BILLY WEAVER SHARK RESEARCH AND CONTROL PROGRAM

FINAL REPORT

by

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April 20, 1961

April 1, 59 TO
March 31, 60

DIVISION OF FISH AND GAME

DEPARTMENT OF AGRICULTURE AND CONSERVATION

STATE OF HAWAII

State of Hawaii
Department of Agriculture and Conservation
Honolulu
DIVISION OF FISH AND GAME

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Introduction:

The Billy Weaver Shark Research and Control Program was initiated after a teen-aged surfer, Billy Weaver, was fatally attacked by a shark off Lanikai, Oahu on December 13, 1958. Following this tragic incident, community leaders, government officials and other interested parties met and discussed ways and means of minimizing the hazard to surfers and swimmers posed by sharks. It was decided that a program which would tend to reduce the shark population within a relatively short period of time and one which would also permit the compilation of scientific data for future use in controlling shark abundance would best meet the requirements.

In order to raise a sufficient sum of money for the program a fund raising committee was organized. This committee under the leadership of Mr. Kenneth M. Young raised $15,704.00 through public donations. Additionally, $11,000.00 was added to this sum by the Governor from his contingency fund. The Bishop Trust Co., Ltd. served as the depository for the fund which was placed in trust to be administered by the Board of Commissioners of Agriculture and Forestry,[1/] through the Division of Fish and Game. This State conservation agency was assigned the immediate responsibility of directing and supervising all shark fishing operations and the collection of biological and ecological data. To assist in technical matters relative to the planning and designing of shark fishing methods and the collection of scientific data, a shark technical committee was formed. A listing of members composing this committee is presented in Appendix A.

The actual shark fishing and data collecting operation was made aboard the aku fishing sampan, HOLOKAHANA I, which was chartered through an agreement executed between the owner and master, Mr. Fred J. Inouye and the Board of Commissioners of Agriculture and Forestry. The charter of the vessel which included the services of the crew was made effective April 1, 1959 at the rate of $2,000 per month. The special conditions agreed to in the charter are listed in Appendix B.

At the end of the initial 6-month charter period, the contract was extended for another 6 months to March 31, 1960 at which time all field activities were terminated. Therefore, the presentation of data included in this report covers a period of a full year from April 1, 1959 to March 31, 1960.

1/ Reorganized into the Department of Agriculture and Conservation on January 23, 1960.

A summary of finances for the program is as follows:

Financial Statement:

Income:

Governor's contingency fund	$ 11,000.00
Donations to Shark Trust Fund	15,704.00
Sale of shark jaws, teeth and fins	736.00
Total	$ 27,440.00

Expenditures:

Charter of Vessel and Crew	$ 24,000.00
Salary of Biologist in charge 2/	462.00
Equipment, materials and supplies	1,490.00
Repair of equipment and gear	530.00
Misc. (advertising, ice, cold storage, office supplies, food for Biologist, etc.)	958.00
Total	$ 27,440.00

Techniques Used:

The gear employed to fish for sharks consisted of three units of specially designed set lines. The main line of each unit which measured about one-half mile in length was made up of connected 10 fathom sections of one-half inch Manila rope (or three-eights inch nylon.) To the main line, 24 hooks attached to gangens of three fathom lengths were suspended at ten fathom intervals. When fished, the main line of each unit was anchored at both ends. Buoys were attached to the main line by means of a 10 fathom float line at every four hook interval to prevent the gear from fouling on the bottom. Details of the sharking gear are illustrated in Figure 1.

The general pattern of fishing was to set the gear in inshore waters (25 fathoms depth) more or less parallel to the shoreline with the units spaced at intervals of one-half to one mile. Normally the lines were set in the afternoon and retrieved at dawn or early morning. Initially, porpoise flesh was used as bait but eventually the porpoises became too difficult to capture. Subsequently, skipjack (Katsuwonus pelamis) caught by the crew of the HOLOKAHANA I or obtained through the courtesy of the Honolulu Biological Laboratory of the U.S. Fish and Wildlife Service were used as bait.

2/ The bulk of the salary of the Biologist in charge was borne by the Board of Commissioners of Agriculture and Forestry.

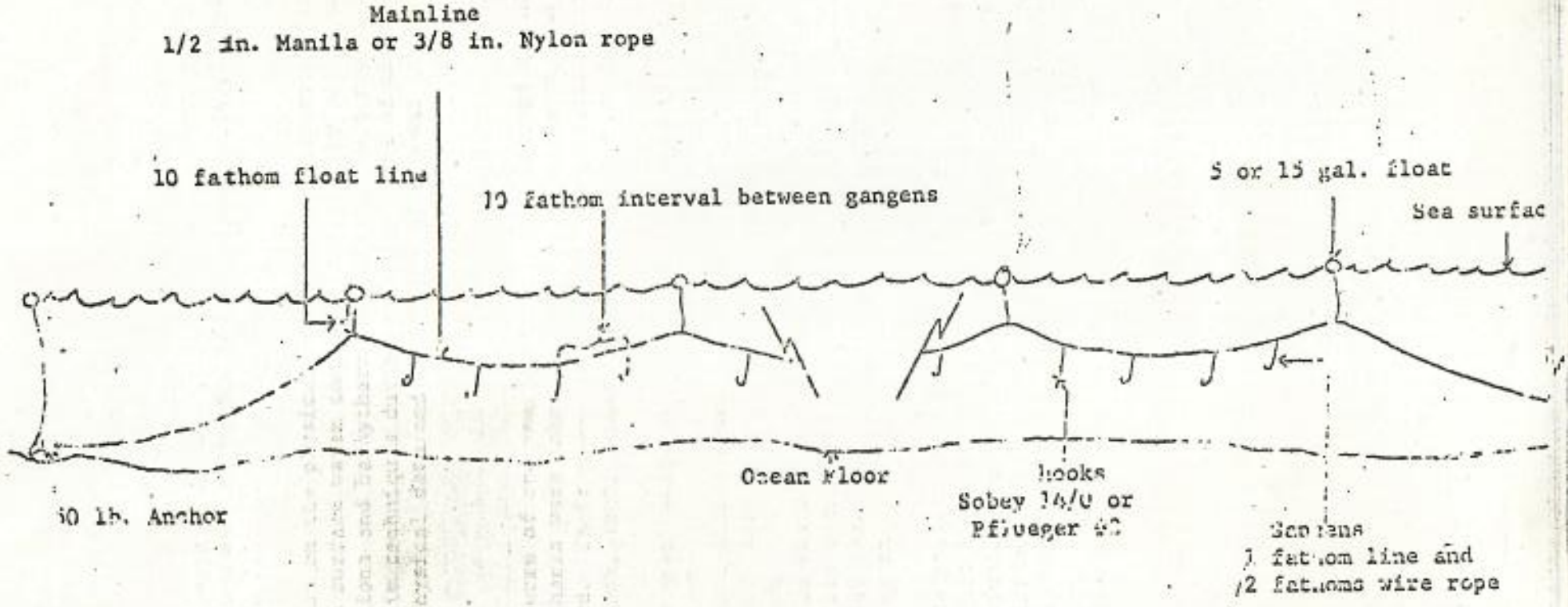


FIGURE 1 - Arrangement Of A Unit Of The 24-hook Shark Gear Showing Anchors, Floats, Mainline and Gangens.

Biological data taken of each captured shark consisted of species identification, total length measurement, weight determination (when possible), and examination of the stomach contents. Also, each shark was sexed and the fetuses from gravid females were counted, measured and sexed. After a few months of sampling, data collection also included recording condition of the uterus, the presence and size of eggs in the ovary or in the uterus and the presence or lack of milt in the vas deferens. The form used to record the various biological observations is illustrated in Figure 2.

For information on the physical and chemical characteristics of the sharks' environment, data on surface water temperature, salinity, water color, water clarity, wind conditions and bathythermal conditions were routinely collected using standard oceanographic techniques during each day's set of the shark lines. The log used to record physical data and conditions of the set is shown in Figure 3.

Taxonomy:

During the course of one year's shark fishing aboard the HOLOKAHANA I, at least 9 species of sharks were taken. Throughout the report, the common names of these sharks are used. Their names and scientific equivalents are as follows: (from Gosline and Brock, 1960; Tinker, 1944 and Bigelow and Schroeder, 1948.)

Sand (or grey) shark(s)	Eulamia sp.
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.

In view of the present confused status of the taxonomy of sharks, there are reasons to believe that a few of the species identification may be in error. Involved in this confusion are the so-called "sand or grey" sharks, Eulamia sp. of the family Carcharhinidae. Gosline and Brock (1960) states, "..... and the classification of the many Pacific species of the Carcharhinus-Eulamia complex is utterly hopeless at the present time. Far more intensive and extensive work on a world-wide basis will have to be done before this situation is rectified."

There is a suspicion that the sand or grey sharks caught during the program may be represented by more than one species. This possibility was disclosed just prior to the termination of the shark fishing phase, therefore, subsequent sampling of sand sharks was inadequate to firmly establish any basis for segregating the species. Hence, the sand sharks are treated as a single species in this report.

Positive identification of the group of sharks referred to as the black-tipped shark has not been determined. Whether this group involves more than one species is also not known, and it is believed too, that sampling on a world-wide basis by taxonomists is necessary to rectify this situation.

FIGURE 2. Shark Research and Control Catch Log

Date ____ Set # ____ Sect. ____ of ____ Sections

Hk#	Hk. Size	Bait	Bait on or off & Sprung Hk.	Species caught	Total Length (in.)	Wt. (Lbs.)	Sex	Code No.	Remarks & % damage by Sharks
1									
2									
3									
4									
5									
6									
7									
8									
9									
10									
11									
12									
13									
14									
15									
16									
17									
18									
19									
20									
21									
22									
23									
24									

Code No.	Embryos SEX no.	Male	Female	Total Length embryos Male	Female	Nuptial Scar Cond.	Stomach Contents	Remarks Uterus Lge./ Sml.	Egg size in	Milt/ No mi
									uterus	
									ovary	

FIGURE 3. Shark Research And Control Fishing Log

Set No. _____ Sheet 1 of _____

Vessel _____ Date _____ Observer _____

General Locality _____

Physical Observations	At Set		At Recovery	
Date				
Time of Observation				
Cloud Cover (%)				
Air Temperature				
Wind Force (Beaufort)				
Wind Direction				
Sea Condition				
Weather (number)				
Current Direction				
Surface Water Temp.				
BT Slide No.				
Water Clarity				
Surface Salinity				
Water Color				

Summary of Gear Set

	Sect. 1	Sect. 2	Sect. 3	
Position Bearings (1)				
(2)				
(3)				
Latitude-Longitude				
Time Start Set				
Time End Set				
Time Start Recovery				
Time End Recovery				
Direction of Set				
Direction of Recovery				
Anchored or Drifting				
Length of Float Line				
Distance Mks. off Bottom				
Type of Bottom				
Water Depth at Start				
Water Depth at End				
Distance between Buoys				

Remarks:

Biologists of the U.S. National Museum, Smithsonian Institution, are presently collecting shark specimens and morphological information for classification purposes. It is hoped that through this work proper classification of the sharks of the Pacific can be established. Specimens of the six-gilled shark, Cooke's shark and deep water stingray caught during the program were sent to the U.S. National Museum for identification. Positive identification of these three fishes are still pending.

Recent communications from the U.S. National Museum revealed also the probable presence of a long-finned and a short-finned Mako shark in Hawaiian waters.

Results:

Upon complete fabrication of the fishing gear the HOLOKAHANA I commenced fishing operations on April 20, 1959 with an experimental shakedown cruise off Ala Moana. The objectives of this cruise were:

1) To test out the new gear and to eliminate possible flaws.

2) To obtain comparison data regarding the optimum fishing depth through examination of variation in catch rates with depth.

3) To obtain comparison data regarding the optimum fishing time through examination of variation in catch rates with time of day (especially, difference in diurnal and nocturnal catch rates.)

The results of this cruise indicated that the gear was adequate for shark sampling and that fishing with hooks dangling near the bottom in areas with depths of about 150 feet would be most productive. The 24 hook units set at depths of 40 feet and 100 feet caught 9 sharks each during a 48 hour period. During the same period, the unit set at a depth of 150 feet caught 46 sharks. Great difficulty was experienced in handling the gear during sets made at depths of 300 feet or more and parts of the gear were lost due to the line fouling on an acutely sloping bottom starting near the 300 feet depth. Therefore, the fishing results from the 300, 400 and 500 feet sets were not conclusive; however, judging from the partial results, it appeared unlikely that the catches from these deeper sets would comprise species normally taken from shallower areas.

Results from the 48 hour continuous fishing experiment during this shakedown cruise indicated that sharks can be caught at night as well as during the day. Thirty-five sharks were caught during the night sets and 29 during the day sets. From these results, it appeared that night fishing may be more productive than day fishing. Also, during the day, fishes such as the trigger fishes tended to strip the bait off the shark hooks.

Thus, it was decided that the 3 units of lines would be employed more effectively if they were set in the late afternoon and retrieved early the next morning. As a standard procedure it was further decided that the lines would be set whenever practical at or near the 150 foot depth with hooks dangling near the bottom.

After replacing lost gear and making repairs to damages, the HOLOKAHANA I began routine shark fishing operations on May 17, 1959. By the end of March, 1960, the vessel was able to make four complete fishing circuits around the island of Oahu. The day to day fishing localities and results are shown in Table I.

A total of 697 sharks plus 641 unborn pups were destroyed. The species breakdown, percentage, and size range of the sharks caught were as follows:

TABLE I. Catch Data For Shark Research And Control Program
April, 1959 to March, 1960

Date	Locality	Number Caught						
		No. of Units set	Sand	Tiger	Sml. Blk Tip.	Others	TOTAL	Remarks
4/20-22/59	Ala Moana	3 for 48 hrs.	59	3	2	-	64	Shakedown Cruise
4/27-30/59	Ala Moana	-	4	-	-	1	5	" "
5/18/59	Kalihi	3	11	-	-	-	11	
5/19/59	Ewa Beach	3	16	1	1	-	18	
5/21/59	Ewa Beach	3	10	-	1	-	11	
5/26/59	Lanikai	2	12	1	-	-	13	
5/27/59	Lanikai-Kailua	3	11	3	-	-	14	
5/28/59	Kailua	3	5	1	-	-	6	
5/29/59	Kaneohe	3	3	1	-	-	4	
6/3/59	Barbers Pt.	3	5	-	-	1	6	
6/4/59	Barbers Pt.-Browns Camp	3	4	2	-	-	6	
6/5/59	Nanakuli	3	5	-	-	-	5	
6/6/59	Nanakuli-Maile	3	4	1	-	-	5	
6/10/59	Waianae-Maile Pt.	2	1	-	-	-	1	1 unit lost
6/11/59	Pokai Bay	2	7	-	-	-	7	
6/12/59	Lahilahi Pt.	2	1	-	1	-	2	
6/13/59	Waikiki	2	9	-	-	-	9	
6/25-7/3/59	Ala Moana-Ewa	-	18	2	6	7	33	50th State Fair
7/21/59	Black Pt.	3	7	-	1	-	8	
7/22/59	Makua	3	7	1	3	-	11	
7/23/59	Haleiwa	3	3	3	-	-	6	
7/24/59	Waialee-Kahuku	3	4	4	-	-	8	
7/25/59	Kahuku Pt.	3	3	1	2	-	6	
7/26/59	Waialee	3	5	2	3	-	10	
7/27/59	Waialee-Waimea	3	3	4	-	-	7	
7/28/59	Waimea-Haleiwa	3	2	3	-	-	5	
7/29/59	Mokuleia	3	5	-	-	1	6	1 mako shark
7/30/59	Kawaihapai-Kaena	3	8	1	-	-	9	
8/4/59	Black Pt.-Koko Head	3	2	1	-	-	3	"Hurricane Dot"
8/12/59	Koko Head-Blow Hole	3	5	2	1	-	8	
8/13/59	Blow Hole-Makapuu	3	4	1	1	-	6	
8/14/59	Rabbit Is.-Makapuu	3	6	-	1	1	8	
8/19/59	Barbers Pt.-Airport	3	10	9	2	-	21	
8/20/59	Barbers Pt. Ewa	1	-	-	-	-	0	2 units damaged
8/21/59	Ewa Beach	2	-	-	-	-	0	
8/24/59	Kaneohe-Mokolii Is.	3	7	3	-	-	10	

TABLE I. (Continued) Catch Data For Shark Research And Control Program
April, 1959 to March, 1960

Date	Locality	Number Caught					TOTAL	Remarks
		No. of Units set	Sand	Tiger	Sml. Blk Tip	Others		
8/28/59	N.W. Kaneohe Bay	3	1	-	6	-	7	
8/29/59	Kualoa Pt.-Kaaawa	3	8	1	4	-	13	
8/30/59	Laie Pt.-Kahuku	3	6	1	-	-	7	
8/31/59	Punaluu-Laie	3	3	2	-	-	5	
9/1/59	Kahana Bay-Punaluu	3	5	1	3	-	9	
9/2/59	S.E. Kaneohe Bay	3	1	1	3	2	7	
9/3/59	Lanikai	3	5	1	1	-	7	
9/9/59	Waikiki	3	2	-	-	-	2	
9/10/59	Black Point	2 2/3	-	-	-	-	0	Part of line lost
9/15/59	Waianae-Maile	3	6	1	-	-	7	
9/16/59	Kaena Pt.-Makua	3	5	3	2	-	10	
9/17/59	Makua-Makaha	3	2	-	-	-	2	
9/18/59	Nanakuli-Maile	3	3	-	-	-	3	
9/22/59	Malakole-Nanakuli	3	2	1	-	-	3	
9/23/59	Kahuku	3	5	-	-	-	5	
9/24/59	Kahuku-Waialee	3	5	1	-	1	7	
9/25/59	Waialee-Waimea	3	2	-	-	-	2	
9/26/59	Waimea	3	5	-	2	-	7	
9/27/59	Waimea-Haleiwa	3	5	-	2	-	7	
9/28/59	Kaena-Kawaihapai	3	2	-	2	-	4	
9/29/59	Wailua-Haleiwa	3	1	-	-	-	1	
9/30/59	Kawaihapai-Mokuleia	3	1	-	-	-	1	
10/7/59	Kaneohe	3	3	-	1	-	4	
10/8/59	Kailua-Lanikai	3	2	1	-	-	3	
10/9/59	Waimanalo-Lanikai	3	4	-	-	-	4	
10/10/59	Mokolii Is.-Kahana	3	2	-	1	-	3	
10/11/59	Kahuku-Laie	3	2	1	-	-	3	
10/12/59	Punaluu-Laie	3	1	-	1	-	2	
10/13/59	Kahana Bay	3	-	-	1	-	1	
10/14/59	N.W. Kaneohe Bay	3	-	-	-	-	0	
10/21/59	Wailupe-Koko Head	3	-	-	-	-	0	
10/22/59	Waikiki	3	2	1	1	-	4	
10/23/59	Blow Hole-Makapuu	3	-	-	1	-	1	
10/24/59	Waimanalo-Lanikai	3	2	-	-	-	2	
10/25/50	Pearl Hbr.-Kalihi	3	2	1	1	-	4	
10/26/59	Pearl Hbr.-Ewa	3	2	-	1	-	3	
10/27/59	Barbers Pt.-Malakole	3	1	-	1	-	2	
10/28/59	Ala Moana-Hon. Hbr.	3	1	-	-	-	1	
11/6/59	Ala Moana	28 hooks	4	1	-	6	11	Special deep set
11/9/59	Ala Moana	26 hooks	1	-	-	7	8	" " "
11/15/59	Pearl Harbor	3	4	-	-	-	4	
11/16/59	Pearl Harbor	3	-	-	-	1	1	
11/17/59	Pearl Harbor	2 2/3	6	-	2	-	8	
11/22/59	Barbers Pt.-Ewa	3	6	-	-	-	6	
11/23/59	Ewa	3	-	-	1	-	1	

TABLE I. (Continued) Catch Data For Shark Research And Control Program
April, 1959 to March, 1960

Date	Locality	Number Caught						Remarks
		No. of Units Set	Sand	Tiger	Sml. Blk. Tip	Others	TOTAL	
11/24/59	Browns Camp-Maile	3	1	-	1	-	2	
11/25/59	Maile-Pokai Bay	3	4	-	-	-	4	
12/2/59	Makaha,-Makua	3	2	1	-	-	3	
12/3/59	Makua-Kaena	3	11	1	1	-	13	
12/4/59	Haleiwa-Waialua	3	4	-	-	-	4	
12/5/59	Kaena Pt.-Kawaihapai	3	4	-	-	-	4	
12/6/59	Kawaihapai-Mokuleia	3	6	-	-	-	6	
12/7/59	Kahuku-Waialee	3	4	-	1	1	6	1 great white shark
12/8/59	Waialee-Waimea	3	1	-	-	-	1	
12/9/59	Waimea-Haleiwa	3	1	-	-	-	1	
12/10/59	Pokai Bay-Kepuhi Pt.	3	1	-	-	-	1	
12/19/59	Koko Head-Blk. Pt	3	2	-	-	-	2	
12/20/59	Diamond Hd.-Kewalo	3	1	2	-	-	3	
1/6/60	N.W. Kaneohe Bay	3	2	1	-	1	4	
1/7/60	Kailua-Mokapu	3	2	1	-	-	3	
1/8/60	Mokapu-Kaneohe	3	1	1	-	-	2	
1/9/60	Kaneohe	3	-	1	1	-	2	
1/10/60	Kaneohe Bay	3	1	-	1	-	2	
1/11/60	Kaneohe Bay	3	1	-	1	-	2	
1/12/60	Kaneohe Bay	3	1	-	1	1	3	
1/15/60	Kahuku-Laie	3	3	1	-	-	4	
1/16/60	Laie Pt.-Punaluu	3	1	-	-	-	1	
1/17/60	Punaluu-Kaoio Pt.	3	1	-	-	-	1	
1/18/60	Lanikai-Kailua	3	-	-	1	-	1	
1/19/60	Waimanalo-Lanikai	3	2	-	-	½	2	
1/20/60	Kewalo-Kalihi	3	2	-	-	1	3	1 great blue shark
1/26/60	Makapuu-Sandy Bch.	3	1	1	-	-	2	
1/27/60	Hanauma Bay-Sandy Beach	3	-	-	-	-	0	
1/29/60	Pearl Harbor	3	4	-	-	1	5	
1/30/60	Pearl Harbor	3	3	-	2	1	6	
2/4/60	Kalihi-Pearl Hbr.	3	-	1	-	-	1	
2/5/60	Pearl Hbr.-Ewa	3	3	-	-	-	3	
2/6/60	Barbers Pt.-Airport	3	3	-	-	-	3	
2/7/60	Barbers Pt.-Browns Camp	3	2	-	-	-	2	
2/8/60	Browns Cmp.-Maile	3	1	-	-	-	1	
2/9/60	Maile-Pokai	3	2	1	-	-	3	
2/10/60	Pokai-Kepuhi Pt.	3	1	-	1	-	2	
2/11/60	Kepuhi Pt.-Makua	3	-	-	-	-	0	
2/12/60	Ewa	3	-	-	-	-	0	
2/17/60	Makua-Kaena	3	4	1	-	-	5	
2/18/60	Waialee-Waimea	3	1	-	1	-	2	
2/19/60	Kahuku-Waialee	3	-	-	-	-	0	
2/20/60	Waimea-Haleiwa	3	2	-	-	-	2	
2/21/60	Haleiwa-Waialua	3	-	-	1	-	1	

TABLE I. (Continued) Catch Data For Shark Research And Control Program
April, 1959 to March, 1960

Date	Locality	No. of lines set	Number Caught				TOTAL	Remarks
			Sand	Tiger	Sml. Blk Tip	Others		
2/22/60	Wailua-Mokuleia	3	-	1	-	-	1	
2/23/60	Mokuleia-Kawaihapai	3	-	1	1	-	2	
2/24/60	Kawaihapai-Kaena	3	1	-	1	-	2	
2/25/60	Diamond Hd.-Ala Moana	3	1	-	1	-	2	
3/3/60	Makapuu-Rabbit Is.	3	3	-	-	-	3	
3/4/60	Waimanalo-Lanikai	3	-	1	-	-	1	
3/5/60	Lanikai	1	2	1	-	-	3	
	Kaneohe-Bay	2	-	-	-	-	0	
3/6/60	Kaneohe	2	1	-	-	1	2	1 great white shark
	Kaneohe Bay	1	-	1	1	-	2	
3/7/60	Mokapu-Lanikai	2	2	-	-	-	2	
	Kaneohe Bay	1	-	-	-	-	0	
3/8/60	Laie-Kahuku	3	2	-	-	-	2	
3/9/60	Kaneohe Bay	2	-	-	-	-	0	
	Kaneohe	1	-	-	-	-	0	
3/10/60	Kahana Bay-Hauula	3	-	1	-	-	1	
3/11/60	Mokolii Is.-Kahana Bay	3	2	-	-	-	2	
3/12/60	Sandy Beach-Hanauma	3	-	-	1	-	1	
3/18/60	Koko Head-Blk. Pt.	3	1	-	-	-	1	
3/19/60	Kewalo-Kalihi	3	1	1	-	1	3	
3/20/60	Kalihi-Pearl Harbor	3	1	-	-	-	1	
3/21/60	Pearl Harbor	3	2	-	-	-	2	
3/22/60	Pearl Harbor	3	-	-	-	1	1	
3/29/60	Ala Moana	1						(Line fouled on bottom and lost) Deep Set

Species	Number	Percent Of Total	Size range (ft. and inches)
Sand	492	70.6	3' 3" - 9' 3"
Tiger	87	12.5	4' 0" -14' 8"
Smallblack-tipped	81	11.6	4' 6" - 7' 8"
Hammerhead	18	2.6	1'10" -10' 6"
Six-gilled	11	1.6	9' 5" -10' 10"
Great white	2	0.3	10' 10"-11' 5"
Cooke's	3	0.4	7' 5" -10' 10"
Great blue	1	0.1	7' 6"
Mako	1	0.1	11' 8"
Unidentified	1	0.1	8' 10"
Total	697		

In terms of the number of sharks caught per unit of gear set, the availability of sharks in the waters around Oahu showed a progressive 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 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 No.	Sand Catch Unit	Tiger No.	Tiger Catch Unit	Sml.Blk.Tip. No.	Sml.Blk.Tip. Catch Unit	Others No.	Others Catch Unit	TOTAL No.	TOTAL 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	

The results tabulated in Table 2 do not include the sharks caught during the experimental shakedown cruise, special deep water sets and those caught for a live shark display during the 50th State Fair. The fishing effort expended during these special attempts were not comparable to those of the routine fishing.

Figure 4 shows the total number of sharks caught in 17 arbitrarily designated areas around Oahu. These results include the sharks caught during the special attempts.

Food and Feeding Habits:

To determine the food and feeding habits, the sharks were dissected and stomachs examined as soon as possible after retrieving the gear. Each of the items found in the stomach was identified as accurately as possible and the numbers of each item recorded. The food items most frequently occurring in the stomachs and the abundance of these items in each stomach were used to determine the importance of the various foods in the diet of the sharks. Table 3 summarizes the items found in the three most important species of sharks captured, namely, the sand, tiger and small black-tipped sharks. Although stomachs that were empty were also recorded, only the stomachs containing ingested material were utilized in calculating the percent frequency of occurrence. Since much of the ingested material were in advanced stages of digestion (especially fishes) it was not possible to identify these remains even grossly to families.

Figure 5 graphically illustrates the major food items found in the stomachs of the sand, tiger and small black-tipped sharks.

Of the 424 sand shark stomachs examined, 166 or 39.2 percent contained ingested material. As shown in Figure 5, fishes and cephalopods (mostly octopus) composed the primary food item. Of the 12 fish families identified, it appeared that the eels, goat fishes and lizard fishes were preyed upon most frequently.

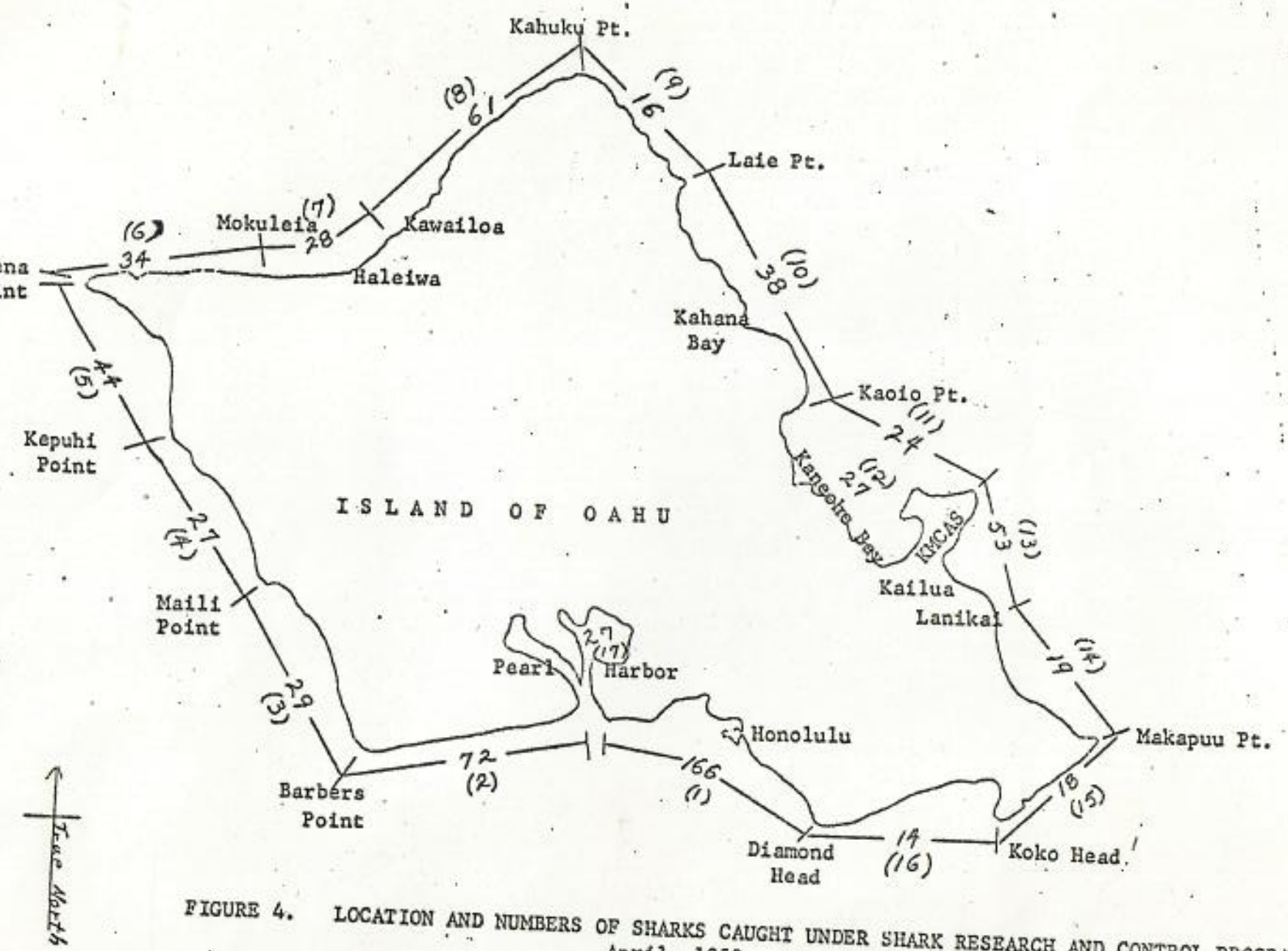


FIGURE 4. LOCATION AND NUMBERS OF SHARKS CAUGHT UNDER SHARK RESEARCH AND CONTROL PROGRAM
April, 1959 to March, 1960

Note: The numbers in parenthesis are arbitrarily designated areas

TABLE 3. CHECKLIST OF FOOD ITEMS FOUND IN THE STOMACHS OF

166 SAND SHARKS - 65 TIGER SHARKS - 43 SMALL BLACK-TIPPED SHARKS

Food Items	Sand Sharks			Tiger Sharks			Small black-tipped		
	No. of Organisms	Stomach Containing Food items		No. of Organisms	Stomach Containing Food items		No. of Organisms	Stomachs containing Food items	
		No.	Percent		No.	Percent		No.	Percent
Crustacea:	8	8	4.8	19	15	23.1			
Spiny Lobster (Panulirus sp.)	2	2	1.2	14	12	18.5			
Kona crab (Ranina serrata)	2	2	1.2	2	2	3.1			
White crab(Portunus sanguinolentus)	2	2	1.2	-	-	-			
Unidentified crabs	2	2	1.2	2	2	3.1			
Isopods	-	-	-	1	1	1.5			
Cephalopods:	64	61	36.7	20	20	30.8	24	23	53.6
Octopus (Polypus sp.)	60	58	34.9	20	20	30.8	24	23	53.6
Squids	4	3	1.8						
Fish:	121	101	60.8	38	31	47.7	26	21	48.8
Parrot fish (Scaridae)	6	6	3.6	1	1	1.5	1	1	2.3
Spiny puffer (Diodontidae)	2	2	1.2	1	1	1.5	-	-	
Unidentified puffer	3	3	1.8	11	11	16.9	1	1	2.3
White eel (Congridae)	3	3	1.8		-	-	-	-	
Unidentified eels	13	13	7.8	4	4	6.2	5	5	11.6
Goatfish (Mullidae)	12	12	7.2	3	3	4.6	2	2	4.6
Lizard fish (Synodontidae)	12	12	7.2				1	1	2.3
Leatherback (Scomberoides sancti-petri)	1	1	0.6						
Trigger fish (Balistidae)	5	5	3.0						
Bone fish (Albula vulpes)	5	5	3.0	2	2	3.1	1	1	2.3
Opelu (Decapterus pinnulatus)	18	4	2.4						
Unicorn fish (Naso sp.)	1	1	0.6	1	1	1.5	5	5	11.6
Amberjack (Seriola dumerilii)		-	-	3	3	4.6			
Aawa (Bodianus bilunulatus)		-	-	-	-		1	1	2.3
Palani (Acanthurus dussumieri)		-	-	1	1	1.5			
Ulua (Caranx sp.)				1	1	1.5			
Scorpion fish (Scorpaenopsis sp.)	1	1	0.6		-	-			

TABLE 3. (Continued) CHECKLIST OF FOOD ITEMS FOUND IN THE STOMACHS OF

166 SAND SHARKS - 65 TIGER SHARKS - 43 SMALL BLACK-TIPPED SHARKS

Food—Items	Sand Sharks			Tiger Sharks			Small black-tipped		
	No. of Organisms	Stomach containing food items		No. of Organisms	Stomach containing food items		No. of Organisms	Stomach containing food items	
		No.	Percent		No.	Percent		No.	Percent
Fish (continued)									
Flying fish (Exocoetidae)	1	1	0.6		-	-			
Stingray (Dasyatidae)	4	4	2.4	2	2	3.1			
Unidentified fishes	34	34	20.5	8	8	12.3	9	9	20.9
Shark remains		7	4.2		15	23.1		2	4.6
Coral shell & sea weeds		5	3.0		-	-			
Turtles		-	-	7	7	10.8			
Birds	2	2	1.2	9	9	13.9			
Mammals remains		7	4.2		5	7.7			
Garbage		14	8.4		4	6.2		1	2.3
Coconut leaf		-	-		2	3.1			
TOTALS:									
Number of stomachs containing food items		166	39.2		65	82.3		43	62.3
Number of empty stomachs		258	60.8		14	17.7		26	37.7
Number of stomachs examined		424			79			69	

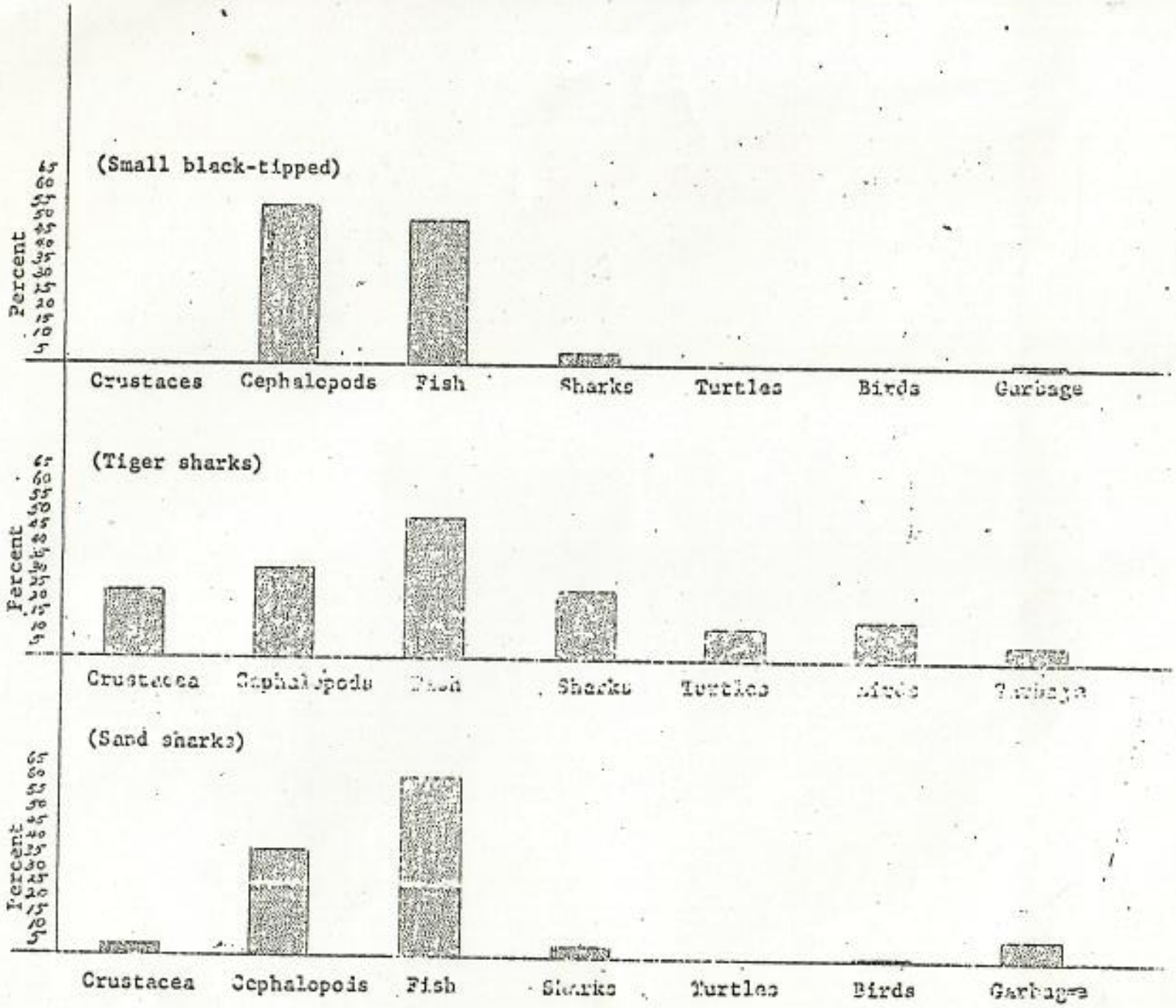


FIGURE 5. PERCENTAGE OF OCCURRENCE OF THE MAJOR FOOD ITEMS

Although a few fast swimming fishes were also eaten by the sand sharks, 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.

Unlike the sand shark, a much higher percentage of the tiger shark stomachs contained ingested material for of the 79 stomachs examined, 82.3 percent contained food items. Fish, cephalopod (octopus) and crustacea, 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 sharks examined for some of the ingested materials found in the tiger shark stomachs were birds, turtles, garbage (mammal bones, grapefruit rind and discarded 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.

Of the 69 small black-tipped shark stomachs examined, 62.3 percent contained food items. Octopus appeared to be the most important dietary item followed by various species of fish. Of the eight fish families identified from the stomachs of the small black-tipped shark, the eels, and a species of surgeon fish were the most commonly occurring forms.

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 2 stomachs, one contained an octopus and the other a belonid (needlefish). 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 of one Cooke's shark stomach disclosed the remains of a shark and a badly digested fish.

Judging from the above results, it appears that the three most frequently caught sharks (sand, tiger and small black-tipped) are primarily bottom foragers. The tiger shark appears to be more opportunistic than the others and also seems to forage near the surface.

Reproduction: Sand Sharks

The smallest gravid sand shark caught measured 5 feet and the largest was 9 feet 3 inches in total length. The 43 gravid sand sharks contained a total of 252 fetuses, with a mean number per gravid female of 6. The smallest fetus measured 1 inch and the largest was 32 inches in total length. The 5 feet female carried only 3 fetuses while the 9 feet 3 inch female carried 8. The greatest number of fetuses found was 9. These were observed from individuals measuring 5 feet 6½ inches and 6 feet 0 inches in total length.

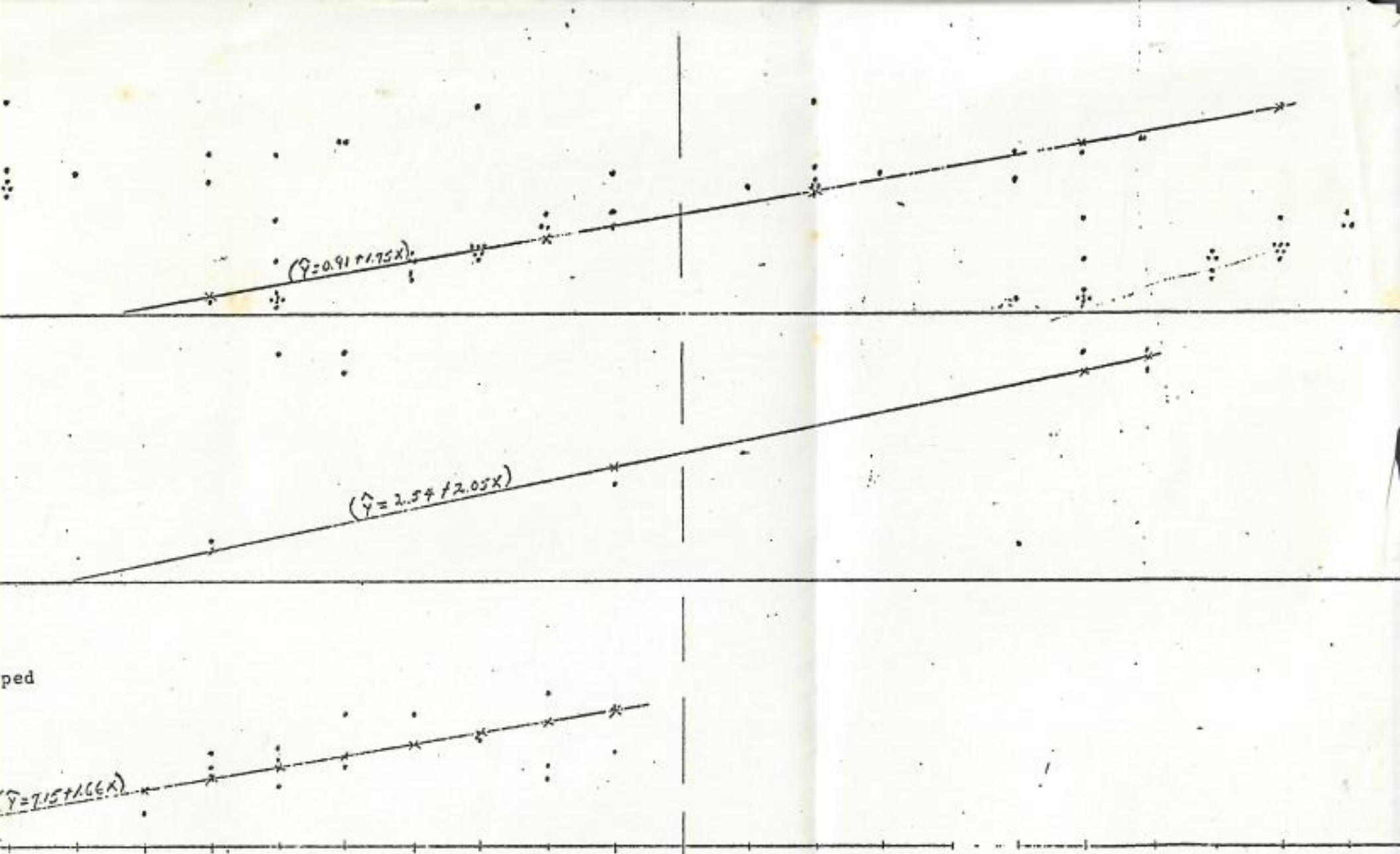
To determine the approximate gestation period, the mean total lenths of 43 litters of sand sharks were plotted by months as shown in Figure 6-A. Fetuses were found throughout the year but the 1 and 2 inch size fetuses appear in August and September only. During the same months, females with fetuses as large as 24 inches in total length were also found. This indicates a gestation period of over a year. Examination of the distribution of the plotted "points" in the figure suggests that there are 2 "populations" of mean fetus sizes. Since only one year's fishing data were available, the increase of the mean fetus size to full term could not be followed. In order to approximate the full gestation cycle, the data were replotted as if fishing had been continued. The manner in which the replotted "points" fitted into the graph indicates a close approximation. A regression line fitted into the data by the least squares method (Snedecor, 1948) intersects the base line 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 32 inches by late fall or early winter of the following year. Using November as the midpoint of the termination of the gestation period, it is hypothesized that the total gestation cycle takes 17 months. Two litters, with mean lengths of 32 and 14 inches were found in May and September, respectively. It is believed that these were aberrant samples or a result of possible errors made in species identification.

There is a possibility that Pearl Harbor is some sort of nursery ground for the sand sharks. Of 19 sand sharks caught in that area all were females and nine were pregnant. Of the 10 non-pregnant sharks, 8 were small sharks below 5 feet 4½ inches in total length and the remaining 2 were larger sharks caught in March when the pupping season should have been over.

Reproduction: Tiger Sharks

The smallest gravid tiger shark caught aboard the HOLOKAHANA I measured 13 feet 1 inch and the largest 14 feet 1 inch. The number of fetuses found ranged from 16 to 57. (One female caught was observed giving birth to pups after she was hooked and tied to the bow of the vessel. Ten pups were still in the uterus when the shark was cut open and 6 pups were observed following the vessel. These were netted, measured, tagged and released. Others which may not have been seen may have been expelled by 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 above mentioned pups, the mean number per litter of the 4 other females is 39 fetuses.

Although only 5 mean total lengths of litters of tiger sharks were available, these were plotted in Figure 6-B because of the dearth of information generally available on the reproductive habits of the tiger shark. Following the same reasoning and procedure utilized for the sand shark, a regression line was fitted to the data by the least squares method. The line intersects the base line in June. This coincides very closely with the field observation of a female tiger shark with what appeared to be fertilized eggs in both uteri during the month of June. In addition, 2 females with near-term pups (32-35 in.) were caught in October. 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.



A Plot Of The Mean Total Length Of Fetuses Found In Each Gravid Shark By Month.

Each dot represents a litter. Regression line by least squares method.

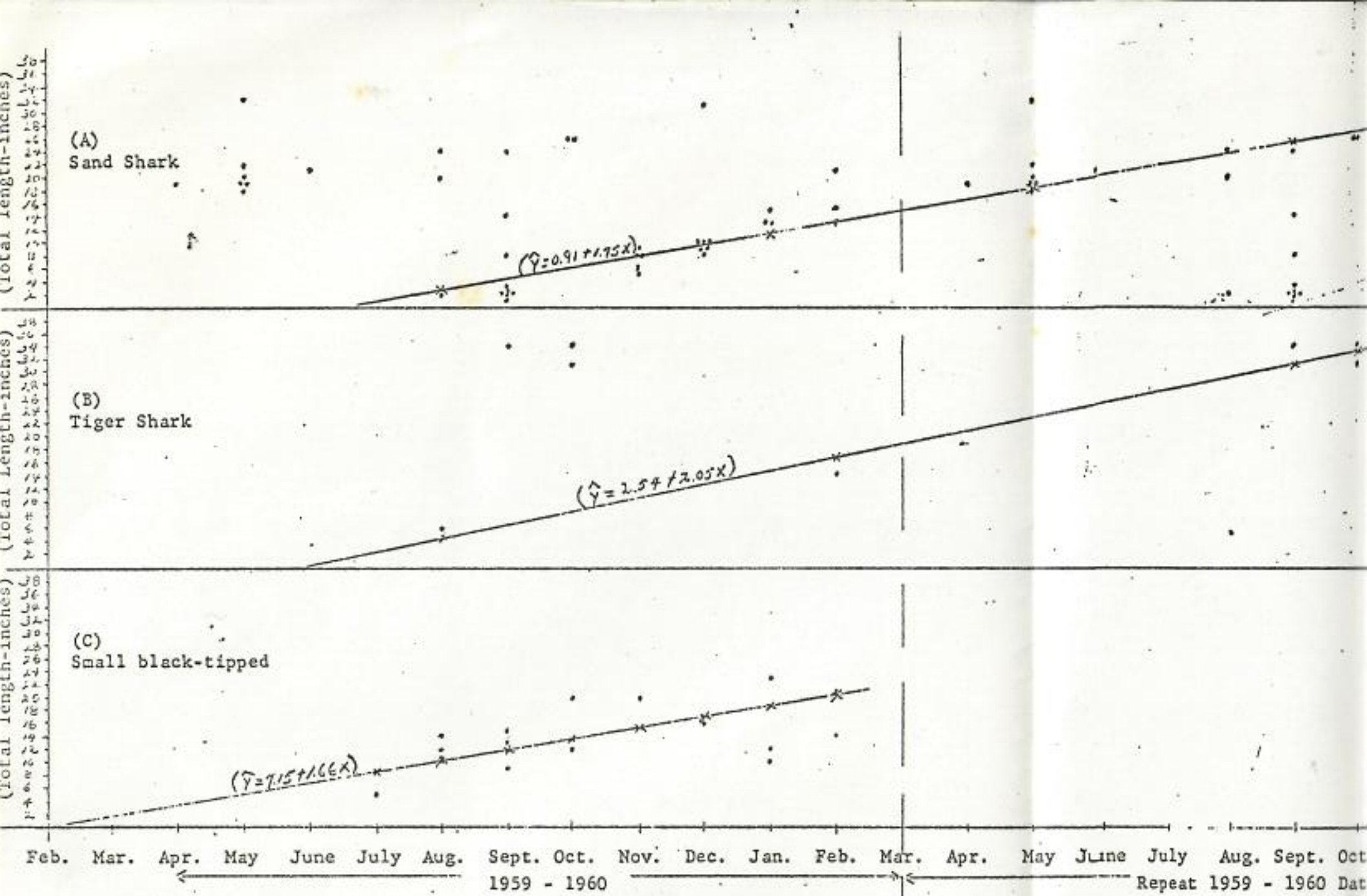


FIGURE 6. A Plot Of The Mean Total Length Of Fetuses Found In Each Gravid Shark By Month.

Each dot represents a litter. Regression line by least squares method.

Reproduction: Small black-tipped sharks

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 of fetuses per litter amounts to 5 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 6-C, the mean total length plots of each litter does not appear to be distributed into 2 groups as does the plots for the sand and tiger sharks. It appears that the gestation cycle of the small black-tipped shark is completed within a year. The regression line calculated by the least squares method intersects the base line in February, which is assumed to be the midpoint of the mating season. The largest fetus found in the small black-tipped shark measured 23 inches and was from a female caught in January. Therefore, if January is assumed to be the midpoint of the pupping season, the gestation period of the small black-tipped shark is estimated at approximately 11 months. The smaller mean size litters plotted in January and February appear to be misidentification of species rather than aberrant samples. These points coincide very closely with the sand shark data.

Miscellaneous Observations:

A cursory examination of the physical data such as water clarity, surface water temperature, water color and vertical water temperature did not reveal any obvious information that would be useful in future shark control work. Perhaps a more refined and intensive sampling regime than was undertakable during the project may offer information which can be put to practical application.

The results of the two successful deep water sets indicate that six-gilled and Cooke's shark may be abundant in depths greater than 480 feet. A point worth noting is that as far as could be determined this is the first catch of the six-gilled shark in Hawaiian waters. The Cooke's shark was first and last reported from the Hawaiian Islands more than 30 years ago. A gravid Cooke's shark contained a total of 114 pups of approximately 24 inches in total length.

During the last few days before the termination of the contract, one attempt at setting a line on the bottom at approximately 1,560 feet was made for exploratory purposes. In spite of precautions taken to keep the line from fouling on the bottom, parts of the line were lost due to snagging, thus, the result was inconclusive.

Ten sand and 4 tiger sharks were tagged and released during the year. The sand sharks tagged, ranged in size from 3 feet 7 inches to 5 feet 7 inches in total length. The 4 tiger sharks tagged were newly born pups measuring 32 to 35 inches in total length. These were tagged and released to determine whether or not the sharks migrate from area to area or establish themselves in a territory and range within this territory. Additionally, information on age, growth and other vital statistics were sought from these tagging studies. However, none of the tagged sharks were recovered following release.

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Appendix A

SHARK RESEARCH AND CONTROL PROGRAM
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Appendix B

WORK AND SPECIAL CONDITIONS

The obligations of the owner and the special conditions that apply are as follows:

1. The effective period for the contract of the vessel shall be for a period of 6 months, with option of renewal if mutually agreeable.

2. The owner shall provide at his own expense a fishing vessel as specified herein and fuel, lube oil, gear, food, water and all equipment, supplies, materials (except materials and supplies to fabricate, repair and maintain the shark fishing gear) labor or facilities required to perform the work as specified herein or in the plan. Ice for storing bait or shark carcasses shall be provided by the Board of Agriculture and Forestry.

3. The owner shall provide at his own expense a Master and two crew members for the vessel. The Board of Agriculture and Forestry reserves the privilege of rejecting with just causes at any time within the effective period of the contract the services of the individuals selected by the boat owner as the Master or crew members of the vessel.

4. When services under the contract is begun, the vessel shall be tight, staunch, strong and well and sufficiently tackled, appareled, furnished and equipped, and in every respect seaworthy and in good running order, condition and repair and in all respects fit and able to perform services as required pursuant to the contract. Specifications of the vessel shall include:

   a. Minimum overall length of 45 feet.

   b. Ice and fish holding capacity of 80 cubic feet.

   c. Capable of storing sufficient provisions and water and providing adequate accommodations for 4 men on extended cruises of at least 10 days duration.

   d. Minimum cruising range of 200 miles.

   e. Radio-telephone communication equipment installed aboard in good operating condition that is capable of maintaining radio contact with the authorized marine radio stations including the U.S. Coast Guard, the commercial ship-to-shore stations and have at least two ship-to-ship frequencies.

   f. Meet with Coast Guard approval relative to fire extinguishing system, life saving equipment, etc.

The Board of Agriculture and Forestry reserves the right to inspect the vessel before and/or after award of contract and to reject the bid or cancel the contract if the vessel does not qualify under these specifications.

5. During the effective period of the contract, the owner shall make the vessel available for 20 fishing days per month as determined by the Board of Agriculture and Forestry.

6. The owner shall carry aboard ship during the specified 20 fishing days per month a biologist or any other person or persons requested to be aboard the vessel by the Board of Agriculture and Forestry. The owner shall follow instructions pertaining to the objectives of the charterer issued by the representative of the Board of Agriculture and Forestry and shall operate with and assist the representative in obtaining and recording species, number, size and sex of sharks caught, the location of all such catches, navigational data necessary for the preparation of a chart of the vessel's cruise track and such other records and biological and oceanographic data as he may desire to collect. Quarters, including bedding shall be provided the Board representatives aboard ship without charge therefore. Meals aboard ship shall be provided the Board representatives at $0.80 per meal payable by the Board to the owner; such payment to be in addition to the contract price payable by the Board. Other than the signed-on crew, only persons authorized by the Board of Agriculture and Forestry shall be permitted aboard the vessel during the specified 20 fishing days per month.

7. All sharks and fish caught in operations pursuant to this contract shall remain the property of the Board of Agriculture and Forestry. All instructions issued by the Board of Agriculture and Forestry relative to the disposal of the shark carcasses or parts thereof shall receive strict compliance by the contractor.

8. No part of the work under contract shall be subcontracted without the prior approval of the Government.

9. The vessel being on her delivery, tight, staunch and strong the owners will maintain her in a thoroughly efficient state in hull and machinery for and during the service.

10. That in the event of loss of time from deficiency of men or stores, breakdown of machinery, fire or damage preventing the working of the vessel for more than 24 hours running, the payment of hire shall cease until she be again in an efficient state to resume her service.

11. The Act of God, enemy, fire, and all dangers and accidents of the seas always mutually excepted.

12. For any substantial breach by the owner, the Board of Agriculture and Forestry reserves the right to cancel this affreightment charter.

13. Nothing herein stated is to be construed as a demise of the boat to the charterer. The owners to remain responsible for the navigation of the boat, insurance, crew and all other matters, same as when trading for their own account.

14. The owner will comply with sections 9-31 to 9-34.

from Tester shark project files

Lotsa baloney

SHARK CONTROL AND RESEARCH PROGRAM

PROPOSAL

FOR THE

COUNTY OF HAWAII

Submitted to

The Department of Economic Development

County of Hawaii

Hilo, Hawaii

Duration: 6 years
Beginning Date: 15 July 1969

Alika C. Cooper
163 Kaiulani Street
Hilo, Hawaii 96720

TABLE OF CONTENTS

SHARK CONTROL AND RESEARCH PROGRAM PROPOSAL
FOR THE COUNTY OF HAWAII

I. BACKGROUND DISCUSSION

At one time shark was of commercial value.....

During the first 50 years of the 1900's, fishing in Hawaii was generally an occupation held by the Japanese people. The shark's meat was of commercial value and in great demand by the people in the fish cake business. Sometime later, the Board of Health stipulated that all products using shark's meat in its ingredients would advertise this fact on the wrapped bag, etc. This new labeling requirement and a sensitive public that was not ready to accept the "shark" concept--although this same purchasing public had always enjoyed eating fish cake of shark meat--created a commercial void for the shark fisherman. Sharks were no longer caught and the shark population increased.

The problem of shark increase was of little concern.....

Public interest in the increase of sharks in the Hawaiian waters was generally passive. Even as reports of shark incidents, two of which are quoted below, intermittently moved into the foreground of attention, the public was generally disinterested. On December 3, 1952, the Honolulu Star-Bulletin headlined the front page, "GIANT SHARK KILLS HONOLULU SKIPPER."

> "A shark said to be over 22 feet long bit off the forearm of Gerbacio Solano, 40 year old Honolulu fisherman, in the waters a mile off Maili today, and the man died from loss of blood."

On December 22, 1955, the Honolulu Advertiser reported, "FISHERMAN MAY LOSE ARM FOLLOWING SHARK ATTACK."

> "A Honolulu fisherman was attacked and his right arm nearly bitten off by a shark yesterday morning off the east coast of Molokai."
>
> "The shark's teeth made one deep laceration which nearly encircled the fisherman's right forearm, doctors said."

The Billy Weaver Fatality ignited public reaction...

Later, public concern and reaction to the increase of sharks and the resultant hazard, rose to a new and profound pinnacle directly after the Billy Weaver tragedy. On December 14, 1958, the Honolulu Advertiser blared the following front page story:

> "A shark at least 15 feet long slipped inside the reef off Lanikai yesterday afternoon, moved unnoticed past a group of happy boys out surfing, and bit off the right leg of 15-year old William (Billy) Weaver. The boy died in the water shortly after."

Following the death of Billy Weaver, in 1959-60, a one year Shark Research and Control Program was conducted. After this one year and for the next five years, the shark population was permitted to increase for the shark was not being fished commercially and it had few natural enemies.

Cooperative Shark Research and Control Program, 1967 to 1969.....

In 1965, Governor John A. Burns appointed an Ad Hoc Shark Advisory Committee that met in the month of May to consider the problem. The present Cooperative Shark Research and Control Program was recommended by a Technical Subcommittee of local fishery scientists. This program, begun in 1967 and planned for a two year period, was largely directed under the auspices of the Institute of Marine Biology, University of Hawaii. However, it has been cooperative in nature for the program has relied, to varying degrees, upon the help and assistance of related agencies. The fishing circuit has provided for four cruises per year to the Kona and Kawaihae areas. (ANNUAL REPORT, 1967-68, Cooperative Shark Research and Control Program, University of Hawaii, June 30, 1968.) This State program is scheduled to end 30 June, 1969. My 50-foot sampan, Alika, and the crewmen in my employ have been with this program for the past year and a half and have been responsible for the actual fishing and disposal of sharks.

An additional Research Program specifically for Mauna Kea Beach Hotel.....

Dr. John Hendrickson, Director of Oceanic Institute, and consultant to the present Cooperative Shark Research and Control program, recommended an additional research project just outside of the Mauna Kea Beach Hotel to augment the amount of shark protection being provided by the present State program, to provide a cross-check on its results, and to permit formulation of the most economical and effective plan for local shark control. This additional program began in September, 1968.

Are there sharks in the waters of Hilo, Kawaihae and Kona.....

Evidence of sightings and "catch" clearly indicate that sharks, including those dangerous to man--frequent the bay waters of Hilo, Kawaihae, and Kona. Evidence also indicate that these sharks may be individual "strays," partners in pairs, and communities of "schools" of adults and litters of pups. Evidence also suggest that the density of shark residence in these bay areas may be accorded a seasonal cycle. However, though this may be, the bay areas are never "free" of sharks during the non-seasonal periods.

1. Sightings of sharks in HILO BAY..

According to reports of sightings by the fishermen who frequent certain areas, schools of Sandbar Sharks, Carcharhinus milberti, are in the HILO BAY during the months of April, May and part of June. These same fishermen have sighted the Hammerhead Shark--considered dangerous to human beings--in the HILO BAY area between the Wailuku River and the first red buoy. Here the Hammerhead Sharks give birth to their pups. Also sighted by the fishermen, pilots, Coast Guardsmen, and other observers, are the Tiger Shark, Galeocerdo cuvieri, Black Tipped Shark, Galapagos Shark, and Gray Reef Shark.

2. Sightings of sharks in KAWAIHAE..

Reports of sightings in the KAWAIHAE area also indicate that schools of Sandbar Sharks breed in a locality closely adjacent to Spencer Park, and again, at a site in front of the "restored" church grounds in Puako. Sightings of sharks here also verify the presence of the Tiger Shark, Galapagos Shark, Black Tipped Shark and the Gray Reef Shark.

3. Recent history of shark attacks in the KAWAIHAE and KONA areas..

Two specific and separate reports of accidental deaths suspected to involve sharks are on file in the records of the Fire Rescue Squad, County of Hawaii.

At Hapuna Beach, on April 7, 1963, P.F.C. Roy Kometani drowned while picking opihi at the south end of Hapuna Beach. On April 8, 1963, the Fire Rescue Squad found parts of the victim's intestines and shreds of his clothing. On April 8, 1963, a large shark swam to the exact spot where the man's intestine was found, then left and headed south.

At Kapulehu, located 18 miles south of Kawaihae, on August 6, 1966, a small airplane crashed in the evening on this date. The three people aboard were Daniel Gardner, Kalani Aldrick, and Mrs. Hilda Captain. On August 7, 1966, the Fire Rescue Squad located the site of the crash. The

airplane was found approximately 600 feet from the shore and in 10 to 12 fathoms of water. No bodies were found. However, torn shirts, torn trousers, a torn sweater, and a litter of other rags and other items of clothing were found. Two large Tiger Sharks were seen in the exact area of the plane crash.

What do research findings reveal about shark behavior and biology.....

To substantiate the reports of sightings, quotations have been extracted from reports compiled by Dr. John Hendrickson, Director of Oceanic Institute, and Dr. Albert Tester, Professor of Zoology and Principal Investigator of the present Cooperative Shark Research and Control Program. Dr. Hendrickson as consultant to the State program has prepared a report entitled "Study of Shark Behavior and Biology, Summary of Activities and Results," January, 1967 - March, 1968.

1. Sandbar Sharks breed in Kawaihae..

Hendrickson stated, "We now have good evidence for a breeding season of the smaller Sandbar Shark, Carcharhinus milberti, and as we gather more data from the Kawaihae area, the suspicion grows that there may be a migration of breeding adults into that area in September-October of each year."

2. Tiger Sharks prey on Sandbar Sharks.

Hendrickson also wrote, "Tiger Sharks exist in much lower concentration, are less restricted to local home ranges than Sandbar Sharks, and wander in randomly from the open sea in a way that Sandbar Sharks do not. While Tiger Sharks are general scavengers and carrion eaters (with a demonstrable liking for mamalian food), they also appear to be important predators on other, smaller sharks. Fully one-fifth of the Tiger Sharks examined for stomach contents so far in this program have contained remnants of other sharks, mostly Sandbar Sharks." Hendrickson concluded, "While admittedly there is not yet sufficient evidence to justify real conclusions, what information we have suggest that there is a definite predator-prey relationship between Tiger Sharks and Sandbar Sharks, and the density of one species in an area is dependent at least in part upon the density of the other. Wandering Tiger Sharks may be more inclined to take up residence in an area if it has an abundance of Sandbar Sharks as potential food supply." (Underlining by author of this project proposal.)

3. Galapagos Sharks in Kawaihae water.....

Hendrickson pointed out that the Kawaihae waters "...have significant resident populations of Galapagos Sharks which we are not getting with present fishing methods."

4. Great White Sharks in Kawaihae water.....

Hendrickson's report further stated, "In the same vein, we cannot forget the three Great White Sharks (one of the most-feared species) which was taken at beginning of our program; we are anxious to begin

fishing tests using live, small sharks as bait. Published information and our evidence from stomach examinations indicate that both Great Whites and Tiger Sharks are important predators upon other, smaller sharks; while the Tiger Sharks are also carrion eaters and catchable with present methods, we could be missing Great Whites which are present."

Dr. Albert Tester, in the Annual Report, 1967-68, "Cooperative Shark Research and Control Program," stated, "Nursery grounds for the young Scalloped Hammerhead Sharks are in shallow water (2 to 5 fathoms; 12 to 13 feet.)" Dr. Tester's finding therefore verifies the fishermen's sighting of the Hammerhead Shark in the Hilo Bay.

5. Shark "catch" in the Mauna Kea Beach Project.....

In September, 1968, an additional research program was begun for the Mauna Kea Beach Hotel. During a nine week period, the permanent fishing line caught a total of 21 sharks, 14 of which were Tiger Sharks. Five of the Tiger Sharks measured over 12 feet long. Six were Sandbar Sharks and one was a Black Tipped Shark.

Can Shark Abundance be controlled...

It is my experience and opinion, and those of others involved in a shark program, that shark abundance can be controlled. It can further be stated that the degree and methods of intensive control measures will directly ascertain control effectiveness and security. Shark Control does not guarantee a "shark vacuum"—a complete and constant depletion of sharks from the bay areas. Shark Control does not guarantee a "seal-proof immunity" from future shark incidents and fatalities.

1. Shark Control insures security.....

Shark Control does offer a system that will "fish out" areas so that the shark population will be controlled and this in turn, will provide greater security to the hundreds and thousands of local residents and tourists who harvest food from the sea, and who bathe, swim, and surf in the bay areas.

2. Shark Control is necessary..

The necessity for Shark Control easily compounds its urgency and importance as the waters of Hilo, Kawaihae, and Kona are more frequently sought out by the growing numbers of local residents and visiting tourists.

II. THE PROPOSED PROJECT: DESCRIPTION, METHOD, AND SCOPE

1. This Program is Primarily a Control System

This shark program proposed for the County of Hawaii is planned and will be operated with one primary objective in view--CONTROL. Although research is also indicated, this phase of the program will be incidental to that of control. Therefore, the system geared to CONTROL will utilize the skills and knowledge of the professional fishermen. It is the experienced line and net fishermen who know the business of fishing and they only can best "fish out" the areas. Some programs of fish research and control have directed the personnel of research to determine "fishing matters" and this has resulted in multiple problems that have frequently terminated in costly adjustments of time and replacement of equipment.

It would be advisable for the evaluators of this project proposal to consider CONTROL as the most focal need. This is not intended to minimize the need and merits of a system of RESEARCH. In view of the information that can be recorded and the findings that can be concluded, RESEARCH will utilize the academic faculties and masteries of the scientist who will serve in the capacity of a consultant to the total program.

2. The Control System will Rely Upon Two Methods of Fishing

The fishing methods will be geared to the behavior and movement of the shark. Research evidence points out two general migratory patterns of sharks into the bay areas. Firstly, there are the sharks that wander into the bay area from the open ocean in search of food. Secondly, there are the "schools" of sharks that breed or nurse in the shallow waters of the bay areas. The system of fishing for control will be planned and operated to catch the wandering shark and the area-resident of the "community" shark.

The control system will fish out areas by Line Fishing and Net Fishing. As research evidence is sometimes in conflict with the productive evidence of a fisherman's catch, one cannot identify and limit the "habitat depths" of the shark to concise fathoms. Therefore, the control ranges of depths will be from 2 fathoms to 30 fathoms, with the greatest concentration placed on 8 fathoms to 10 fathoms.

3. Line Fishing will be Permanent Lines and Daily Lines

The shark lines for Line Fishing will be designed especially for the specification requirements of each of the three general areas - Hilo, Kawaihae, and Kona. These long shark lines will be of two particular types. One type will be the Permanent Lines and the other type will be the Daily Lines.

The Permanent Lines will be set and anchored by 50 pound anchors. These lines will be floating at approximately 6 fe feet below the surface. These Permanent Lines will secure coverage for the duration of the time period set aside for working the specified area. These lines will vary in length, depending upon the natural forces and factors present in the specified area. The length of these lines will have from 10 to 20 hooks. These hooks will vary in design and size. Hooks specification call for number 14 and custom designed blacksmith hooks ranging from 6 inches to 12 inches in height.

The Daily Lines will be set each evening and hauled out the next morning. Information relating to length and hooks is similar to the specifications as mentioned under Permanent Lines.

4. Net Fishing Will Catch the Stray and Surround the School.

Custom-designed nets that measure 18 feet deep to 30 feet deep, and approximately 3,000 feet in length with a mesh of 12 inch eye will be used to surround and haul the schools of sharks. This net will be used to surround the schools during the breeding season. This net will also be laid at night, periodically, to catch the stray sharks that may have escaped the hooks on the Permanent Lines and the Daily Lines. Net fishing can only be done in the areas where the bottom terrain is sandy.

5. Bait Preferences Include Certain Types of Fishes.

In the three month Line Fishing program specifically for Mauna Kea Beach Hotel, a controlled study of "Bait Preferences" was included. The results as determined by "catch quantity" have shown certain fishes--Kala, Pualu, and Palani--as the preferred bait. Other bait samples such as the aku, chicken, squid, pig, and cat were used. In conjunction with this present proposal, it is recommended that this phase of research be continued.

6. The Fishing Circuit will Rotate Between Hilo, Kawaihae and Kona.

The fishing circuit will divide the 20-day work month between the three general control areas of Hilo, Kawaihae and Kona.

For purposes of general understanding, it may be stated that the assignment of the number of days specified for each particular area may be that of 6 days in Hilo, 7 days in Kawaihae, and 7 days in Kona.

However, in the practical operation of the fishing circuit, this work-day allowance per control area cannot be as absolute and binding. The fishing circuit must remain flexible so that concentrated fishing days in any one of the three areas will be determined by the conditions of weather, the abundance of sharks, the seasons of breeding and nursing, and a number of other contributing variables.

The professional fisherman can best plan the work chart to expediently adjust to the conditions that prevail. In some programs of research and control, the research team has directed this "fishing circuit" and this has often proven disastrous.

7. The Research System will Involve the Practical Fisherman and the Pure Scientist.

The professional fisherman with his life-time and first-hand experience of catching fish does show remarkable acuity in this, his "natural" environment. He is at home at sea. He expertly handles sharks of all lengths and in all circumstances with ease, skill and mastery.

In this proposal, I recommend that the firsherman, a logical resource, be instructed and trained by the scientist to compile the data and keep the Shark Fishing Log (See a sample sheet of a Shark Fishing Log, Page 8A.)

The scientist will oversee this operation, he will analyze and interpret data, and compile an annual report. This annual report will be made available to all interested persons. The Project Director will also be expected to contribute to this annual report.

It might be anticipated that the University of Hawaii may wish to allow some of their students to participate in some phases of this program. At our convenience, we would be pleased to extend this opportunity for observation to certain students and faculty members, provided certain provisions be met. These, may be discussed in greater detail at a later date.

Date _____

Current: Kohala Kona

Tide: High Low

Temperature ____° at ____ft.

Sea Conditions: Calm Mod. Rough Bad

Wind Direction: N.E. Kona

Sky: Sunny Cloudy Rain

Hook No.	Kind of Bait	(Condition of bait & hook) No. Days on Hook	Bait On / Part Gone / Bait Off / Hook Bent / Hook Gone — Shark species caught	Sex (M,F)	Total Length (in.)	Length to Notch (in.)	Embryos? (total lengths of first 10, in inches)	Stomach Contents (cont. other side)

Signed _____

III. SCHEDULE OF WORK OPERATIONS

Barring all conditions that may prevail to force a departure from the established order of fishing, it can be stated that "generally", the following work detail will be scheduled in the Hilo, Kawaihae, and Kona areas:

1. The Permanent Lines will be set on the first morning and will be hauled out on the last day of the "fishing" week. These lines will be set in fathoms of distributive depths. These lines will be baited and checked every morning.

2. The Daily Lines will be set daily, in the evening, and will be hauled out the next morning. These lines will be set in fathoms of distributive depths, ranging from 2 to 30 fathoms.

3. The Nets, measuring approximately 3,000 feet in length and 18 feet deep to 30 feet deep, will be laid from shore to sea, on at least 8 days per month. This Net Fishing will provide greater control security for it will catch the stray sharks that may not have been caught on the line and hook.

4. During the breeding and nursing seasons, the "schools" of sharks in the bay areas, provide unequaled conditions for density eradication. In this instance, Net Fishing is the most feasible and productive method. The net will surround the "schools" and capture the shark communities of adults--male, female--and young.

In this particular net operation, two basic strategic steps are imperative to the measurement of productive success. The first necessary step is defined as Sight and Definement. The "school" must be sighted and identified and the locality must be pin-pointed. The second necessary step is the Surround. In both of these steps, it will be necessary to rely upon the directives and directions of a skilled individual who will fly overhead in an airplane. Air service is essential to this net operation for clear and direct visibility is important to the strategic blueprints of order, system, production, and safety.