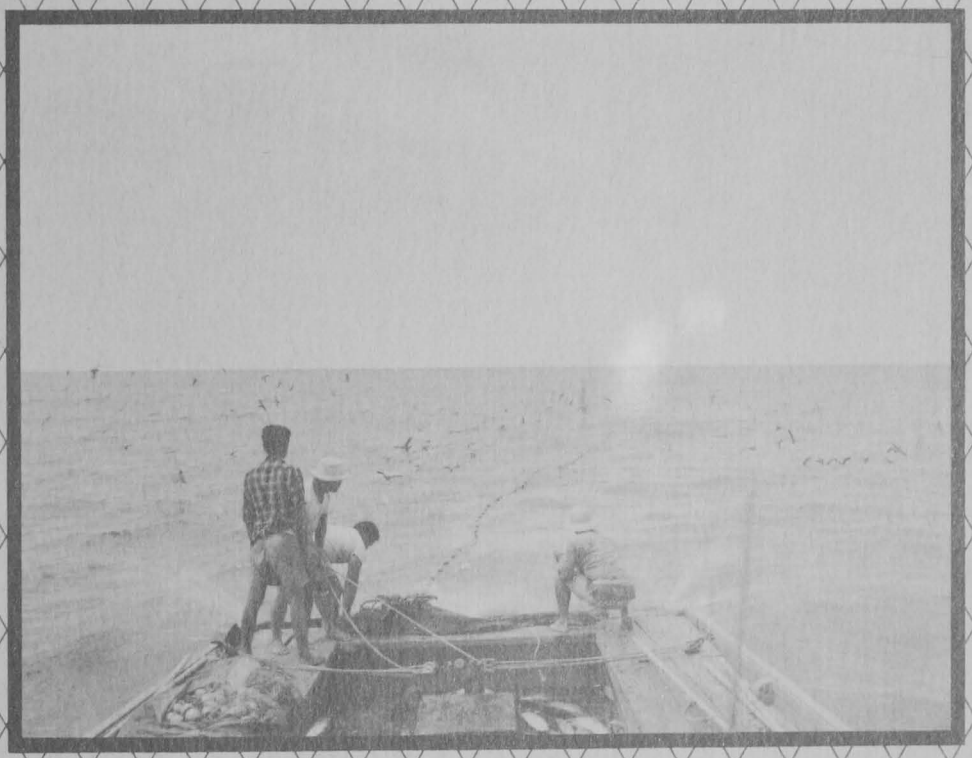
MONOFILAMENT GILL NET FISHING FOR SKIPJACK TUNA IN HAWAIIAN WATERS, 1961-62



U.S. DEPARTMENT OF THE INTERIOR
FISH AND WILDLIFE SERVICE
BUREAU OF COMMERCIAL FISHERIES

CIRCULAR 170

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Cover Photo: Setting gill nets from a Hawaiian skipjack boat.

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MONOFILAMENT GILL NET FISHING FOR SKIPJACK TUNA IN HAWAIIAN WATERS 1961-62

BY

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CORRECTION

On page 10, in the heading of table 7, in place of "Number of skipjack taken by gear type" read "Number of units of gear fished" and in place of "Other catch and mesh size in which caught" read "Catch and mesh size in which caught."

ABSTRACT

The Hawaiian skipjack fishery is showing signs of economic trouble. This is especially evident in the size of the fleet, which has decreased 40 percent since 1948. The problem is one of a static level of fishing efficiency with the pole-and-line method, and increasing operational costs. The solution requires increasing the catch without a proportionate increase in cost.

On the basis of recent developments in monofilament fibers and the success of monofilament gill nets in other fisheries, netting techniques for catching skipjack tuna were investigated in 1961 and 1962, with the joint support of the State of Hawaii and the Bureau of Commercial Fisheries. The study was carried out by Bureau personnel on a chartered skipjack boat from July 23 to September 29, 1961, and May 9 to August 25, 1962.

The results indicated that the monofilament gill net method of fishing will not supplant nor effectively supplement the present pole-and-line method of catching skipjack tuna.

The principal method of fishing used in the tests was to locate a skipjack school, chum the school to the stern of the boat using live baitfish, set the net while continuing the chumming, and haul in the net with a powerblock. Although skipjack can be captured by this method, the catch was found to be too small to be of commercial significance. The largest catch from a single set was 127 skipjack.

The passive method of gill net fishing was tried on 14 occasions. In this method the nets were set at sunset and allowed to drift passively throughout the hours of dark. The gear and the catch were then picked up the following morning. The catch of only one skipjack from the 14 sets indicated that the method is not applicable for commercial skipjack fishing in Hawaiian waters.

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EXPERIMENTAL GILL NET FISHING FOR SKIPJACK

At present, despite the generally vigorous growth of Hawaii's economy, the Hawaiian skipjack fishery gives indications of slow deterioration. From a modest start in the early 1900's this fishery increased in importance until in recent years the skipjack landings have represented from 50 to 70 percent of the total fish landings in the State of Hawaii (Yamashita, 1958). Since 1948 the annual skipjack landings have varied between 6.1 and 14.0 million pounds (fig. 1). Total landings do not, however, show the serious condition facing the fishery; trends in the size and age of the fishing fleet more accurately depict the existing situation. The history

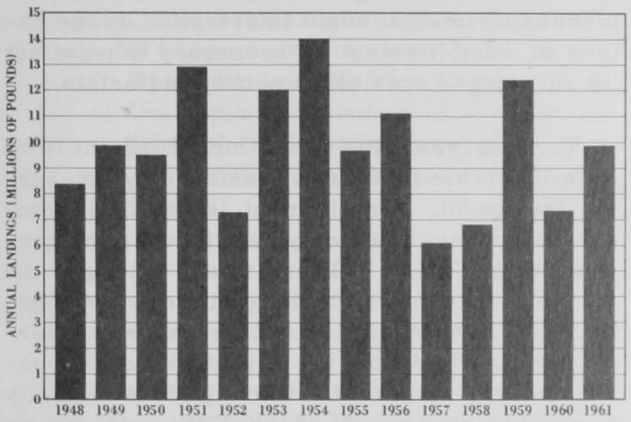

Figure 1.--Annual landings of Hawaiian skipjack fishery, 1948-61.

of the fishery in the post-World War II period shows an initial flurry of activity, born of optimism, which included the construction of nine new vessels between 1946 and 1950 (fig. 2). This was followed by a stable period in the early 1950's when only one new vessel was added to the fleet. In recent years, with the withdrawal of a number of the older boats from the active fleet and the absence of new construction, the fleet has been reduced from a total of 32 boats in 1948 (June, 1951) to the present total of 20 boats. Even with the withdrawal of some of the older boats the present fleet may still be considered old; of the 20 boats fishing today, 7 were built between 1926 and 1931.

While the factors responsible for this state of decay in the fishery are complex, they are basically related to the wide fluctuations in the catch from year to year and to a method of fishing, with pole-and-line and live bait, which has remained virtually unchanged since the beginning of the fishery. This unchanging level of fishing efficiency, against a background of constantly rising operational costs, has had serious effects on the industry, particularly during poor seasons. A similar situation which affected the competitive strength of the U.S. west coast tuna industry a few years ago was met by increasing the fishing efficiency of the purse seiners by using nets of synthetic fiber and powerblocks to haul the nets (McNeely, 1961).

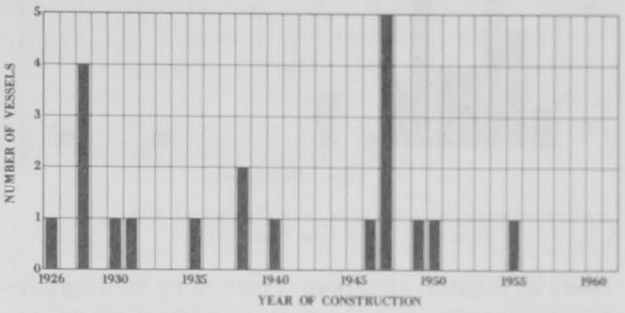

Figure 2.--Year of construction for skipjack boats active in 1961.

The pole-and-line fishery has several aspects which can be considered inefficient. Studies by the Bureau of Commercial Fisheries Biological Laboratory in Honolulu show that approximately 50 percent of the fish schools actively pursued and chummed do not respond to the chum (Royce and Otsu, 1955; Yuen, 1959). Observations made on commercial boats also show that the catch per school is very small, suggesting that only a small fraction of each school is being landed. Yuen (1959) counted the catch from 73 schools successfully fished by commercial fisherman. The catch from 20 of the 73 schools (27 percent) was less than 25 fish per school and 53 (73 percent) of the schools gave catches numbering less than 25 fish per school and 53 (73 percent) of the schools gave catches numbering less than 125 fish per school (fig. 3a). An additional factor contributing to the low catches is the relatively short time each school is fished. Of a total of 72 schools examined, 60 (83 percent) were fished for a period of less than 25 minutes (fig. 3b).

In essence, the solution to the problem of restoring the Hawaiian skipjack fishery into the family of growing industries is to increase the

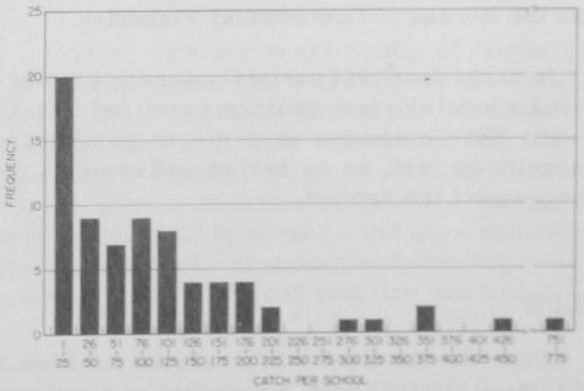

Figure 3a.--Frequency distribution of skipjack catch per school. (Data from Yuen, 1959).

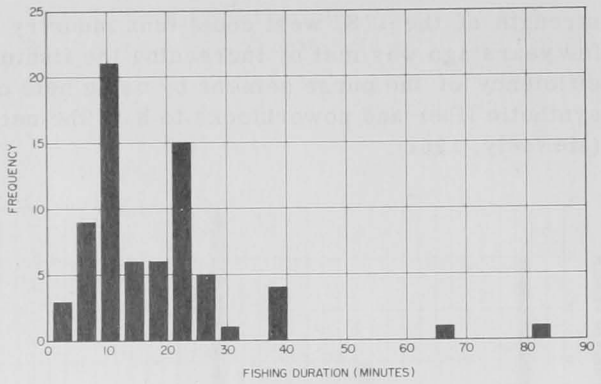

Figure 3b.--Frequency distribution of fishing duration. (Data from Yuen, 1959).

level of fishing efficiency, either by (1) improving the existing pole-and-line method or (2) introducing an entirely different mode of fishing. The present study is primarily concerned with the latter approach.

FUNDS

Aware of the recent success of net fishing methods in the west coast tuna industry, the Bureau of Commercial Fisheries and the State of Hawaii decided to undertake a study to determine the commercial feasibility of netting skipjack in Hawaiian waters. The objective of the study was to be the development of a method of netting skipjack which could be adopted by the existing fleet. In April 1961 the Fish and Wildlife Service made available $25,000 in Saltonstall-Kennedy funds to the Bureau of Commercial Fisheries Biological Laboratory in Honolulu for the purchase of equipment and gear. The State of Hawaii Legistature, in its 1961 session, passed Senate Bill 387, appropriating $45,000 for the program. This bill was signed by the Governor on June 22, 1961. The State of Hawaii Fish and Game Division, under the alternatives granted by the Act, elected to contract the services of the Bureau's Biological Laboratory to carry out this program. Additional funds to carry the program to completion in 1962 were provided by the State of Hawaii and the Bureau of Commercial Fisheries.

In early June 1961 parties and agencies interested in local skipjack problems met and formed a Gill Net Committee to serve in an advisory capacity as well as to review and evaluate the progress of the project.

PLANS

Prior to the field trials carried out from a chartered skipjack boat, a program was outlined which included: (1) an evaluation of the operational aspects of fishing monofilament gill nets, to be carried out on the Bureau's research vessel Charles H. Gilbert; and (2) a consideration of possible methods of fishing the gear. The methods contemplated fell either into an active fishing category, in which a skipjack school would be pursued and the net set in the midst of the school or into a passive fishery category, where the net would be set at a predetermined location and allowed to drift over a period of time, usually during the hours of darkness.

MONOFILAMENT NETS

Before detailing the types and specifications of the monofilament gill nets purchased and used in the experiments, some information on the nature of monofilament is necessary to point out its advantages over other netting materials.

In recent years the use of monofilament fiber for gill nets has increased considerably throughout the world. Monofilament is one of several synthetic fibers commonly known under the general term "nylon." These fibers belong to the polyamide group, which along with other synthetic fibers have revolutionized the textile and fishing industries. Among the advantages nylon possesses over natural fibers are: (1) it is virtually unaffected by age, (2) it loses strength only on prolonged exposure to sunlight, (3) it is resistant to many chemicals, and (4) it is immune to bacteria action, which permits leaving the gear in water for prolonged periods of time. The important attribute of monofilament nylon fiber is its very high transparency in water, which gives it a higher fishing efficiency than natural or other synthetic fibers. Molin (1959) discussed the results of comparative fishing tests using gill nets made of cotton, multifilament nylon, and monofilament nylon fibers. He reported that monofilament gill nets caught more than seven times as many fish as cotton nets and approximately four times as many fish as multifilament nylon nets. The fishing efficiency of monofilament is so high that the states of Washington, Oregon, and Alaska have banned these nets for salmon fishing.

The monofilament gill nets used in the present study were of clear fiber of three mesh sizes. On the basis of simple tests consisting of passing skipjack of various sizes through meshes of different sizes, a net with a mesh size of 5-1/2" (stretched measure) was selected for skipjack ranging from about 4 to 10 pounds. The fiber was of the size designated by the manufacturer as 22 MF (approximately 22-pound test line). Since the bulk of the season's catch is made up of fish

larger than 10 pounds, monofilament nets of mesh sizes of 7-3/4'' and 9'' (stretched measure) were chosen for the attempts to capture these larger skipjack. The fiber sizes were 35 MF (approximately 35-pound test line) and 45 MF (approximately 45-pound test line) for the two mesh sizes.

For the 1961 field work each unit of gear measured 100 fathoms (hung measure) along the corkline and 102 fathoms (hung measure) along the leadline. The webbing was hung in 50 percent along the corkline, i.e., 200 fathoms of webbing was hung on 100 fathoms of corkline. All of the nets measured 10 fathoms in depth.

Because of difficulty in handling the 10 fathoms of webbing, the gear was modified for the 1962 field work. The nets were reduced in length from 100 to 50 fathoms and in depth from 10 to 5 fathoms. The reduction in depth was made on the basis of the depth distribution of the skipjack catch in the 1961 trials, when most of the skipjack were taken in the upper one-fourth of the 10-fathom nets.

VESSEL

Since the results of field trials had to be applicable to the existing skipjack fleet, it was desirable to carry out the field work from a commercial skipjack boat. In this way the efficiency of the gear, the operational costs, and the earnings from the catch would be directly comparable with those of the commercial boats. Through bid procedures the Government accepted the services of the M/V Broadbill. The Broadbill was utilized throughout the 1961 and 1962 field trials. Details of the boat and the results of a stability test are given in appendices 1 and 2.

RESULTS OF PRELIMINARY TRIALS

In May 1961, while financial matters and the program itself were still being discussed, we were fortunate in obtaining several days of vessel time on cruise 52 of the Charles H. Gilbert. In view of the short notice given for gill net trials on the Gilbert, we felt that this opportunity could best be used to examine the operational aspects of gill net fishing and to carry out a simple comparative fishing test using only a single unit of monofilament gill net. The net was 100 fathoms long, 4 fathoms deep, and the mesh was 5-1/2'' (stretched measure). For comparison a 50-fathom length of multifilament nylon, dyed green, was attached to each end of the monofilament net. The mesh size of the multifilament net was also 5-1/2'' (stretched measure).

The method of fishing developed in the preliminary trials, which appeared to be applicable on a skipjack boat, was to (1) locate a skipjack school by the usual method of looking for a ''working'' bird flock, (2) pursue and chum the school to the stern of the boat with live bait, and (3) pay-out the gill net from a wooden bin situated at the stern of the boat. During the setting operations chumming was continued, and upon completion of the set the vessel was maneuvered into a position with the bow at the net and chumming was then continued from the bow.

The results from three sets showed that skipjack could be taken by this method of active gill net fishing. The distribution of the catches also revealed the superiority of the monofilament netting over the multifilament nylon netting. Catches for the three sets were 34, 63, and 225 skipjack, and only 5 of these were taken on the two multifilament nylon sections.

Direct observations of the net and the reaction of the skipjack to it were made from the underwater viewing chambers of the Gilbert. The ''hang'' of the monofilament section in the water appeared ideal, with the meshes open and the leadline straight. The multifilament section, on the other hand, tended to bunch in, causing the meshes to close. In terms of visibility to human observers, the difference between the two types of nets was striking, the monofilament net being far more transparent and difficult to see than the multifilament nylon. Observations on the reaction of the skipjack to the net were somewhat puzzling. At the multifilament sections the skipjack were apparently able to see the net at a considerable distance and avoided coming close to it. At the monofilament section the skipjack seemed to show a similar avoidance reaction at times. This, however, was not always the case, as attested by the catch and also by some direct observations of fish being gilled. On a number of occasions skipjack were seen hitting the net at a relatively slow speed (unlike a feeding dash), suggesting that they did not see the webbing.

In order to evaluate the ability of skipjack to see monofilament line, five skipjack were caught by the pole-and-line method and transported alive to ponds at Kewalo Basin, Honolulu. These ponds were specifically constructed for tuna behavior studies (Nakamura, 1960). Although the test was limited in scope, it did show that skipjack are capable of seeing and avoiding monofilament lines (22-pound test line was used).

RESULTS OF FIELD TRIALS

Gill net fishing experiments were carried out on board the M/V Broadbill in 1961 and 1962. Although the skipjack fishing season in Hawaiian waters extends from May through September, we were unable to start the 1961 field work until July 23. Operations were suspended on September 29, when skipjack became scarce, indicating the close of the fishing season. Field work was resumed in 1962 on the basis that all of the possible methods of gill net fishing had not been explored and that the active method of gill net fishing showed some promise of supplementing the pole-and-line catches of commercial vessels. The field trials for 1962 extended from May 9 to August 25.

OPERATIONAL DATA

Except for a change in baiting procedure in July-August 1962, when bait fish were purchased from a State-operated plant, the time schedule and sequence of operations followed during the field work were similar to those of the commercial skipjack boats. These involved locating and catching a supply of bait fish, taking on ice and other supplies, and then scouting and fishing the general areas where good commercial catches were being made. Table 1 gives a summary of the distribution of effort for 1961 and 1962, while figures 4a and 4b show the general area of scouting and fishing. A complete station list for the two years is given in appendices 3 and 4.

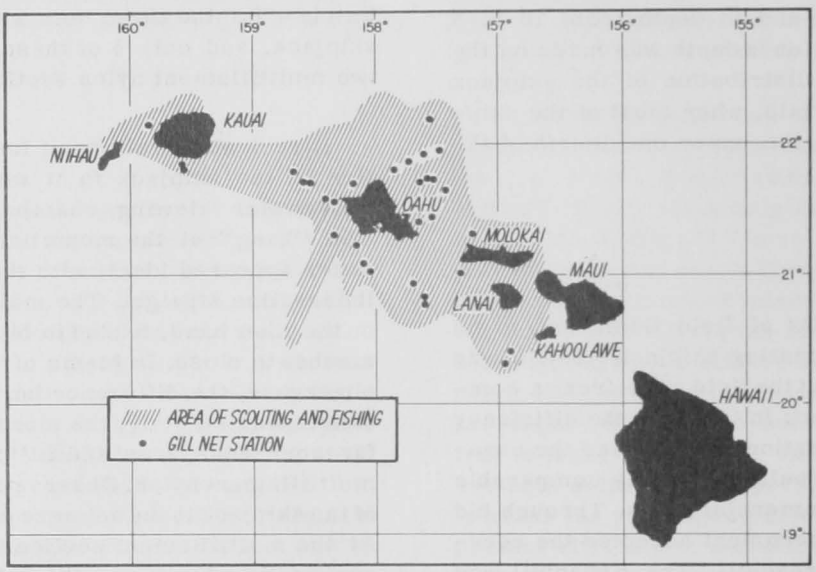

Figure 4a.--Area of scouting and fishing by M/V Broadbill, July 23, 1961 to September 29, 1961.

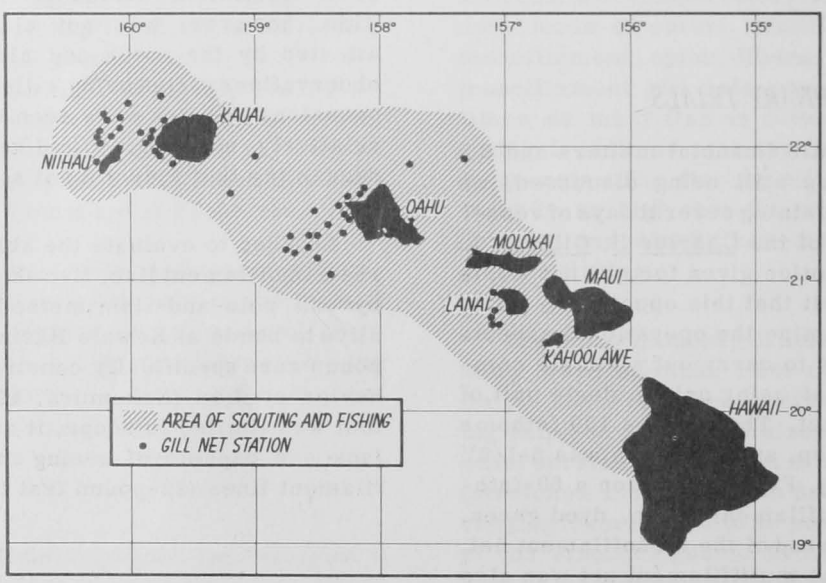

Figure 4b.--Area of scouting and fishing by M/V Broadbill, May 9, 1962 to August 25, 1962.

Table 1.--Distribution of effort, 1961 and 1962

	1961 (7/23-9/29)	1962 (5/9-8/25)
Days spent baiting	18	14
Days spent scouting and fishing	27-1/2	49
Days running without bait	1-1/2	5
Days spent repairing vessel and gear	10	29
Days of rest	12	13
TOTAL DAYS	69	110

Basically, gill net fishing involves setting the nets, hauling in the nets, picking the catch, and restacking the nets.

The setting procedure for the 1961 field trials was the same as that developed on the preliminary trials on the Charles H. Gilbert. The nets were set from a 10' x 12' x 3' wooden bin attached to the stern of the Broadbill (fig. 5). At the end of the 1961 field work the results showed that the gill nets would not supplant the pole-and-line method; however, there was an indication that the nets could be used to supplement the pole-and-line catch. Since the immobility of the large wooden bin reduced the efficiency of the pole-and-line fishing operation, the setting arrangement was modified for the 1962 field trials. A turntable (figs. 6a and 6b) made up of four compartments, each capable of holding 1 or 2 shackles of nets, was constructed to increase the mobility of the setting arrangement. In addition, the turntable was mounted on tracks which permitted moving the entire structure toward the stern during setting of the gill nets and forward when pole-and-line fishing was being carried out. After several weeks of trial the turntable was abandoned. Instead of increasing the efficiency of gill net fishing, the turntable proved to be cumbersome and difficult to handle. When not in use the turntable had to be secured to the vessel by means of chain and turnbuckles. In moderate seas the moving of the apparatus was time-consuming and hazardous. Subsequently, the setting procedure was simplified by wrapping each unit of the net in a piece of canvas and keeping one unit on the port side and a second net on the starboard side of the Broadbill (fig. 7). The other nets were placed on the roof of the main engine house.

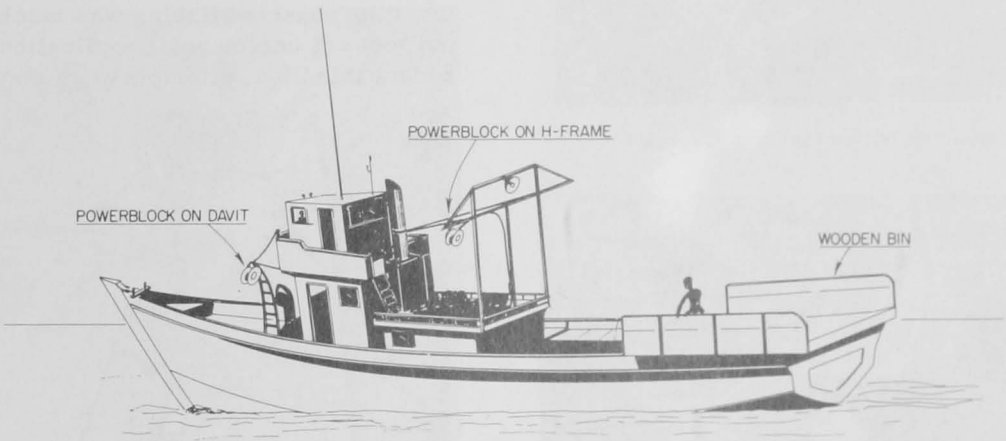

Figure 5.--Schematic diagram of M/V Broadbill.

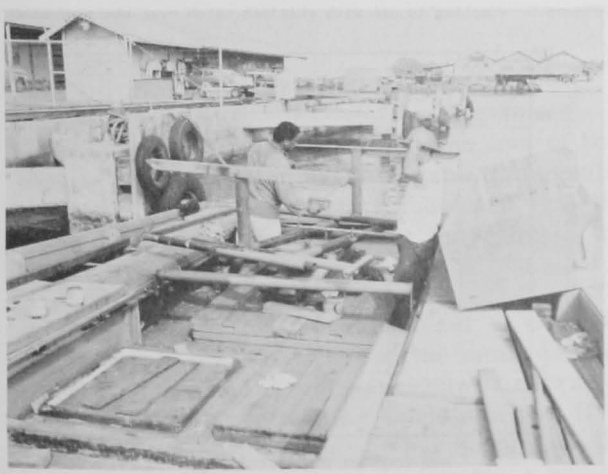

Figure 6a.--Installing framework of the turntable.

Figure 6b.--Pole-and-line fishing with turntable moved forward.

At the start of the field trials in 1961, the powerblock for hauling the net was situated on an H-frame which was located about amidships (fig. 5). The net, along with the catch, was pulled over the powerblock and onto the deck. After hauling had been completed, the fish were removed from the net and the net was restacked in the bin. Although the hauling operation went very well in slight seas and winds, it became very difficult under strong trade wind conditions. This difficulty was traced to our inability to maneuver the vessel in proper relation to the lay of the net. To increase maneuverability, the powerblock was relocated to a davit on the port side just forward of the wheelhouse (fig. 5). This modification improved the hauling operation considerably. The hauling time (table 2) ranged from 7 to 45 minutes and averaged 14 minutes for 21 sets in which times were recorded. The catches on these sets ranged from 0 to 103 skipjack. For the 1962 field trials, the powerblock was relocated to the starboard side (fig. 8) and closer to the midline of the boat. This move improved hauling by placing the powerblock inboard of the rail.

Figure 7.--Simplified setting arrangement for gill net fishing.

Figure 8.--Hauling in the gill net, 1962.

Table 2.--Time required for hauling nets, picking fish, and restacking nets (1961)

Station	Mesh size of net		Time taken for hauling	Time taken for picking and restacking
	5-1/2"	7-3/4"		
			Minutes	Minutes
22	x		11	14
26	x		13	19
33	x		45	30
37		x	18	18
39	x		13	46
41		x	17	15
43		x	9	15
45	x		12	36
51	x		11	58
62	x		10	10
63	x		11	27
66	x		11	12
73		x	9	24
79		x	11	14
89	x		15	64
98		x	12	12
113	x		7	19
114	x		14	39
116	x		11	33
125	x		11	21
126	x		13	58
Average time			13.5	27.8

The most difficult aspect of gill net operation is the removal of fish from the net and the restacking of the net. In 1961 the net and the catch were hauled over the powerblock (fig. 9) and then dragged to the stern of the boat, where picking and restacking were carried out. The time taken for this phase of fishing was much too long for purposes of commercial application (fig. 10). To reduce this time, attempts were made to remove

Figure 9.--Hauling in net with skipjack catch over the powerblock.

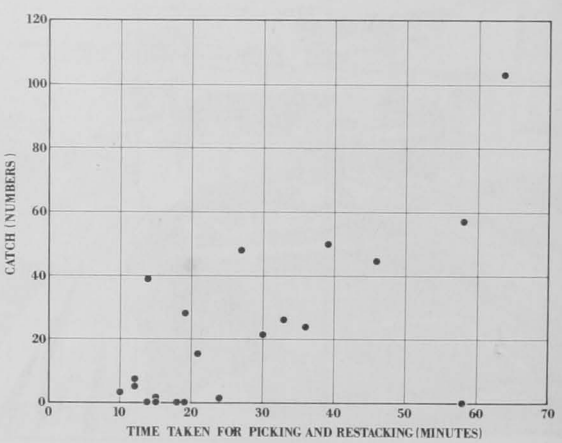

Figure 10.--Relation of total catch with time taken for picking and restacking.

the fish before the net passed over the power-block (fig. 11). The time available at this stage of hauling for picking out the fish was insufficient, and only the few fish which were not thoroughly enmeshed could be removed. For the most part the large skipjack were too badly tangled in the webbing to be removed during hauling (fig.12).

Figure 11.--Removing skipjack during hauling.

Figure 12.--Extracting badly entangled skipjack from gill net.

BAITING

Although field tests without the use of live bait were part of the overall plans, the results from the preliminary trials indicated that the best approach initially was to incorporate the use of live bait.

For the 1961 and the early part of the 1962 field trials bait was obtained by the methods used by the commercial pole-and-line fishermen. This involves scouting for schools of bait fish, usually the nehu (Stolephorus purpureus), in the bay areas. After a school is located a small-mesh bait net is set around it from a skiff powered with an outboard motor. The net usually measures 80 to 100 fathoms long and is about 4 fathoms deep. After the set has been made, the ends of the net are taken in until only a small "pocket" remains. If the skipjack boat is near, the bait is transported in the "pocket" to the boat where it is brailed into the bait holds (fig. 13). If the distance between the locality of capture and the boat is great, the bait is first brailed from the "pocket" into the holding well of the skiff, transported to the boat, and again brailed, this time into the bait holds. June (1951) gives a detailed description of the entire operation.

Figure 13.--Brailing bait fish onto the Broadbill.

Bait fish for the last 2 months of operations (July-August 1962) were purchased from the tilapia-rearing plant established by the State of Hawaii. The success of tilapia as a bait fish for skipjack and the feasibility of rearing tilapia under controlled conditions have been discussed by King and Wilson (1957) and Hida, Harada, and King (1962).

GILL NET FISHING

In 1961 and 1962 various methods of using the monofilament gill nets were tried. Except for a limited effort at night fishing, when the gear was fished passively as a drift net, all of the methods were variations of the active-fishing type. In early 1961 the basic method for actively fishing gill nets was developed; it involved locating a skipjack school by means of a "working" bird flock (fig. 14) and, following the standard pole-and-line method, chumming the school to the stern of the boat with live bait. Upon a determination of the size of fish, either by estimating the size from surfacing skipjack or by the capture of a few by pole-and-line, the proper mesh-size net was set. Chumming was carried out at a heavy rate during the setting operation. After the net

Figure 14.--Skipjack school being attracted to stern of Broadbill. (Note men preparing gill nets for setting.)

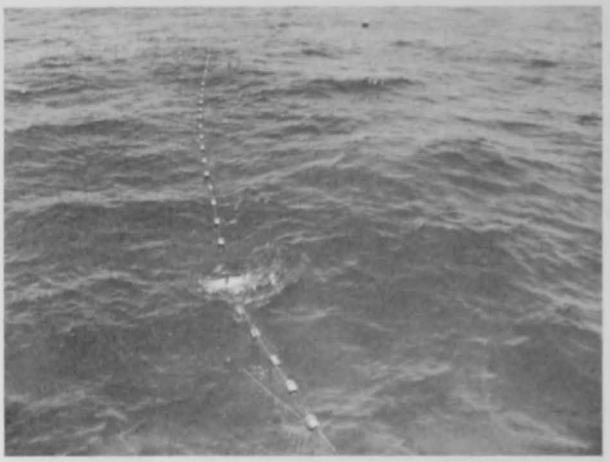

Figure 15.--Skipjack caught in the gill nets during the setting operation.

had been set, fishing was either continued by pole-and-line or completely stopped. Hauling in of the gill net was carried out with the use of a gill net powerblock.

For the active method of fishing four different techniques were tried. These were: (1) setting surface nets in a straight line, (2) setting surface nets with a gate located in the center part of the net, (3) setting subsurface nets in a straight line, and (4) semi-encircling a school with several units of net joined together.

Primarily because of the lack of large skipjack in Hawaiian waters during the 1961 field work, effort during that year was directed toward fishing small skipjack. To test the fishing efficiency of this method with larger skipjack, the 1962 field trials were devoted to the larger fish. The skipjack catches from the straight sets us-

Table 3.--Results of fishing surface nets in a straight line

Year	Station	Date	Number of fish caught by gill nets			Number of fish caught by pole-and-line	Fish size range	Comments
			Mesh net				Pounds	
			5-1/2"	7-3/4"	9"			
1961[1/]	5	7/25	1			4	4-5	Poor set--net payed-out in bunch.
	18	7/31		1		-	3	
	19	7/31	29			21	2-4	
	22	8/1	42			53	3-4	
	26	8/4	28			39	2-4	
	29	8/5	37			86	3-6	Part of webbing (with undetermined number of gilled fish) cut off-net caught in propeller.
	33	8/10	23			25	4-5	School sounded shortly after setting completed.
	37	8/11		0		5	12-20	School sounded at start of setting operation.
	39	8/11	45			22	4-6	
	41	8/14		1		5	26-37	
	42	8/14		0		3	26-37	
	43	8/14		0		5	29-36	
	45	8/14	26			4	2-6	
	61	8/30	0			6	4	School sounded.
	62	8/30	3			No fishing		
	63	8/30	50			23	3-4	
	66	8/31	7			7	3-6	
	74	9/2	16			32	2-4	
	88	9/7	127			2	2-5	
	89	9/7	106			446	3-6	
1962[2/]	8	5/2		0		27	5-9	
	15	5/16		0	0	113	14-33	
	17	5/17		0		73	11-28	
	19	5/17		0		49	17-30	
	28	5/25	0			9	15-20	
	34	5/27	10			88	5-8	
	44	5/30	3	2		21	5-14	
	55	6/14	11			25	4-12	
	57	6/14	4			52	4-9	
	59	6/14	37			116	5-11	
	63	6/14	13			110	4-10	
	68	6/15		6	0	136	22-33	9" net fouled during set.
	77	6/19			0	42	22-32	
	78	6/19		0	0	154	19-34	
	79	6/19		4	0	62	20-34	
	83	6/20	15			78	6-8	
	85	6/20			4	104	19-30	
	91	6/23			1	83	20-33	
	102	6/25			0	32	19-32	
	104	7/13		1	lost	30	19-34	9" net sank--lost.
	106	7/13		0		22	22-34	
	107	7/13		0		51	20-32	
	112	7/14		2		87	19-34	

[1/] All nets used in 1961 were 100 fathoms in length and 10 fathoms in depth.

[2/] All nets used in 1962 were 50 fathoms in length and 5 fathoms in depth.

ing surface nets are given in table 3. Figure 15 shows a shipjack gilled during the setting of a surface net. Although trials with the 9''-mesh net were not as extensive as those with the 5-1/2'' and 7-3/4'' nets, there appeared to be a progressive loss in the fishing efficiency with an increase in mesh size (table 3). On the basis of surface observations it appeared that the large skipjack were more deliberate in their feeding and could not be induced into as intense a feeding frenzy as could be achieved with small skipjack. This loss in efficiency is evident in the number of sets in which no skipjack were taken: 2 sets out of a total of 23 sets for the 5-1/2'' mesh net, 10 of 17 sets for the 7-3/4'' mesh net, and 6 of 9 sets for the 9'' mesh net. The 9'' mesh net was lost on station 104 when it sank out of sight. Since skipjack were not taken on the preceding sets, it is unlikely that the sinking was caused by a large catch of skipjack, but the loss of the net remains unexplained.

Although skipjack can be taken by the surface nets, the catches were considered too small to be of commercial significance. This is especially true in view of the heavy chumming necessary during the setting operation. It was the belief of the fishermen aboard the boat that, for the amount of bait-fish chummed, the pole-and-line method would have produced several-fold more skipjack than was taken with the gill nets.

Since the gilling and entangling of skipjack in the gill nets appeared to occur only during the setting operation, an attempt was made in 1961 to increase the catch after setting by constructing a ''gate'' through which the vessel could pass over the middle of the set. It was hoped that by chumming heavily during the passage the school might be brought to a feeding frenzy near the net. The results of this experiment are given in table 4. There is no noticeable difference between the skipjack catches from this method and those from the straight sets for 1961 (table 3). From visual observations during the passage across the net it appeared that the skipjack avoided the net by either veering off or sounding.

The principal shortcomings of the gate method were (1) the apparent ability of the skipjack to see the surface nets and (2) difficulty in crossing over the net in moderate to rough seas. To overcome these problems trials were conducted in 1962 using subsurface nets. The floats on these nets were small enough to allow the net to sink. The fishing depth was then controlled by attaching large rubber floats with float lines spaced at intervals throughout the net. The float lines were made 12 feet long, so that there would be no danger of the nets entangling in the ship's propeller. The greater fishing depth was expected to make the nets less visible to the skipjack. The results of fishing by this method are given in table 5. The method was ineffective and was abandoned on the basis of observations of the reactions of the skipjack. Where the skipjack had either sounded or veered away from the net when the gate method was used, in the case of the subsurface net method the fish simply followed the vessel over the submerged net. The failure to catch even one fish on the 9'' mesh net indicated that the large skipjack were still able to see the net at the depth fished and avoid it. The single skipjack taken on the 7-3/4'' mesh net could have been caught during the setting operation.

The last of the active methods of gill net fishing tried was that of attempting to encircle a school while keeping the fish at one side of the boat during the setting operation. Four trials were made using 3 or 4 units of gear, but in none of them were we successful in completing the encirclement (table 6). The skipjack catches were all made while the gear was being set. Aside from the ability of the skipjack to avoid the net, the difficulty of hauling the net in rough water precluded any further experiments. The encircling method necessitated hauling in gear with the vessel lying in the trough part of the time. In rough seas the rolling of the vessel

Table 4.--Results of fishing with a gate net

Station	Date 1961	Number of fish caught by gill nets			Number of fish caught by pole-and-line	Fish size range	Passage through gate		Comments
		Mesh net				Pounds	yes	no	
		5-1/2''	7-3/4''	9''					
51	8/17	1	--	--	13	3-8		x	Seas too rough for crossing over net.
73	9/2	--	1	--	4	14-16	x		
76	9/3	--	--	--	1	28		x	Unable to stop school; net set in front of school.
79	9/3	--	--	--	20	27-37	x		
96	9/11	--	1	--	74	22-32		x	Gate section tangled.
98	9/11	--	7	--	21	9-16	x		
113	9/17	--	--	--	10	--		x	School sounded during setting operation.
114	9/17	51	--	--	2	3-5		x	School sounded during setting operation.
116	9/18	27	--	--	76	3-5	x		
125	9/23	15	--	--	7	3-6	x		
126	9/23	59	--	--	138	4-6	x		
127	9/23	27	--	--	59	5-7		x	School sounded after setting operation.

made the operation not only difficult but hazardous.

The gill nets were fished passively at night in July and August 1962. The usual procedure was to set the nets at sunset, allow the gear to drift throughout the night, then haul in the nets at daybreak. To a large extent we selected for these night sets areas where we had observed skipjack schools during the day. A total of 14 night sets was made with the results given in table 7. Although the catch was varied and of academic interest, the capture of only one skipjack indicated that the method does not show much promise as a means of catching skipjack in commercial quantities.

Table 5.--Results of fishing with subsurface nets
(floatlines 12 feet)

Station	Date 1962	Number of fish caught by gill nets		Number of fish caught by pole-and-line	Fish size range	Comments
		Mesh net			Pounds	
		7-3/4"	9"			
107	7/13	1		51	20-32	Crossed over net once.
114	7/16		0	57	18-33	Crossed over net once.
116	7/16		0	95	20-30	Crossed over net once.
120	7/17		0	15	26-33	Crossed over net once.
121	7/17		0	46	22-36	Crossed over net once.
126	7/19		0	12	20-29	School sounded after net set.
128	7/21		0	38	20-33	Crossed over net once.
132	7/21		0	111	19-29	Crossed over net once.

Table 6.--Results of semi-encircling skipjack school with surface nets

Station	Date 1962	Number of Shackles	Number of fish caught by		Fish size range
			gill nets	pole-and-line	Pounds
146	8/3	4	1	No fishing	16
153	8/4	4	0	30	6-12
154	8/4	3	0	8	13-19
199	8/23	4	16	35	7-10

Table 7.--Results of passive fishing

Station	Date 1962	Number of skipjack taken by gear type								Other catch and mesh size in which caught
		Monofilament (surface)			Monofilament (subsurface)			Multifilament (surface)		
		Mesh net			Mesh net			Mesh net		
		5-1/2"	7-3/4"	9"	5-1/2"	7-3/4"	9"	4"	6"	
134	7/24	2	2	1						5-1/2" - porpoise 7-3/4" - porpoise, pilotfish (Naucrates ductor) 9" - porpoise
135	7/25	2	2	1						5-1/2" - bramid
136	7/26	2	2	1						7-3/4" - skipjack, bramid
137	7/28	2	2	1						5-1/2" - bonito (Sarda orientalis)
175	8/13	2	1			1 1/		1	1	7-3/4" - porpoise
180	8/14	2	1			1 1/		1	1	No catch
181	8/16	2	1		1 2/	1 2/		1	1	5-1/2" - monofilament subsurface - frigate mackerel (Auxis thazard)
184	8/17	2	1		1 2/	1 2/		1	1	5-1/2" - monofilament surface - 3 dolphin (Coryphaena hippurus) 7-3/4" - monofilament subsurface - porpoise
185	8/18	2	1		1 2/			1	1	7-3/4" - monofilament surface - Japanese mackerel (Scomber japonicus)
194	8/21	2	2		2 3/	2 3/	1 3/			No catch
197	8/22	2	2		2 3/	2 3/	1 3/			No catch
201	8/23	2	2		2 4/	2 4/	1 4/			7-3/4" and 9" - monofilament subsurface - bramid
204	8/24	2	2		2 3/	2 3/	1 3/			5-1/2" - monofilament surface - shark
207	8/25	2	2		2 3/	2 3/	1 3/			No catch

1/ Floatlines 18 feet in length.
2/ Floatlines 30 feet in length.
3/ Floatlines 60 feet in length.
4/ Floatlines 180 feet in length.

CANNERY ACCEPTABILITY OF GILL NET SKIPJACK

In order to evaluate the acceptability of gill net-caught skipjack for canning, three groups of fish were processed through the cannery. Each test included equal numbers of skipjack caught from the same school by the pole-and-line and gill net methods. Each fish was identified with a numbered metal tag and followed through the processing at the local cannery. In tests 1 and 3, definitely more blood spots occurred in the skipjack taken by the gill net method than those taken by the pole-and-line method (table 8). The results of test number 2, however, did not show such a difference.

The conflicting results obtained from the three tests point out the desirability of additional acceptability experiments. At this point it seems unlikely, based on the results of the second test, that the method of capture is solely responsible for the amount of blood spotting. In a number of the gill net-caught fish bruises were noted in the cooked flesh, possibly from injuries sustained while going over the powerblock.

Table 8.--Cannery acceptability tests of gill net-caught skipjack
[Number of skipjack]

Degree of blood spots	Test No. 1		Test No. 2		Test No. 3	
	Pole-and-line	Gill net	Pole-and-line	Gill net	Pole-and-line	Gill net
None	1	-	1	1	3	1
Slight	24	16	20	18	4	3
More than usual (Compared to commercial pole-and-line catch)	-	9	12	13	1	3
Rejected	-	-	-	-	2	3
TOTAL	25	25	33	32	10	10

SUMMARY AND CONCLUSIONS

This cooperative experiment in capturing skipjack tuna with monofilament gill nets was undertaken by the Bureau of Commercial Fisheries and the State of Hawaii in the hope of aiding an economically depressed fishing industry by developing a new method of harvesting skipjack tuna in Hawaiian waters.

The major part of the study was devoted to active methods of fishing the monofilament gill nets. Basically, these methods involved attracting a school of skipjack to the stern of the boat by chumming with bait-fish, setting the net while continuing the chumming, and finally hauling in the net with a gill net powerblock. Field trials showed that while skipjack can be taken by this method, the catches were too small for commercial fishing. The consensus of the experienced fishermen on board the boat was that a far greater quantity of skipjack could have been caught by the pole-and-line method with the amount of bait-fish expended in the gill net trials. The largest catch on a single gill net set was 127 skipjack.

The passive method of fishing gill nets was tried on 14 occasions. This method, which is the conventional way of using gill nets in other fisheries, involves setting the nets at sunset, allowing the nets to drift passively with the currents, and finally hauling in the gear and catch the following morning. The capture of only one skipjack by this method of fishing indicated that the passive method is not commercially feasible in Hawaii.

The results of the 1961 and 1962 field tests show clearly that, at the present state of the art, monofilament gill nets cannot be counted on to catch skipjack in Hawaiian waters in commercial quantities by any of the fishing methods that we have been able to devise. It has been demonstrated that the monofilament nets will effectively entrap skipjack which swim into them. However, the high efficiency shown by these nets in other fisheries, an efficiency presumably due to their transparency, is evidently not high enough to overcome the clarity of Hawaiian waters and the ability of skipjack to detect and avoid obstacles. The essential problem, which we have been unable to solve, is one of regularly bringing about contact between large numbers of skipjack and our nets. For successful fishing by passive methods this requires a knowledge of the detailed distribution and the daily behavior patterns of skipjack that we do not presently have. For active fishing methods of the type tried, the need is evidently for a way of bringing a skipjack school to a pitch of feeding frenzy more intense than can be induced by the most prodigal use of live bait. Until we are better able to predict and control the behavior of skipjack, gill net fishing, even with monofilament nets, offers no promise of a solution to the problem of raising the productive efficiency of the Hawaiian skipjack fishery.

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APPENDIX 1

DESCRIPTION OF THE M/V BROADBILL

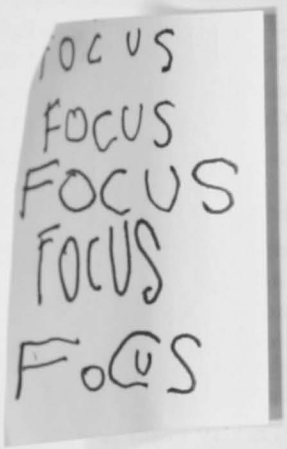
The M/V Broadbill is typical of the sampan-type boats used exclusively in the Hawaiian skipjack fishery. She has a sharp and high bow, and the pilothouse is located just forward of amidships. The entire after section is open and low to allow for efficient pole fishing from the stern. Detailed specifications of the Broadbill are as follows:

Type of hull	Wood
Date of construction	1926
Gross tonnage	36 tons
Registered length	66.8 feet
Registered beam	12.8 feet
Registered depth	6.0 feet
Main engine	General Motors Corporation (Model 62200)
H.P. of main engine	275 horsepower
Auxiliary generator	General Motors Corporation (Model 13609)
Output of auxiliary	20 KW

The deck arrangement of the Broadbill includes six bait wells capable of holding about 30 buckets of the local anchovy (nehu). We were forced to use the two after bait wells for holding ice because the large wooden gill net bin which covered the entire stern section extended forward and over the large single hold normally used for this purpose. Our normal bait holding capacity, therefore, was reduced to 20 buckets.

A mechanical water circulation system is lacking, and the aeration of the bait wells is accomplished by a direct exchange with the surrounding water through a number of screened holes along the bottom of the wells.

There are no mechanical means of refrigerating the catch. The catch is either stored directly in the ice holds or placed in cooled sea water in the bait wells, the latter being accomplished by the addition of crushed ice.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APPENDIX 2

A REPORT ON A SIMPLIFIED STABILITY TEST TO DETERMINE WHETHER THE AKU SAMPAN TYPE HULL IS SATISFACTORY FOR USE WITH THE MARCO POWER-BLOC AND MONOFILAMENT SEINE

TEST PERFORMED: July 22, 1961

PURPOSE:

The Bureau of Commercial Fisheries is in the process of conducting experiments in the Hawaiian Islands to ascertain the feasibility of rigging the local aku sampan for tuna fishing using the Monofilament seine hauled by use of the "Power-bloc." These vessels are of a narrow, wall-sided type having little initial stability and depending on a long range of positive righting moment supplied by generous freeboard for safety at sea; a large sponson also providing additional reserve righting moment if a heavy roll is taken. Since there is little or no knowledge of how these vessels will react to applied capsizing moments such as those encountered in the use of the power-bloc, it was deemed essential that some simple check be made to determine whether the aku sampan obviously appears to have sufficient stability, or whether a detailed inclining experiment is called for for such use.

VESSEL USED:

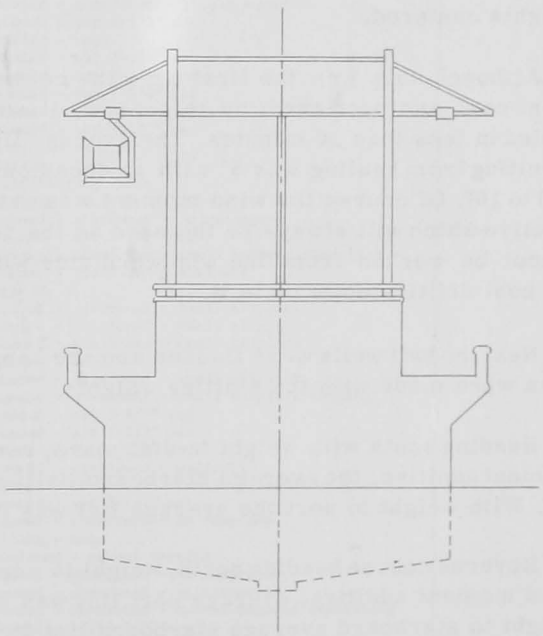
The Bureau of Commercial Fisheries has chartered and converted the aku sampan "Broadbill." The "Broadbill" appears to be ideal for this type of experiment since she is one of the older narrower models possessing less stability than the newer vessels which should possess greater stability, thus possessing a greater margin of safety.

The "Broadbill" was built in 1926 of wood with very heavy scantlings, in fact, there is sufficient reserve buoyancy in the framing of these vessels to float all their machinery. Her principle dimensions are: length 66.8 feet; breadth 12.8 feet and depth 6.0 feet. Power is supplied by a single G. M. six-110 diesel engine.

A net bin weighing in excess of 1,000 pounds was built on the stern and a tubular steel frame was erected on the after end of the engine trunk from the port side of which a Marco power-bloc Model 13A was suspended. The accompaning sketch shows the general arrangement of this frame with the power-bloc. In the interest of safety, the height of the block was set at the minimum considered practical to pull the net. The aku sampan has no cargo mast or boom.

METHOD OF TESTING:

It was decided that for a quick reliable check it would be best to test the boat at sea in as near identical conditions as possible. The stall line pull of the power bloc was found by dynamometer to be 450 pounds. This can of course be increased by the pulling of the crew hence, an inclining weight of approximately 1,000 pounds was decided upon. For the moving weight seven members of the crew with an average weight of 150 pounds were used. Puns were to be made each way in the trough with wind and sea abeam with the weight on the sponson as far outboard as possible, approximately 6 feet both port and starboard with bait wells empty and full observations of angle of inclination being taken and a visual check of minimum freeboard on the low side to estimate reserve stability. Also a 100 fathom shackle of seine was to be cast and retrieved with the vessel in the trough.



THE TEST AND RESULTS:

At 9:06 a.m. July 22, 1961 the "Broadbill" cast off from her moorings at Kewalo Basin, Honolulu for the open sea with 13 men and all necessary gear aboard. Seas were found to be slight to moderate about 3 feet, with an easterly breeze of approximately 5 miles off shore.

The first run was made in a southerly direction at 9:20 a.m. with bait wells dry and inclining weight to starboard, inclining moment of the wind additive. The average angle of heel was 15° with 19° maximum. The vessel was judged to be safe in this position and was quite steady. The port chine was still nearly a foot below the water and 18 to 20 inches of freeboard to starboard remained, apparently allowing adequate reserve for safety and a payload as well. A payload would lower the center of gravity and add to stability.

With the inclining weight to port and the inclining moment of the beam wind subtractive, the average list was 0°, the vessel rolling either way a few degrees.

Next at 9:30 a.m. a run was made in a northerly direction with the wind a beam to starboard.

First with weight to port, wind moment additive an average list of 10° to 12° was observed and with the weight to starboard, wind moment subtractive, the average list to starboard was but 3°.

At 9:40 a.m. a 100 fathom shackle of net was set in a north and south direction; as it was desired to test the vessel working in the trough. In going back to pick up the net a maximum roll of 26° was noted while making a hard turn with weights centered.

Although this was the first time the net had been cast and retrieved by this crew, it was hauled in less than 20 minutes. The average list resulting from hauling was 5° with an occasional roll to 10°. Of course the wind moment was subtractive which will always be the case as the net cannot be worked from the windward side with the boat drifting down on to it.

Next the bait wells were flooded and the same runs were made with the shifting weights.

Heading south with weight to starboard, wind moment additive, the average starboard list was 13°. With weight to port the average list was 0°.

Reverse course heading north, weight to port, wind moment additive, average port list was 9°; weight to starboard average starboard list 3°.

Since the vessel was slower in her motion due to the damping effect of the water and appeared more stable with the wells flooded, it was decided not to haul the net again.

CONCLUSION:

The results of this test indicate that it should be quite safe and practical to conduct seining experiments using the "Broadbill." If, as a result of these experiments, it is found the power-block should be higher, it might well be raised somewhat on vessels of greater stability. A simple test such as this could then be run if desired, at little expense.

(Sgd.) E. R. Simmerer
E. R. Simmerer

APPENDIX 3

STATION LIST, M/V BROADBILL, JULY 23, 1961 TO SEPTEMBER 29, 1961

Station	Date	Position 1/		Type of Activity
		Latitude	Longitude	
1	7/23/61	Pearl Harbor		baiting - nehu
2	7/24/61	21°18.1' N.	158°13.7' W.	chummed - abandoned - small skipjack
3	7/24/61	21°15.2'	158°10.2'	chummed - abandoned - no response - med. skipjack
4	7/24/61	21°36.9'	158°19.0'	chummed - abandoned - no response - sml. skipjack
5	7/25/61	*21°34'	158°19'	chummed - set 5-1/2" net
5A	7/25/61	21°34'	158°19'	chummed - abandoned - small yellowfin
6	7/25/61	21°33.1'	158°16.5'	abandoned - porpoise
7	7/25/61	21°22.4'	158°20.5'	chummed - abandoned - small skipjack
8	7/25/61	21°09.4'	158°01.5'	chummed - abandoned - small skipjack
9	7/26/61	Pearl Harbor		baiting - nehu
10	7/27/61	*21°00'	157°30'	chummed - abandoned - mahimahi
11	7/27/61	*20°45'	157°05'	trolled around log
11A	7/27/61	3/4 mile south of Cape Kaea, Lanai		blind chumming - abandoned - no response
12	7/29/61	Kuliouou Stream		baiting - mosquito fish
13	7/31/61	Pearl Harbor		baiting - nehu
14	7/31/61	21°13.5'	158°02.5'	chummed - abandoned - no response
15	7/31/61	*21°10'	158°08'	chummed - abandoned - no response - med. skipjack
16	7/31/61	*21°10'	158°08'	chummed - abandoned - small skipjack
17	7/31/61	21°05.7'	158°11.1'	chummed - abandoned - small skipjack
18	7/31/61	21°04.5'	158°11.2'	chummed - set 7-3/4" net
19	7/31/61	21°01.7'	158°10.1'	chummed - set 5-1/2" net
20	8/ 1/61	20°47.5'	158°43.6'	chummed - abandoned - no response
21	8/ 1/61	21°13.5'	158°25.4'	chummed - abandoned - small skipjack
22	8/ 1/61	*21°20'	158°20'	chummed - set 5-1/2" net
23	8/ 2/61	*21°23'	158°12'	blind chumming - abandoned - no response
24	8/ 2/61	Off Barber's Point, Oahu		chummed - abandoned - no response
24A	8/ 2/61	Off Ewa Beach		blind chumming - abandoned - no response
25	8/ 3/61	Pearl Harbor		baiting - nehu
26	8/ 4/61	21°02.0'	157°20.2'	chummed - set 5-1/2" net
27	8/ 4/61	5-10 miles southwest of Lanai		trolled around log
27A	8/ 4/61	5-10 miles south of Lanai		chummed skipjack school - abandoned - no response
28	8/ 5/61	Kaiwi Channel		chummed - abandoned - no response
29	8/ 5/61	5-10 miles northeast Makapuu Pt., Oahu		chummed - set 5-1/2" net
30	8/ 9/61	Pearl Harbor		baiting - nehu
31	8/10/61	5-10 miles southeast Barber's Pt., Oahu		chummed - abandoned - no response
32	8/10/61	21°05.9'	158°25.1'	chummed - abandoned - yellowfin
33	8/10/61	21°41.2'	158°09.0'	chummed - set 5-1/2" net
34	8/11/61	5-10 miles north of Kahuku Pt., Oahu		chummed - abandoned - small skipjack
35	8/11/61	5-10 miles west of Kahuku Pt., Oahu		abandoned - school sounded
36	8/11/61	21°35.9'	158°21.2'	chummed - abandoned - small unidentified fish
37	8/11/61	21°31.3'	158°15.9'	chummed - set 7-3/4" net
38	8/11/61	21°09.6'	158°15.0'	chummed - abandoned - little tunny
39	8/11/61	21°13.9'	158°10.4'	chummed - set 5-1/2" net
40	8/13/61	Pearl Harbor		baiting - nehu
41	8/14/61	21°38.4'	157°29.1'	chummed - set 7-3/4" net
42	8/14/61	21°44.5'	157°30.9'	chummed - set 7-3/4" net
43	8/14/61	21°33.6'	157°23.8'	chummed - set 7-3/4" net
44	8/14/61	21°33.2'	157°28.8'	chummed - abandoned - skipjack school sounded
45	8/14/61	ca. 5 miles north of Makapuu Pt., Oahu		chummed - set 5-1/2" net
46	8/15/61	Pearl Harbor		baiting - nehu
47	8/16/61	Keehi Lagoon		baiting - iao
48	8/16/61	Kaneohe Bay		night baiting - iao
49	8/17/61	Kaneohe Bay		baiting - iao
50	8/17/61	*21°40'	157°35'	chummed - abandoned - no response
51	8/17/61	*21°17'	157°12'	chummed - set 5-1/2" net
52	8/18/61	21°13.7'	157°24.0'	chummed - abandoned - small unidentified fish
53	8/18/61	21°12.1'	157°28.5'	chummed - abandoned - mahimahi
54	8/18/61	20°49.5'	157°37.8'	porpoise
55	8/18/61	20°52.6'	157°39.0'	chummed - abandoned - small skipjack
56	8/18/61	20°50.4'	157°43.1'	chummed - abandoned - small skipjack
57	8/18/61	20°55.8'	157°46.7'	chummed - abandoned - small skipjack
58	8/29/61	Pearl Harbor		baiting - nehu
59	8/30/61	21°32.8'	158°21.1'	chummed - abandoned - small skipjack
60	8/30/61	21°38.2'	158°26.9'	chummed - abandoned - small skipjack sounded
61	8/30/61	*21°40'	158°28'	chummed - set 5-1/2" net
62	8/30/61	21°43.5'	158°31.9'	chummed - set 5-1/2" net
63	8/30/61	*21°40'	158°30'	chummed - set 5-1/2" net
64	8/30/61	21°38.0'	158°30.0'	chummed - abandoned - mahimahi
65	8/30/61	*21°30'	158°25'	chummed - abandoned - small unidentified fish
66	8/31/61	*21°34'	158°21'	chummed - set 5-1/2" net
67	8/31/61	21°15.0'	158°26.8'	chummed - abandoned - no response
68	9/ 1/61	Pearl Harbor		baiting - nehu
69	9/ 2/61	*21°39'	158°11'	abandoned - school sounded
70	9/ 2/61	22°02.7'	157°53.6'	chummed - abandoned - no response
71	9/ 2/61	*22°56'	157°48'	chummed - abandoned - no response
72	9/ 2/61	*21°49'	157°42'	chummed - abandoned - school sounded (skipjack)
73	9/ 2/61	21°44.0'	157°38.5'	chummed - set 7-3/4" net
74	9/ 2/61	21°43.9'	157°46.1'	chummed - set 5-1/2" net
75	9/ 3/61	21°40.0'	157°34.2'	chummed - abandoned - no response (large skipjack)
76	9/ 3/61	*21°40'	157°30'	chummed - set 7-3/4" net
77	9/ 3/61	*21°38'	157°31'	chummed - abandoned - no response (large skipjack)
78	9/ 3/61	*21°38'	157°31'	chummed - abandoned - no response (large skipjack)
79	9/ 3/61	21°39.1'	157°32.1'	chummed - set 7-3/4" net
80	9/ 5/61	Pearl Harbor		baiting operation - nehu
81	9/ 6/61	21°37.0'	157°30.9'	chummed - abandoned - no response
82	9/ 6/61	21°44.2'	157°34.4'	chummed - abandoned - mahimahi
83	9/ 6/61	21°44.2'	157°34.4'	chummed - abandoned - no response
84	9/ 6/61	21°46.0'	157°34.5'	chummed - abandoned - mahimahi
85	9/ 6/61	21°51.1'	157°31.6'	chummed - abandoned - no response
86	9/ 7/61	20°53.5'	157°04.9'	blind chumming - abandoned - no response

STATION LIST, M/V BROADBILL, JULY 23, 1961 TO SEPTEMBER 29, 1961 (con.)

Station	Date	Position 1/		Type of Activity
		Latitude	Longitude	
87	9/ 7/61	*20°48'	157°02'	chumned - abandoned - small skipjack
87A	9/ 7/61	*20°48'	157°02'	chumned - abandoned - no response (mixed small &
88	9/ 7/61	20°27.4'	156°59.2'	chumned - set 5-1/2" net med. size skipjack)
89	9/ 7/61	20°24.2'	157°02.2'	chumned - set 5-1/2" net
89A	9/ 8/61	21°06.6'	157°40.9'	chumned - abandoned - no response
90	9/ 8/61	21°01.7'	157°51.1'	chumned - abandoned - mahimahi
91	9/ 8/61	20°50.1'	157°59.4'	chumned - abandoned - mahimahi
92	9/ 8/61	21°11.1'	158°07.9'	chumned - abandoned - mahimahi
93	9/ 8/61	Off Ewa Beach		blind chumming - abandoned - no response
94	9/ 8/61	Off Ewa Beach		chumned - abandoned - small skipjack
95	9/10/61	Pearl Harbor		baiting operation - nehu
96	9/11/61	21°45.5'	157°23.0'	chumned - set 7-3/4" net
97	9/11/61	21°51.0'	157°24.0'	chumned - abandoned - no response
98	9/11/61	21°56.5'	157°23.2'	chumned - set 7-3/4" net
99	9/11/61	21°59.0'	157°21.8'	chumned - abandoned - no response
100	9/11/61	22°00.6'	157°22.0'	chumned - abandoned - small skipjack
101	9/11/61	21°59.1'	157°22.9'	chumned - abandoned - small skipjack
102	9/12/61	Pearl Harbor		baiting operation - nehu
103	9/13/61	21°36.5'	157°28.1'	chumned - abandoned - no response
104	9/13/61	21°28.9'	157°25.8'	chumned - abandoned - no response
105	9/13/61	21°53.6'	157°42.2'	chumned - abandoned - small skipjack
106	9/13/61	21°53.0'	157°28.5'	abandoned - small skipjack
107	9/13/61	21°54.0'	157°27.0'	chumned - pole-and-line only - small skipjack
108	9/13/61	21°46.3'	157°30.8'	chumned - abandoned - no response
109	9/13/61	21°48.5'	157°29.5'	chumned - abandoned - no response
110	9/13/61	*21°48'	157°29'	chumned - abandoned - small skipjack
111	9/13/61	Off Mokumanu, Oahu		chumned - abandoned - no response
112	9/16/61	Pearl Harbor		baiting operation
112A	9/17/61	*21°50'	159°35'	chumned - skipjack school sounded
113	9/17/61	*21°50'	159°35'	chumned - set 5-1/2" net
114	9/17/61	*21°50'	159°35'	chumned - set 5-1/2" net
115	9/18/61	Port Allan, Kauai		baiting operation - nehu
116	9/18/61	*22°06'	159°49'	chumned - set 5-1/2" net
117	9/18/61	Hanalei Bay, Kauai		baiting operation - nehu
118	9/19/61	*22°07'	160°07'	chumned - abandoned - no response
119	9/19/61	*22°01'	160°01'	chumned - abandoned - school sounded
120	9/19/61	*21°54'	159°42'	chumned - abandoned - small unidentified fish
121	9/20/61	Kauai Channel		no attempt - lack of bait
122	9/21/61	Pearl Harbor		baiting operation - nehu
123	9/22/61	Pearl Harbor		baiting operation - nehu
124	9/23/61	20°56.5'	157°46.5'	chumned - abandoned - no response
125	9/23/61	20°56.5'	157°46.5'	chumned - set 5-1/2" net
126	9/23/61	20°52.3'	157°45.4'	chumned - set 5-1/2" net
127	9/23/61	20°53.2'	157°45.3'	chumned - set 5-1/2" net, 7-3/4" net
128	9/26/61	Keehi Lagoon		baiting operation - nehu
129	9/27/61	21°23.8'	158°27.7'	chumned - abandoned - no response
130	9/27/61	*21°31'	158°17.5'	chumned - abandoned - small unidentified fish
131	9/28/61	21°15.5'	157°29.5'	abandoned - porpoise
132	9/28/61	20°58'	157°27'	chumned - abandoned - no response
133	9/28/61	20°58'	157°27'	chumned - abandoned - no response
134	9/28/61	20°58.4'	157°27.1'	chumned - abandoned - school sounded
135	9/28/61	20°58'	157°27'	chumned - abandoned - small skipjack

1/ Positions preceded by * are based on dead reckoning.

APPENDIX 4

STATION LIST, M/V BROADBILL, MAY 10, 1962 TO AUGUST 25, 1962

Station	Date	Position[1/]		Type of activity
		Latitude N.	Longitude W.	
1	5/10/62	Pearl Harbor		baiting - nehu
2	5/11/62	Pearl Harbor		baiting - nehu
3	5/11/62	Kalihi Channel		night baiting - nehu
4	5/12/62	*21°15.6'	158°13.8'	chummed - abandoned - small skipjack
5	5/12/62	*21°30.0'	158°28.0'	abandoned - porpoise
6	5/12/62	21°30.1'	158°24.4'	chummed - abandoned - small skipjack
7	5/12/62	21°30.1'	158°24.4'	chummed - abandoned - no response
8	5/12/62	21°25.9'	158°24.5'	chummed - set 7-3/4" surface net
9	5/14/62	Honolulu Harbor		night baiting - nehu
10	5/16/62	22°09.3'	159°47.0'	abandoned - small skipjack
11	5/16/62	22°06.7'	159°48.2'	chummed - abandoned for larger school
12	5/16/62	22°07.0'	159°49.2'	chummed - abandoned - school sounded
13	5/16/62	22°03.2'	160°06.7'	chummed - abandoned - no response
14	5/16/62	22°02.5'	160°10.0'	chummed - abandoned - no response
15	5/16/62	22°05.2'	160°09.1'	chummed - set 7-3/4" and 9" surface nets
16	5/17/62	22°03.8'	160°15.1'	chummed - abandoned - no response
17	5/17/62	22°02.5'	160°16.1'	chummed - set 7-3/4" surface net
18	5/17/62	22°03.0'	160°15.9'	chummed - abandoned - no response
19	5/17/62	22°04.4'	160°16.6'	chummed - set 7-3/4" surface net
20	5/22/62	Honolulu Harbor		night baiting - nehu
21	5/23/62	Pearl Harbor		baiting - nehu
22	5/24/62	21°20.1'	157°36.1'	chummed - abandoned - small skipjack
23	5/24/62	21°29.6'	157°29.6'	chummed - abandoned - mahimahi
24	5/24/62	21°42.5'	157°36.7'	chummed - abandoned - mahimahi
25	5/25/62	21°43.7'	157°42.0'	chummed - abandoned - mahimahi
26	5/25/62	21°09.1'	157°19.7'	chummed - abandoned - small skipjack
27	5/25/62	20°40.6'	157°08.1'	chummed - abandoned - school sounded
28	5/25/62	20°39.0'	157°03.6'	chummed - set 5-1/2" surface net
29	5/25/62	20°38.7'	157°01.6'	abandoned - school sounded
30	5/26/62	21°03.3'	158°05.7'	abandoned - mahimahi
31	5/26/62	21°19.0'	158°13.3'	chummed - abandoned - no response
32	5/26/62	21°26.6'	158°16.7'	chummed - abandoned - small skipjack
33	5/27/62	21°33.4'	158°17.6'	blind chumming - abandoned - no response
34	5/27/62	21°37.5'	158°15.7'	chummed - set 5-1/2" surface net
35	5/27/62	21°28.5'	158°14.3'	chummed - abandoned - small skipjack
36	5/27/62	Honolulu Harbor		night baiting - nehu
37	5/28/62	Kalihi Channel		night baiting - nehu
38	5/29/62	Pearl Harbor		baiting - nehu
39	5/30/62	21°29.5'	157°33.8'	chummed - abandoned - no response
40	5/30/62	21°34.0'	157°32.0'	chummed - abandoned - mahimahi
41	5/30/62	21°46.1'	157°22.7'	chummed - abandoned - no response
42	5/30/62	21°54.7'	157°29.6'	chummed - abandoned - no response
43	5/30/62	21°55.7'	157°33.3'	chummed - abandoned - no response surface net
44	5/30/62	21°52.2'	157°46.3'	chummed - set 5-1/2" and 7-3/4"
45	5/30/62	Kaneohe Bay		night baiting - nehu
46	5/31/62	Kaneohe Bay		baiting - nehu
47	6/1/62	Kaneohe Bay		baiting - nehu
48	6/7/62	Wahiawa Reservoir		baiting - threadfin shad
49	6/8/62	Wahiawa Reservoir		baiting - threadfin shad
50	6/12/62	Pearl Harbor		baiting - nehu
51	6/13/62	21°23.4'	158°12.4'	abandoned - small skipjack
52	6/14/62	Hanalei Bay, Kauai		baiting - nehu
53	6/14/62	22°14.1'	159°36.0'	chummed - abandoned - small skipjack
53A	6/14/62	22°13.2'	159°36.5'	chummed - abandoned - small skipjack
54	6/14/62	22°11.9'	159°38.5'	chummed - abandoned - small skipjack
55	6/14/62	22°10.6'	159°43.0'	chummed - set 5-1/2" surface net
56	6/14/62	22°06.3'	159°47.9'	chummed - abandoned - small skipjack
57	6/14/62	22°07.3'	159°49.2'	chummed - set 5-1/2" surface net
58	6/14/62	22°05.7'	159°48.7'	chummed - abandoned - no response
59	6/14/62	22°04.5'	159°49.7	chummed - set 5-1/2" surface net
60	6/14/62	22°03.3'	159°49.6	chummed - abandoned - no response
61	6/14/62	22°01.8'	159°48.8'	chummed - abandoned - no response
62	6/14/62	21°59.4'	159°47.5'	abandoned - small skipjack
63	6/14/62	22°03.7'	159°52.4'	chummed - set 5-1/2" surface net
64	6/14/62	Hanalei Bay, Kauai		baiting - nehu
65	6/15/62	Hanalei Bay, Kauai		baiting - nehu
66	6/15/62	22°19.4'	160°00.3'	chummed - fished by pole-and-line
67	6/15/62	22°19.0'	160°00.0'	chummed - abandoned - no response
68	6/15/62	22°19.8'	160°01.3'	chummed - set 7-3/4" and 9" surface nets
69	6/16/62	21°23.8'	159°04.7'	chummed - abandoned - no response
70	6/16/62	21°22.5'	158°47.0'	abandoned - school sounded
71	6/16/62	21°22.2'	158°42.0'	chummed - abandoned - school sounded
72	6/16/62	21°11.3'	158°38.3'	chummed - abandoned - no response
73	6/16/62	21°11.1'	158°28.5'	chummed - abandoned - small skipjack
74	6/18/62	22°02.3'	159°06.8'	chummed - abandoned - mahimahi
75	6/18/62	Hanalei Bay, Kauai		baiting - nehu
76	6/19/62	22°23.3'	159°44.5'	chummed - abandoned - no response
77	6/19/62	22°22.5'	159°45.7'	chummed - set 9" surface net
78	6/19/62	22°12.3'	160°10.9'	chummed - set 7-3/4" and 9" surface nets
79	6/19/62	22°13.4'	160°04.3'	chummed - set 7-3/4" and 9" surface nets
80	6/19/62	Hanalei Bay, Kauai		baiting - nehu
81	6/20/62	Hanalei Bay, Kauai		baiting - nehu
82	6/20/62	22°08.7'	160°24.0'	abandoned - large yellowfin
83	6/20/62	22°05.9'	160°15.8'	chummed - set 5-1/2" surface net
84	6/20/62	22°05.7'	160°14.6'	abandoned - school sounded
85	6/20/62	22°08.7'	160°04.9'	chummed - set 9" surface net

[1/] Positions preceded by * are based on dead reckoning.

STATION LIST, M/V BROADBILL, MAY 10, 1962 TO AUGUST 25, 1962 (con.)

Station	Date	Position[1/]		Type of activity
		Latitude N.	Longitude W.	
86	6/20/62	22°09.2'	160°04.6'	chummed - abandoned - small skipjack
87	6/20/62	22°07.2'	160°05.6'	chummed - abandoned - no response
88	6/20/62	22°07.7'	160°04.6'	chummed - abandoned - school sounded
89	6/22/62	State bait-rearing plant		bait-fish - tilapia
90	6/23/62	21°55.3'	159°00.2'	chummed - abandoned - school sounded
91	6/23/62	21°56.5'	159°00.3'	chummed - set 9" surface net
92	6/23/62	22°02.5'	159°00.3'	chummed - fished by pole-and-line
93	6/23/62	22°04.8'	159°01.3'	chummed - abandoned - small skipjack
94	6/23/62	22°15.3'	159°05.8'	chummed - fished by pole-and-line
95	6/24/62	Wainiha Bay, Kauai		baiting - nehu
96	6/24/62	22°23.8'	159°19.5'	chummed - school sounded
97	6/24/62	22°22.8'	159°25.0'	abandoned - school sounded
98	6/24/62	22°07.3'	159°06.8'	chummed - abandoned - small skipjack
99	6/24/62	22°06.5'	159°08.2'	chummed - abandoned - small skipjack
100	6/24/62	21°55.1'	159°09.3'	chummed - abandoned - no response
101	6/25/62	21°44.1'	159°10.6'	chummed - abandoned - no response
102	6/25/62	21°39.1'	159°12.1'	chummed - set 9" surface net
103	7/12/62	State bait-rearing plant		bait-fish - tilapia
104	7/13/62	21°03.6'	158°22.3'	chummed - set 7-3/4" and 9" surface nets
105	7/13/62	21°12.2'	158°28.8'	chummed - abandoned - no response
106	7/13/62	21°13.5'	158°31.0'	chummed - set 7-3/4" surface net
107	7/13/62	21°13.5'	158°31.0'	chummed - set 7-3/4" surface and 7-3/4" subsurface nets
108	7/13/62	21°13.6'	158°26.9'	chummed - abandoned - no response
109	7/13/62	21°13.6'	158°26.9'	chummed - abandoned - small skipjack
110	7/13/62	21°14.5'	158°26.8'	chummed - abandoned - small skipjack
111	7/14/62	21°15.6'	158°36.9'	chummed - abandoned - no response
112	7/14/62	21°19.8'	158°42.1'	chummed - set 7-3/4" surface net
113	7/15/62	Pearl Harbor		baiting - nehu
114	7/16/62	21°14.1'	158°33.9'	chummed - set 9" subsurface net
115	7/16/62	21°20.5'	158°39.8'	chummed - abandoned - mahimahi
116	7/16/62	21°12.8'	158°45.5'	chummed - set 9" subsurface net
117	7/16/62	21°12.9'	158°36.0'	chummed - abandoned - no response
118	7/16/62	21°15.2'	158°31.1'	chummed - abandoned - small skipjack
119	7/16/62	21°15.2'	158°31.1'	chummed - abandoned - no response
120	7/17/62	21°09.8'	158°30.3'	chummed - set 9" subsurface net
121	7/17/62	21°12.1'	158°40.7'	chummed - set 9" subsurface net
122	7/17/62	21°13.5'	158°40.7'	chummed - abandoned - no response
123	7/18/62	Fort Kamehameha		baiting - nehu
124	7/18/62	Pearl Harbor		baiting - nehu
125	7/18/62	State bait-rearing plant		bait-fish - tilapia
126	7/19/62	21°55.2'	157°18.9'	chummed - set 9" subsurface net
127	7/21/62	*21°15.0'	158°32.0'	chummed - abandoned - mahimahi
128	7/21/62	*21°20.0'	158°33.0'	chummed - set 9" subsurface net
129	7/21/62	*21°20.0'	158°33.0'	abandoned - school sounded
130	7/21/62	*21°25.0'	158°29.0'	chummed - abandoned - small skipjack
131	7/21/62	*21°20.0'	158°37.0'	chummed - abandoned - no response
132	7/21/62	*21°20.0'	158°30.0'	chummed - set 9" subsurface net
132A	7/21/62	*21°20.0'	158°30.0'	chummed - abandoned - small skipjack
133	7/24/62	*20°43.0'	157°10.0'	chummed - abandoned - no response
134	7/24/62	20°39.8'	157°05.7'	passive gill net fishing at night
135	7/25/62	20°42.1'	157°05.2'	passive gill net fishing at night
136	7/26/62	*20°46.0'	157°05.0'	passive gill net fishing at night
137	7/28/62	*20°54.5'	157°04.5'	passive gill net fishing at night
138	7/29/62	Pearl Harbor		baiting - nehu
138A	8/1/62	State bait-rearing plant		bait-fish - tilapia
139	8/2/62	21°23.2'	158°34.6'	chummed - abandoned for another school
140	8/2/62	21°24.0'	158°34.7'	chummed - abandoned - no response
141	8/2/62	21°24.4'	158°32.1'	chummed - abandoned - small skipjack
142	8/2/62	21°25.9'	158°27.2'	chummed - abandoned - small skipjack
143	8/2/62	21°27.5'	158°21.5'	abandoned - school moving too fast
144	8/3/62	21°40.7'	158°06.6'	chummed - abandoned - no response
145	8/3/62	21°34.6'	158°20.8'	chummed - abandoned - small skipjack
146	8/3/62	21°32.9'	158°18.8'	chummed - set nets around school
147	8/3/62	21°30.3'	158°15.1'	chummed - abandoned - small skipjack
148	8/3/62	21°29.0'	158°15.0'	chummed - abandoned - no response
149	8/4/62	21°33.5'	158°17.1'	blind chumming - no response
150	8/4/62	21°31.8'	158°18.9'	chummed - abandoned - no response
151	8/4/62	21°34.8'	158°20.3'	chummed - abandoned - no response
152	8/4/62	21°34.2'	158°20.2'	chummed - abandoned - small skipjack
153	8/4/62	21°33.1'	158°19.2'	chummed - set nets around school
154	8/4/62	21°33.1'	158°19.2'	chummed - set nets around school
155	8/4/62	21°33.1'	158°21.0'	chummed - abandoned - no response
156	8/4/62	21°25.5'	158°13.3'	abandoned - small skipjack
157	8/4/62	State bait-rearing plant		bait-fish - tilapia
158	8/6/62	21°27.6'	158°14.8'	abandoned - small skipjack chummed
159	8/6/62	21°23.8'	158°11.9'	chummed - abandoned - small skipjack
160	8/7/62	21°34.1'	158°21.4'	chummed - abandoned - no response
161	8/7/62	21°33.4'	158°21.1'	chummed - abandoned - small skipjack
162	8/8/62	20°56.6'	157°19.1'	chummed - abandoned - no response
163	8/8/62	20°52.8'	157°13.5'	chummed - abandoned - mahimahi
164	8/9/62	20°13.1'	155°55.1'	chummed - abandoned - small skipjack
165	8/9/62	20°06.5'	155°55.0'	chummed - abandoned - no response

[1/] Positions preceded by * are based on dead reckoning.

STATION LIST, M/V BROADBILL, MAY 10, 1962 TO AUGUST 25, 1962 (con.)

Station	Date	Position		Type of activity
		Latitude N.	Longitude W.	
166	8/9/62	20°05.4'	155°57.0'	chummed - abandoned - no response
167	8/9/62	20°08.4'	155°57.0'	chummed - abandoned - school sounded
168	8/9/62	20°05.8'	155°56.5'	chummed - abandoned - no response
169	8/9/62	19°51.7'	156°04.5'	chummed - abandoned - small frigate mackerel
170	8/9/62	19°50.5'	156°05.6'	chummed - abandoned - large yellowfin
171	8/9/62	19°45.8'	156°05.7'	chummed - abandoned - no response
172	8/10/62	20°08.4'	156°02.6'	chummed - abandoned - school sounded
173	8/10/62	20°33.5'	156°19.1'	chummed - abandoned - no response
174	8/11/62	21°08.1'	157°23.9'	chummed - abandoned - mahimahi
175	8/13/62	21°20.8'	158°17.8'	passive gill net fishing at night
176	8/14/62	21°33.2'	158°19.2'	chummed - abandoned - small skipjack
177	8/14/62	21°33.4'	158°19.7'	chummed - abandoned - no response
178	8/14/62	21°33.3'	158°23.6'	chummed - abandoned - no response
179	8/14/62	21°30.2'	158°27.4'	chummed - abandoned - no response
180	8/15/62	21°27.6'	158°14.4'	passive gill net fishing at night
181	8/16/62	21°29.2'	158°16.8'	passive gill net fishing at night
182	8/17/62	21°30.6'	158°16.5'	chummed - abandoned - no response
183	8/17/62	21°35.5'	158°16.5'	chummed - abandoned - mahimahi
184	8/17/62	21°39.4'	158°08.5'	passive gill net fishing at night
185	8/18/62	21°39.9'	158°08.0'	passive gill net fishing at night
186	8/19/62	21°29.9'	158°14.7'	chummed - abandoned - small skipjack
187	8/19/62	21°29.3'	158°15.1'	abandoned - small skipjack
188	8/19/62	21°29.2'	158°14.5'	chummed - abandoned - no response
189	8/20/62	State bait-rearing plant		bait-fish - tilapia
190	8/21/62	21°48.3'	159°07.9'	chummed - abandoned - no response
191	8/21/62	21°48.0'	159°31.1'	chummed - abandoned - no response
192	8/21/62	21°52.5'	159°34.7'	chummed - abandoned - small skipjack
193	8/21/62	21°57.3'	159°47.0'	chummed - abandoned - small skipjack
194	8/21/62	21°57.7'	159°47.4'	passive gill net fishing at night
195	8/22/62	22°05.5'	160°05.2'	chummed - abandoned - large yellowfin
196	8/22/62	22°09.7'	160°04.7'	chummed - abandoned - large yellowfin
197	8/22/62	21°58.7'	159°47.7'	passive gill net fishing at night
198	8/23/62	22°11.3'	159°53.3'	chummed - abandoned - no response
199	8/23/62	22°14.6'	160°12.3'	chummed - set nets around school
200	8/23/62	22°13.0'	160°07.8'	chummed- abandoned - no response
201	8/23/62	22°07.7'	159°55.2'	passive gill net fishing at night
202	8/24/62	22°03.7'	159°59.4'	chummed - abandoned - small skipjack
203	8/24/62	22°02.4'	160°06.8'	abandoned - large yellowfin
204	8/24/62	21°52.5'	160°15.8'	passive gill net fishing at night
205	8/25/62	22°01.5'	160°07.9'	chummed - abandoned - mahimahi
206	8/25/62	22°01.8'	160°04.6'	chummed - fished by pole-and-line
207	8/25/62	21°52.5'	159°39.1'	passive gill net fishing at night