all frequenters of that coast. Each of these sharks, too, had its *Kahu* (keeper), who was responsible for its care and worship. The office of *Kahu* was hereditary in a particular family and was handed down from parent to child for many generations, or until the family became extinct.

It is to these inherited shark *aumakua* that *Puhi*'s helper belongs. Mr. Emerson has listed a number of similar shark *aumakua* identified along the coasts of various islands, the manuscript notes of which he kindly allows me to print here. For the *Puna* group my informants corroborated, in cases where the name was familiar to them, the story set down some thirty years ago by Mr. Emerson. At the name of *Kupanihi*, for example, a wooden-legged man of the party, named *Moses Kuaana*, spoke up. "That is my shark," he said. "He puts a person under his arm; he is like a father to me." *Moses* told me that his shark was rainbow-colored, that it was man before and became shark, and that it acted as protector to his family. Another bystander recalled the story of the abortive child of *Aia* of *Palama* (Emerson's *Akia*) which was thrown into the sea. Its spirit came to the grandmother and told her it was living and wanted *awa* to drink, warning her to attend to its message lest one of the family die. This proves that the data not only

[1] *Papers of the Hawaiian Historical Society*, no. 2, page 8.

[2] But one informant tells me that the owl is classed as a god, not as an *aumakua*. According to old Hawaiian ceremonial, the *opelu* and *aku* fish, excellent for eating, were held tabu each for six months at a time. On January 13 was performed a religious ceremony accompanied by human sacrifice, at which the *aku* season closed and the *opelu* began. This commemorated the voyage of the priest *Paao* from *Tahiti* with chief *Pili*, when schools of *aku* and *opelu* accompanied the canoe all the way to still the waves. See Malo, *Hawaiian Antiquities*, pages 25, 199.

preserve the tales of old and mythical shark gods, but represent a living faith to-day.

From Mr. Emerson's notes we learn something of the form in which the belief survives. Shark gods may be male or female. Those described are invariably red, shining, light or spotted to correspond with their sacred character, as allied to the gods. They are of human origin, the constant reference of shark or lizard gods to an abortive child being possibly suggested by the appearance of the partly formed foetus. Their worship is handed down from father to son, a special keeper (*Kahu*) being intrusted with their care. They are invoked with particular prayers and have temples erected for their worship. Their special function is to aid in the food supply of the household—generally by giving the fisherman good luck at sea—and to protect him from drowning. They are, in fact, regarded as spirits of half-human beings which, rendered strong by prayer and sacrifice, take up their abode in some shark body and act as supernatural counselors to their kin, who accordingly honor them as household divinities.

In most cases the *aumakua* has the power to take either human or animal shape. Most old Hawaiian hero tales are based upon the exploits of some supernatural being born as a rope, a chicken, or in some abortive form, cast out to die, but, being nurtured by a seer, survives to avenge family wrongs at the hands of well-nigh invincible foes, to furnish culture gifts, or undertake strange adventures. Hence follow a number of transformation stories, of which the tale of the pig-god, *Kamapua'a*, and of the shark *Kamoho-alii*, brother to *Pele* of the volcano, are the most popular survivals. Says Emerson of the latter:

> His place of abode on Hawaii was *Ka-puli-kapu-o-kamohoalii* ("The sacred steep of Kamahoalii") on the northern edge of the crater of *Kilauea* on Hawaii. So awful and sacred was this spot that *Pele*, though his own sister, dared not allow the smoke from her fires to rest upon it.

His girdle too was of red, corresponding to the sacred color ascribed to supernatural sharks.

A popular form of the transformation story is that of the shark-man born with a shark's mouth on his back and the power to become a shark the moment he leaps into the sea.[1] This tale, four variants of which Emerson has collected on Hawaii, resembles the stories of robbers or man-eaters that waylay unsuspecting travelers who pass by on the highway at some narrow passage. Two such spots I have seen, one an upland pass on Oahu between two gorges where *Aikanaka* lay in wait for his cannibal feasts,[2] the other in *Puna*, where a high cliff presses upon the shore road. Here the natives still point out the mass of stones hurled in the final struggle with the dreaded highwayman *Aloki*.

In Emerson's first version, the shark-man (unnamed)

> lived in *Kawaihu* at *Kaalualu*, *Kau* district. He had the form of a man with a mouth on his back. He was a great farmer and when people went to *Kawaihu*, he resumed his shark form and devoured them. To destroy him the chief ordered all the men to assemble on a given day and cultivate the ground. A *makaula* (prophet) discovered this shark-man among them by his concealing his back with a *pau* (strip of bark cloth). By the prophet's orders, the monster was seized before he could reach the sea and resume his shark form. They killed him and burned him up.

Portions of this shark, says Emerson, were cooked in the ovens (now open) of *Kaluapuali*, *Papalaheiau*, *Palalauhala*, *Mohoiki*, *Kahiu*. The oven *Puuolokuana*, however, remains unopened, for *Kane* and *Kanaloa* and the other gods were cooking the shark there when the day dawned, at which time gods cease their activities on earth.

The second version comes from *Waipio* valley.

> *Neuewe* lived beside the large basin at the bottom of the water-fall on the west side of *Waipio* valley. As he cultivated his little sweet potato patch he was in the habit of watching the passers-by, and sometimes called out to them "Where are you going?" Perhaps the answer would come "We are going to bathe in the sea at *Muli-wai*" in which case he might answer, "Then look out that the shark there does not eat you." He would then rapidly get over the intervening space of about two miles, and, as a shark, await their coming at the seashore. In due time he would seize and devour one of their number. When this had happened several times, people began to suspect the fellow at the potato patch of being in some way connected with the shark of *Muli-wai*. They accordingly seized him one day at his home, and discovered the shark's mouth under the *kihei* (cape) which he always wore on land.

[1] See Thrum's *Hawaiian Folk Tales*, page 255.

[2] Compare *Ibid.*, page 139.

In a third version corresponding with the above in almost every particular, the shark is named *Niho-kahi* (single tooth) and lives at *Laie*, on the north coast of Oahu.[1]

A fourth occurs under the name *Ka-ai-poo* (the head-eater). He lives at *Kapaahu*, *Puna*, and carries the mark of the shark's mouth on his back.

Hawaiians often think of their *aumakua* as going to war among themselves.[2] A second famous shark myth detailed by Emerson is that of the great shark war, in the course of which the man-eating sharks were driven from the group. To this event belong the most ancient and formidable gods described in the notes. Some details of the war point to a symbolic rendering of a real struggle between chiefs, but whether of a literal struggle to weed out cannibalism from the group is doubtful. There is no evidence that cannibalism was ever practised in Hawaii, nor, says Fornander, in the Society Islands. Among the Tongans the practice is said to be exceptional. But in the Fiji and the Marquesas, in New Zealand, to some extent in Samoa, the custom prevailed. The cannibal rite must therefore at various periods in the settling of the group have forced a decision. It is, however, more in accordance with Hawaiian symbolic analogy to employ the figure of the man-eater to represent a great war chief, who "eats" the land or his rivals in war, than in the more obvious analogy of the cannibal rite.[3]

The story itself includes so many inconsistencies that it is hardly worth while in this paper to enter into its detail. I will merely enumerate the sharks named by Emerson, and indicate their place in the legend.

Kaakupahau (w)[4] and her brother (or son) *Kahi'aka*, live in the *Ewa* lagoon off Oahu. She is in one version the friendly deity of the *Ewa* natives, who her-

[1] Collected April 10, 1907, from J. A. Kahiona, a mormon of Laia.

[2] Compare the story of the great owl war, Thrum's *Hawaiian Folk Tales*, page 200.

[3] At one place in the story the hero shark and his companions meet a man-eater. "They engaged him in conversation, when it appeared that he ate human flesh. They told him it was wrong, to which he replied that it was nice and that they must defeat him before he would stop doing so." In another passage "the spirit of the man-eater revived again, and as a tongue, now restored and alive, made its way to the coasts of Maui and Hawaii, pleading with the sharks of those regions for vengeance."

[4] k stands for male (*kane*) w for female (*wahine*).

self instigates the war against the man-eaters,[1] in another,[2] one of the man-eaters and slain by the hero *Kealiikaua*.

Kuheimoana (w) is the greatest of all sharks. She lives at *Kaula* and is thirty fathoms long. Subdued by the *Kau* shark-god, she joins his party, but being mistrusted, is led into shoal water where she is stranded, and decides to return home.

Kupiopio (k) is her son, seven fathoms long, who lives at *Kumoku*, *Haena*. He is slain by the *Kau* shark-god. According to Emerson's notes "He came from *Kaula* to live at *Hamakua*. On his way he fell in with *Makaluakaa* (k) of *Kalihi*, Oahu, who became his *aikane*, and went with him to *Hamakua*. There their spirits rested and directed the people of *Puaukau* to plant *awa*, which their keeper brought to feed them."

Kealiikaua (k) is the hero of the great shark war. He is born at *Ninole*, *Kau*, on Hawaii. He acts as the friend of man, his great work being to travel about the islands and slay all those sharks who feed on human flesh. Four companions accompany him.

Kalani (k) is "born on the coast of *Waiohinu* (*Kau* district) from the eye of his mother. His blood has been seen on the forehead of some who worshiped him. He guarded all the people of *Kau* from the other sharks who might harm them. He went to the great shark war at *Ewa*, Oahu, with his kinsman and friend *Kaholeakane*. They were swallowed up by *Kuheimoana* in this war. The little *Kalani* went first into the mouth of the monster, followed by his larger friend, whose size forced the monster to disgorge him. As he came out, the nimble *Kalani* darted out too. Then they swam into shoal water and thus led *Kuheimoana* to her fate. She got stranded on a shoal and was kept from the battle. *Kalani* went too near the shore and had a portion of flesh cut from his back by the people of *Ewa*, who ate it." In another version, two pieces of his flesh form the spouting horn at *Kealae*. The natives say "If a man in a canoe wears anything red, *Kalani* will pursue the canoe and upset it."

Kaholiakane (k) is companion to *Kalani* in the great shark war, *Kua* (k) a *Kau* shark who joins *Kalani* in the shark war, *Kane* (k) companion to *Kalani*.

Ke-alii-holo-i-ka-moana (the chief sailing over the ocean) (k) lives off *Kekaha*, *Puna*, from *Ka-lai-o-kawili* in *Apua* district to *Ka-lai-o-wili-es* in *Panau-nui*. "He began life a human child living on land, was a *kaukau-alii* (low chief) under *Iwakakaolos*, the blind chief of *Puna*. He was an expert fisherman, frequenting the sea in a canoe. At death, wrapped in *Kapa-ahu-na'lii*, he was cast into the sea at *Kealakomo* and became a shark-god of the class called *akua-noho* who were supposed to 'dwell with or be over men as guardians.' He showed his friendship to men by warning them of the approach of hostile sharks by exhibiting himself above the level of the sea. He went with the other sharks to the great shark war at Oahu."

[1] *Papers of the Hawaiian Historical Society*, no. 2, page 10.

[2] Collected March, 1888, from *Kaamuamua*, and dictated by Mr. Emerson to H. E. M. Alexander.

Malu'o[1] (k) lived with *Ke-alii-kalo-moana* and went with him to the war.

Ka-pani-la[2] (the shutting out of the sun) (k) is so-named "because his enormous bulk would obscure the sun should he come to land. He is the largest of the sharks. His usual haunts extended from the point *Ka-lae-o-lamaulu* in *Kapoho, Puna*, to *Kumukahi* point in *Kapele*." He was friendly to the natives and "great things were expected of him when he led the Hawaiian sharks to war, but off Diamond Head he got stranded in shallow water and could proceed no further."

Besides these mythical and fabulous beings who are famous in the great shark war, Emerson lists a number of well-known shark-gods worshiped at various points about the group:

1. *Hiku-welo-ula*[3] (k) of *Puna*, Hawaii, son of the *Kaw* shark, *Ke-alii-kaua* and of *Akia*, a woman of *Kalapana*. At birth he was covered with red tapa, the kind called *pukohnkohu*, and became a red shark. He had two forms, that of a shark at sea, that of a man on land.

2. *Kane-i-kanpaku*[4] (k) of *Puna*, Hawaii.

3. *Kane-makua*[4] (k) of *Puna*, Hawaii.

4. *Ke-au* (k) *Puhi's* shark off *Kumukaki*, Hawaii.

5. *Haloa*, a shark of *Mahana, Kau*, who comes in his spirit form and teaches his *kahu* the medicine to use to cure diseases.

6. *Humeke*, of *Kaalualu, Kau*.

7. *Mikololo*,[5] of *Pokini, Malilele* cliff, *Kau*.

8. *Pai*.

9. *Uukanipo* ("the *uu* that sounds at night"), two great sharks of *Kaeaihae* in *Kohala*, twin brothers. They lived at *Kamani*, and were regularly fed with *awa*. When the king wished to see them the keeper hung two bowls of *awa* from a forked stick, and each shark drank from his own bowl and went away.

10. *Ohiki*,[6] a stone image of a shark at *Kapuahoo*, in *Puuepa, Kohala*, near the coast. It is about eight feet long and very heavy, and was the great god of Kamehameha I. It is situated a quarter of a mile south of the temple of *Mookini*.

11. *Hikeaweaweula*,[7] a shark who lives in a cave called *Ke-ana-o-hikeaweaweula* off *Kakulaana puli, Kohala*.

[1] Collected March, 1888.

[2] Collected December, 1892.

[3] Collected April 2, 1886.

[4] Collected March, 1888.

[5] Collected March 16, 1907, from W. P. Kanealii.

[6] Collected in 1888. Such images occur at many a good fishing ground along the coast, the shark being preëminently the fisherman's god. In a brackish pool on the coast below *Hilea*, Hawaii, I was shown such a rock. It lay on its side in water up to the waist, somewhat resembling a fish in shape, and was one of a pair once highly prized as gods who brought the fish; but a recent earthquake had destroyed the natural sluiceway up which the fish were wont to be driven, and the god's mate had since been sold for a couple of dollars to an enterprising collector.

[7] Collected in 1885.

12. *Hin*[1] (w) (tail of a fish), listed among both *Kohala* and *Maui* sharks.

13. *Ka-ahu-kalu*[1] (k) of *Kohala*.

14. *Luahine*[1] (w) (old woman) of *Kohala*.

15. *Malihine*[1] (w) (stranger) of *Kohala*.

16. *Moe-kikoo*[1] (w) of *Kohala*.

17. *Na-kiaha* (k) (the drinking cups) of *Kohala*.

18. *Kaakupahau* (k), a shark born of human parents and living along the coast of *Kohala*. Emerson has seen it, and talked with the son of its late keeper. He quotes the prayer addressed to it.

19. *Kaaipai* (k), living at *Kaeaihae*, Hawaii. *Keiwi* told me his story as follows: A couple lived at *Puako*, in *Kaeaihae*. People from *Maui* used to bring food to *Puako* because the taro plant did not grow there. The shark would go out, capsize the boat, swallow the food and make off to his cave, where he would deposit it. Then he would go in a dream to his protegés and tell them where to find it. Emerson quotes the prayer by which the couple invoked him to capsize the boats when they needed food.

20. *Maonalaau* (k) of *Kohala*, born of human parents, *Koakou* and *Keiwi*, now dead. In time of famine he sends a great turtle to "the lands of *Nindii, Waiapuka*, and *Auau*." The invocation is as follows: "O *Maonalaau*, listen to *Nihoeleki, Nihoeleki* of *Kahiki*, the ancient one. Hear this cry. The children suffer with hunger. Behold the food; bring the turtle."

21. *Pehu*[2] (k) (swollen), listed for *Hamakua*, Hawaii, and said to have eaten some natives there, also listed second among the great sharks of *Maui*.

22–26. *Mahiki*[2] (k), *Kaeaiiki* (w), *Kaaku* (w), *Kai* (w), *Uhanui* (k), sharks of *Hamakua*, Hawaii.

27. *Ka-ili-pulepule*[4] (the spotted skin) of *Kekaha*, Hawaii.

28. *Kawelo* (k) off *Kuaokaimla* Point, ten fathoms long, friendly to man, but avenges any ceremonial lapse with disease and trouble.

29–31. *Kane-hamama*[5] (kane of the open mouth), *Kolo-pulepule* (spotted creeper), and *Likoliho* (very hot), all of North *Kona*, Hawaii.

32. *Likiliki-muumuu*[6] (*Likiliki* the maimed), the shark-queen of *Kona*, who had lost one of her fins. She was very friendly to the natives and made circuit of *Kona* every year.

33. *Moanaliha*,[7] chief of all the sharks of *Maui*, also ascribed to North *Kona*, Hawaii.

34. *Kane-i-kokala* (k) of *Makikiuui, Maui*.

[1] Collected December, 1892, and March, 1907 from *Kaiooni*, church elder and expert fisherman at *Kahei, Kohala*.

[2] Collected April 10, 1907.

[3] Collected December 19, 1892, from *Kaiooni*.

[4] Collected in 1885.

[5] Collected April 20, 1886.

[6] Collected March 28, 1886.

[7] Collected April 2, 1907.

35. *Kaala-miki-hau* (k) of *Maui*, whose invocation reads as follows:[1]

Eia ka ai	Here is food.
Eia ka ia	Here is fish.
Eia ke kapa	Here is cloth.
Nou e Kaala-miki-hau	For you, O Kaala-miki-hau.
Nana ia'u kau pulapula	Look upon me, your worshiper.
I mahiai	Let me plant.
I lawaia	Let me fish.
Kuku kapa	Beat the tapa bark—
A e ola ia'u, Kanui	Grant me life, Mighty one.

36. *Mano-hī'u-wiwi* (shark with a slender tail) of Oahu.

37. *Nui-kala*, formerly of *Loko Uko'a* in *Waialua*, Oahu.

38. *Puhi-ula*[2] (red eel), associated with *Lani-wahine* and living at *Loko Uko'a*.

39. *Lani-wahine* (her highness), said to have a temple for her worship in *Waialua*, Oahu.

40. *Kala-kiki*[3] (k) of Waialua, who is worshiped in a *heiau* (temple) called *Ku-keiau-o-Kalakiki* just above *Kaupaknāele* on the west side of *Makaleka* valley.

41. *Na-naulu* (k), also of *Waialua* and worshiped in the temple called *Ka-heiau-o-kauua* north of *Kala-kiki's* temple.

Such is the form which the shark worship takes in Hawaii. What is the exact nature of the *aumakua* belief? The ancient Hawaiians worshiped three classes of deities, *akua*, *aumakua*, and *unihipili*. *Akua* were thought of as spirits only, not born of humans. *Aumakua* were the offspring of god and human, or those human beings who were marked by an abnormal shape which might be assumed at will, such as that of some animal or object. *Unihipili* were the spirits of departed relatives. To prepare an *unihipili* the flesh was stripped from the body and the bones wrapped in tapa and mats, or sewed into a woven case which took the form of the body. Such a god, if properly worshiped, was bound to fulfill the requests of its devotee. Both *aumakua* and *unihipili* belong to the class of *akua noho* or "gods indwelling," that is, of those spirits who enter into and possess human beings, through whom their messages to their devotees are uttered.[4]

[1] Recited by *Makiloua* of *Paukule*, Maui.

[2] Collected in 1888.

[3] Collected March 16, 1907, of Barenaba.

[4] For this classification I am indebted to Miss Laura Green, social worker among the Hawaiians of Honolulu, whose informant was an intelligent Hawaiian woman well versed in native custom. See also Malo, *Hawaiian Antiquities*, pages 142, 155–158, and Emerson in *Hawaiian Historical Papers*, no. 2.

The idea of the *aumakua* in the Hawaiian theogony seems to be that of enforced helpfulness within a kinship group as a means to insure superhuman coöperation in individual human affairs; individual, because the *akua* is a national god, to be invoked in time of war or national calamity. The *aumakua* interests himself in providing food for the particular family to whose protection he is devoted, in curing disease, or avenging an enemy. For all such personal services, says Miss Green's informant, the sufferer fears to invoke a national god, lest he be angry; he therefore calls upon his lesser gods. We find the *aumakua*, therefore, closely concerned with affairs of sorcery, and his keeper looked upon as a magician of malignant power. Malo scoffs at the claims of the *aumakua* keepers, whom he accuses of duping the people by pretending to speak as if inspired by the god.

Nor is the *aumakua*, like the *unihipili*, subject to a particular keeper only. Emerson makes the ancestral, family character of the *aumakua* his distinguishing feature from the *unihipili*. He serves the whole family, and when one keeper dies, another takes his place.

For although worshiped like a god, the *aumakua* is nevertheless ranked as *kauwa*, or of the servant class, because bound to obey those whom he serves. He may be compared with the Arabian genii whose supernatural assistance is forced through the possession of some special talisman. In the case of the Hawaiian *aumakua*, that talisman seems to be the social fact of kinship, the act of invocation perhaps serving as a charm to enforce service. This same enforced obedience characterizes the relation between the *unihipili* and his keeper. "The dead are honored by being laid away in caves," says Miss Green's informant. "By being placed above ground they are humbled in their own eyes, as well as in the eyes of those who see their *pu-o-lo* (package form). Hence their implicit obedience to the will of the priests. They are truly *kauwa*, of the lowest class."

Malo, in a curious chapter, which Emerson tells us has undergone mutilation, applies the strict laws of descent to the *kauwa* class. He says:

Those who were *kauwa* to their chiefs and kings in old times continued to be *kauwa*, and their descendants after them to the latest generation; also the descendants of the kings and chiefs, their masters, retained to the latest generation their position of masters. It was for this reason they were called *aumakua*, the meaning of which is ancient servant—*kauwa kahiki*. They were also called *akua*, *i. e.*, superhuman or god-like, from some superstitious notion regarding their power.[1]

Now according to Polynesian habits of analogy, we should look for the prototype of such a supernatural relationship as that involved between an *aumakua* and its keeper in the social organization itself. Malo himself, if we interpret his words correctly, asserts a close relation between the *kauwa* and the *aumakua*. It is possible to assume that *Wakea's kauwa* may have been an *aumakua*, and *Papa's* liaison was with that supernatural demi-god whose keeper and master *Wakea* was. Such relations with a *kauwa* were in Malo's day, as they still are, considered highly disgraceful and for this reason chiefs of pure blood were closely guarded to escape such a connection. According to Malo, members of the class bore distinct tatoo marks—a dot or V-shape over the eyes, or curved lines on either side of the temples—which recalls Mr. J. S. Emerson's note on the shark god *Kalani* "His blood has been seen on the forehead of some who worshiped him." These things point to a direct relation between *kauwa* and *aumakua*.

The whole matter, however, remains still obscure. Light may be thrown upon it by comparing the Hawaiian *kauwa* with the Fijian *tauvu* relation described by Mr. Basil Thomson in *The Fijians*. Thomson explains the meaning of the word as "sprung from the same root" or "of common origin." He finds the *tauvu* relation existing between tribes "who may live in different islands, speak different dialects and have, in short, nothing in common but their god." He says:

A tribe never forgets the tribe with which it is *tauvu*. Members of this tribe may run riot in its village, slaughter its animals and ravage its plantations, while

[1] The *kauwa* class Malo derives from the *kauwa* of *Wakea* (ancestor of the Hawaiian race) whom his wife *Papa* took for her husband after *Wakea's* death. This seems to have occurred elsewhere than in Hawaii, for not until the fifth generation from *Papa* and her *kauwa* husband does Malo trace the "actual and real *kauwa* of Hawaii." Malo, *Hawaiian Antiquities*, pages 96–101.

it sits smiling by: for the spoilers are its brothers, worshipers of its common ancestors, and are entitled in the fullest sense to the freedom of the city.

On the other hand, in case of war, *tauvu* tribes aid the warring chief. Thomson explains the relation as due to intermarriage at a distance, but one is inclined to suspect the presence of the *aumakua* idea, that is, of a union between a human and a god, especially since one origin tale tells how the ancestress of a *tauvu* family in the village of *Nambundra*, while in bathing, was seized and brought thither by a monster shark, god of that place. The individual relation between keeper and *aumakua* may have here been generalized, and the master tribe be entitled to make free with the property of the *aumakua* or servant tribe, or summon its aid in war, as a result of kinship between them.

In short, given the abortive or premature foetus forms, which the primitive mind might most readily explain by supernatural beast unions, and under the stress of Polynesian preoccupation with ideas of kinship, rank, and inheritance, the concept might emerge of an *aumakua* or supernatural helper, part beast, part human, and bound to the service of the family as *kauwa* to his chief. Further investigation is, however, required to establish the historical relation between the *kauwa* and the *aumakua* ideas in Hawaii. We may be looking for a correspondence where the primitive mind sees only an analogy.

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ANALYSES OF TURTLE PARTS RECOVERED FROM SHARK STOMACHS SAMPLED AT PEARL AND HERMES REEF AND FRENCH FRIGATE SHOALS, NORTHWESTERN HAWAIIAN ISLANDS

by

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