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FISH AGGREGATION DEVICE (FAD) ENHANCEMENT OF OFFSHORE FISHERIES IN AMERICAN SAMOA

by

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ABSTRACT

Fish Agregation Devices (FADs) have become an established part of modern efforts to enhance catches of offshore fishery recources throughout the Pacific region, even though there has been little scientific evidence which verifies that FAD's meet this objective. Support for FAD program success has usually been based on fishery catch reports providing only sporadic, qualitative and circumstantial information.

Federal funding for a FAD program in American Samoa began in 1979. Troll fishing test fishery analysis of FADs in American Samoa began in 1980. In 1985, test fishery procedures were standardized to use quantitative troll fishing techniques to assess the effectiveness of FADs in enhancing offshore fisheries through comparisons with offshore banks and open-water "control" areas.

There was no significant difference between FADs and banks based on test fishery CPUE figures. Catches were always lower in open-water areas. Combined test fishery information from three years gave catch rates of 5.8 kg/hr for open-water, 21.0 kg/hr for FADs and 31.0 kg/hr for banks. There were significant differences between FADs and open-water plus banks for mean lengths of yellowfin tuna and skipjack tuna. The smaller sizes of yellowfin and skipjack tuna at FADs is discussed in terms of statistical and biological differences, and for possible size range bias in the test fishery catches.

INTRODUCTION

Fish Aggregation Devices (FADs) have become an established part of modern efforts to enhance catches of offshore pelagic fishery resources throughout the tropical Pacific Ocean. This current enthusiasm for anchoring buoys in the open ocean to attract and "hold" schools of tunas (Scombridae) and other pelagic fishes seems to be based on the successful use of "payaos" - anchored and drifting bamboo rafts - in the Philippines in the early 1970's to enhance the purse seine fishery for tuna (Matsumoto et al 1981). Virtually all of the countries in the South Pacific had or were planning FAD programs by 1982 (de San 1982, Preston 1982), and there were a number of efforts to improve the physical design for FAD systems to increase their durability in the high energy ocean environment (Shomura and Matsumoto 1982, Boy and Smith 1984).

The widespread use of FADs to enhance catches of pelagic fishes received considerable funding support from various states and nations in the Indo-Pacific region even though there was little, if any, scientific evidence which verified that FADs met this objective. The support for FAD programs was based on their popularity with fishermen and fishery agencies as the only practical method for increasing the availability of oceanic fishery resources by "controlling" the movements of wandering schools of fish. It had long been known to fishermen and fishery scientists that many valuable pelagic fishes had an affinity for objects floating in the open ocean. It was also "known" that if FADs were properly sited, they would take advantage of this behavioral response and attract large numbers of pelagic fish, providing the opportunity for increasing catches, while decreasing the searching time and operating costs for fishing vessels (Matsumoto et al 1981, Brock 1985, Frusher 1986).

U.S. Government funding for the FAD program in American Samoa began in 1979 when ten FADs were deployed (lasting apparently very short periods) using funding form the National Marine Fisheries Service (NMFS) and the Pacific Tuna Development Foundtion (PFDF). From 1981 through 1983, the "second generation" FAD system deployed and redeployed six FADs utilizing U.S. Fish and Wildlife Service (FWS) funding; deployment times ranged from 0 to 13 months, and average deployment time was 3.0 months.

Deployment of the "third generation" FADs in American Samoa began in August 1984 under an analysis program to test specific engineering and design criteria for FADs anchrored in depths ranging from 915 to 1,646 meters. The program goal of six FADs remaining on-station for one year each has never been attained, primarily due to construction and deployment infrastructure problems. By January 1985, three FADs had been deployed, and the number of FADs (and the percent time) on-station fluctuated between three (42%), four (24%), and five (34%) through September 1987 (Fig. 1) (Office of Marine and Wildlife Resources- OMWR, unpublished reports). The longest deployment times achieved in the third generation of FADs were 31 and 32 months and are still on station and in good condition.

Most of the studies and reports on the effectiveness of FADs in improving catches in offshore fisheries have been primarily qualitative and based on sporadic catch reports from fishermen, or on the results of short-term, non-standardized test fisheries (for example, Quarterly Reports, PTDF and Pacific Fishery Development Foundation - PFDF, unpublished). The few studies which have attempted to present quantitative analysis of FAD fishery enhancement programs have been hampered by relying to various extents on voluntary catch reports, short duration and irregular sampling periods, and inadequate information from control areas (for example, Matsumoto et al 1981, Frusher 1986). It is the objective of this paper to quantitatively evaluate the effectiveness of FADs to enhance the catches of pelagic fishes in offshore fisheries in American Samoa. Two areas of interest in this evaluation are the comparisons of FADs with offshore banks, which are natural fish aggregation "devices", and with open-water (control) areas.

METHODS

Test fisheries were conducted approximately monthly from November 1984 through September 1987, using a research vessel rigged for trolling at a standard fishing power of six lines, and one lure per line. Catches were recorded for the time spent fishing at FADs (within 1.6 km of the buoy), on offshore banks (at depths less than or equal to 183 meters), and in open-water areas (at depths greater than 183 meters and greater than 1.6 km from a FAD buoy). Fishing was conducted in all three areas to maximize catches. A fish was recorded as caught if it was landed, or if it was lost near enough to the vessel to have been identified and landed.

The catch was summarized based on the annual cycle (November through October) of seasonal wind conditions which had the greatest effect on offshore fishing: November through April - calm seas with moderate northerly winds; May through October - moderate seas with strong southeast trade winds. Catch-per-unit-of-effort (CPUE) was expressed in kg/vessel hour for the research vessel.

The Kruskal-Wallis test and nonparametric multiple comparisons test (Zar 1984) were used to evaluate statistical differences in CPUE. Normal approximation of the Mann-Whitney U test (Zar 1984) was used to test for statistical differences in mean lengths of fish.

RESULTS AND DISCUSSION

Test fishery catch data have been available from offshore waters of Tutuila Island, American Samoa since 1975 (OMWR Annual Reports, unpublished). Unfortunately, the data from 1975 to 1984 can only be used for qualitative comparisons within and between years due to the irregular sampling periods and the lack of standardization in fishing effort and data recording procedures (catches were summarized by destination of the fishing trip and cannot be separated by area - i.e., open-water, FAD, bank, etc.). This eliminates any accurate estimation of offshore fishing success prior to the introduction of FADs in 1979, although the relative trends in the catch rates provide some information on the impact of FADs on the accessibility and abundance of the pelagic fish resources.

Test fishery CPUE figures for 1975 through 1979 showed a steady decrease from 7.6 kg/hr to 4.4 kg/hr, but increased to 7.0 kg/hr in 1980 (Table 1), apparently attributable to fishing success at three FADs which accounted for approximately 33% of the total test fishery catch. However, the test fishery in 1981 recorded a slightly increased CPUE of 7.3 kg/hr when only one, poorly producing FAD was on station (R. Wass, 1981 Annual Report No. F-2-R-5, unpublished). In 1982, the total test fishery CPUE of 7.4 kg/hr was comprised of a FAD fishing trip CPUE of 13.7 kg/hr and a "non-FAD" fishing trip CPUE of 5.9 kg/hr (R. Wass, 1982 Annual Report No. F-2-R-6, unpublished). These trends seem to indicate that the introduction of FADs had a positive impact on the accessiblility of the pelagic fishes, even during the early years of the program (1979-1983) when the FADs were on station for only short periods.

In 1983, the total test fishery CPUE increased to 8.1 kg/hr, but "FADs cannot account for 1983 catches because little effort was expended in their vicinity" (R. Wass, 1983 Annual Report No. F-2-R-7, unpublished). A new research vessel made it possible to reach offshore banks which had not been fished in previous test fisheries. The 1983 test fishery recorded a bank trip CPUE of 10.3 kg/hr and a non-bank CPUE of 4.2 kg/hr (Table 1). This trend followed in 1984, with a total test fishery CPUE of 8.3 kg/hr that was derived from a bank trip CPUE of 11.4 kg/hr and a non-bank trip CPUE of 6.6 kg/hr (D. Itano, 1984 Annual Report No. F-2-R-8, unpublished). In both 1983 and 1984, the total amount of test fishing effort expended around FADs connot be determined because it is included in the "non-bank trip" data. The comparability between the catch rates for the bank trips and the FAD trips from 1980 to 1982, provides an indication that FADs had the potential to "create" target fishing locations which were more accessible than offshore banks, and to produce catches of the same relative magnitude.

Complete standardization of the test fishery procedures in 1985 enabled quantitative comparisons between the catches of pelagic fishes made around FADs, on offshore banks, and in open-water areas. The area delineation around the FADs (1.6 km) was based on the observed behavior of FAD associated schools of tuna to remain relatively close to the buoy during the day. This observation is supported by sonic tagging of FAD yellowfin tuna in Hawaii, which were found to stay within 200 m of the buoy during daylight (k. Holland, Univ. of Hawaii, pers. comm.). It was possible to make standardization corrections in the test fishery data taken in November and December 1984, which provided comparative catch rate data for three annual cycles of the seasonal winds that affect the offshore fisheries, hereafter referred to as Year 1, Year 2 and Year 3 (Tables 2-4). This data is presented for the eight species of pelagic fish commonly caught on troll fishing gear in the offshore waters of American Samoa. All of these species are acceptable catches in the subsistence, recreational, or commercial fisheries, and they have the potential to be found on all three areas. Two of the species do not fulfill this assumption - blue marlin were not caught on the offshore banks, and dogtooth tuna were not caught around FADs, however they were retained in the analysis because the primary objective was to examine FAD enhancement of the offshore fisheries in relation to the total complex of species.

There were significant differences between open-water areas, FADs and offshore banks for the total seasonal test fishery CPUEs for Years 1,2 and 3 (p=.05, H=11.0). The total test fishery CPUEs for Years 1,2 and 3 were 3.8, 7.5 and 6.3 kg/hr for open-water control areas; 16.1, 24.2 and 26.1 kg/hr for FADs; and 41.6, 26.1 and 27.6 kg/hr for offshore banks, respectively (Tables 2-4). These figures indicate that catch rates were always lower in the open-water "control" areas, but the only appreciable difference between the FAD's and offshore banks occurred during the Year 1 test fisheries.

There was a significant difference between the total seasonal test fishery CPUEs for open-water areas and offshore banks (p=.05, Q=3.2), but no significant difference between the CPUEs for FADs and offshore banks (p=.05, Q=.6). The offshore banks were the most productive "natural fish aggregation devices" available in American Samoa for comparison with the enhancement effectiveness of FADs. These banks are highly desirable target fishing locations, but they are located well beyond the cruising range of most of the fishing fleet (Fig. 1) and they are often difficult to locate due to poor navigational conditions.

Combination of the test fishery information from Years 1, 2 and 3 gives average catch rates of 5.8 kg/hr for open-water areas, 21.0 kg/hr for FADs and 31.0 kg/hr for offshore banks. This is further indication that overall, the lowest potential for fishing success was in open water areas by factors of 3.6 compared to FADs and 5.3 compared to offshore banks. This combined information also indicates that fishing around offshore banks was 1.5 times better than at FADs, however this difference was shown to be insignificant over the course of the study. It is very likely that a longer and more frequent sampling program would have verified a difference between these two types of fishing locations.

There were significant differences between FADs and open-water areas plus natural banks for the mean lengths of yellowfin tuna (p=.05, z=5.6) and skipjack tuna (p=.05, z=7.6) caught in the test fisheries for Years 1, 2 and 3 combined. The frequency distribution of the yellowfin tuna at the FADs (mean = 60.7, range = 30 to 120 cm) was nearly the same as in the "natural areas" (mean = 68.5, range = 50 to 111 cm) except for a few small fish (Figs. 2 and 3). The frequency distributions of the skipjack tuna at the FADs (mean = 45.5, range = 30 to 75 cm) was almost exactly the same as in the natural areas (mean = 51.3, range = 30 to 79 cm) (Figs. 4 and 5). This indicates that the statistical differences in the (smaller) sizes of the yellowfin tuna and skipjack tuna caught at the FADs does not necessarily equate to biological differences based on aggregation of select groups of fish. A full size range of both species seems to have been present at the FADs and the natural areas, but they were caught at different rates. This could have been caused by disproportional abundance by size, or disproportional recruitment to the test fishery trolling gear by size.

Baited hook-and-line test fishing in Years 1, 2 and 3 at various depths at the FADs often caught larger yellowfin tuna than were taken with surface trolling gear. This demonstrates that these larger fish were not fully recruited to the standardized test fishery methods at the FADs, possibly due to the great depths available to the fish (915 to 1.646 m). It has been shown that yellowfin tuna feed on deep dwelling oplophorid shrimp around FADs (Brock 1985), but there is not an indication that there is a depth distributioh by size. The test fishing at the banks, which accounted for 73% of the yellowfin tuna caught in the natural areas (Tables 2-4), would not encounter this situation, as the restricted depths (less than 183 meters) would have a greater potential to bring large fish in the area into the effective range of the surface trolling gear. Although there is insufficient information to answer this question, there appears to be some evidence for a disproportional recruitment by size of yellowfin tuna to the test fishery. A similar situation cannot be demonstrated for the skipjack tuna, which were caught primarily (66%) in the open-water areas, at sizes comparable to the banks.

This possibility of a size range bias in the test fishing catches does not invalidate the assessment of FAD enhancement because trolling is the standard fishing method for the offshore pelagic fishery in American Samoa. It does indicate, however, that the length frequency information from the test fishery catches can be used to assess the effects of the FADs on the fishery, but care should be taken in extrapolating this information to possible effects of the FADs on the stocks of fish. Even with this restriction, it does not appear from the size ranges of yellowfin tuna and skipjack tuna caught at the FADs that the FADs in American Samoa are selectively aggregating juveniles of these species as has been reported for FADs in Papua New Guinea (yellowfin: range 21 to 35 cm; skipjack: range 19 to 39 cm; Frusher 1986), and suspected for yellowfin for FADs in Hawaii (R. Brock, Univ. of Hawaii, pers. comm). However, the majority of the yellowfin tuna (93.7% to 96.6%) are smaller than the 91 to 100 cm length-at-first-spawning reported for eastern central pacific yellowfin tuna (Baylifs 1980). The majority of the skipjack tuna (81.0% to 90.6%) are larger than the 40 to 43 cm length-at-first-spawning reported for this species in the same area.

The quantitative information in this study on differential catch rates between open-water areas, FAD and offshore banks, conclusively shows that FADs are an effective method for enhancing the troll fishery catches of commonly caught pelagic fishes in American Samoa. It is not possible to make a concise extrapolation of this result to the "total value" that FAD enhancement may have in the fisheries, because the study did not consider quantitative information on the variety of other factors that would be part of this analysis; for example, FAD deployment costs, fish resource status, vessel operation costs, fishery market demands, etc. However, it is general knowledge that there is a demand for fresh fish in American Samoa for local retail markets, subsistence, and some export and that the present local fishing fleet is not technologically capable or economically motivated to fulfill these demands without some assistance. Considering the present biological information on FAD related catches (no apparent excess harvest of juveniles) and the present success in FAD design and engineering (2.5 years + on station), it seems both desirable and practical to use FADs to create productive target fishing locatons within practical distances from harbors in American Samoa.

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Table 1. Numbers of fish caught and catch-per-unit-of effort (CPUE) for the 1975-1983 troll fishery test fisheries in American Samoa (data from, R. Wass, 1983 Annual Report No. F-2-R-7, unpublished).

Year	No. Trips	Total Hrs.	Ave. Hrs.	Numbers Caught by Species*							
				B.M.	Df.	Yf.	Sj.	Kk.	W.	O.	CPUE
1975	46	271.4	5.9	4	20	37	315	68	3	8	7.6
1976	42	239.4	5.7	4	22	54	238	39	2	13	7.4
1977	17	103.7	6.1	0	12	7	90	2	1	6	6.3
1978	19	119.7	6.3	1	8	26	57	0	4	9	5.7
1979	14	86.8	6.2	0	6	8	60	0	0	15	4.4
1980	10	64.0	6.4	0	6	14	33	2	2	0	7.0
1981	11	83.6	7.6	1	6	27	54	2	13	5	7.3
1982	10	70.0	7.0	4	3	16	33	3	0	1	7.4
1983	12	87.6	7.3	1	7	44	126	1	9	5	8.1
1983 Bank	8	56.0	7.0	1	1	44	95	0	6	3	10.3
1983 Other	4	31.6	7.9	0	6	0	31	1	3	2	4.2

* B.M.- Blue marlin (*Makaira nigricans*)
Df. - Dolphinfish (*Coryphaena hippurus*)
Yf. - Yellowfin tuna (*Thunnus albacares*)
Sj. - Skipjack tuna (*Katsuwonus pelamis*)
Kk. - Kawakawa (*Euthynnus affinis*)
W. - Wahoo (*Acanthocybium solandri*)
O. - Other probably includes -
D.T. - Dogtooth tuna (*Gymnosarda unicolor*)
R.R. - Rainbow runner (*Elagatis bipinnulatus*)

Table 2. Numbers of fish caught and catch-per-unit-of-effort (CPUE), by seasonal periods, for the Year 1: November 1984 - October 1985 troll fishing test fishery in American Samoa.

	November 1984 - April 1985						May 1985 - October 1985					
	Open-water		FAD		Bank		Open-water		FAD		Bank	
Trips	16		13		4		13		16		1	
Hrs.	49.2		22.0		10.6		36.5		19.0		3.6	
Ave.	3.1		1.7		2.7		2.8		1.2		3.6	
Species*	No.	kg	No.	kg	No.	kg	No.	kg	No.	kg	No.	kg
B.M.	0		1	45.36	0		1	54.4	0		0	
Df.	0		3	34.9	0		4	38.1	27	157.2	0	
Yf.	5	23.1	10	96.8	28	233.0	0		21	112.5	9	5.4
Sj.	27	85.9	33	101.4	2	5.9	16	29.0	51	63.9	5	17.7
Kk.	30	25.9	4	12.2	1	1.8	40	24.0	7	9.0	1	.5
W.	0		0		1	15.8	3	25.4	3	25.8	1	15.9
D.T.	0		0		9	74.1	2	13.2	0		8	69.3
R.R.	5	6.8	0		60	58.0	0		1	1.4	10	13.6
Total	67	141.7	51	290.7	101	388.7	66	184.1	110	369.8	34	122.4
CPUE		2.9		13.2		36.7		5.0		19.5		34.0

November 1984 - October 1985

	Open Water		FAD		Bank	
Trips	29		29		5	
Hrs.	85.7		41.0		14.2	
Ave	3.0		1.4		2.8	
Species*	No.	kg	No.	kg	No.	kg
B.M.	1	54.4	1	45.36	0	
Df.	4	38.1	30	192.1	0	
Yf.	5	23.1	31	209.3	37	318.4
Sj.	43	114.9	84	165.3	7	23.6
Kk.	70	49.9	11	21.3	2	2.3
W.	3	25.4	3	25.8	2	31.8
D.T.	2	13.2	0		17	143.5
R.R.	5	6.8	1	1.4	70	71.6
Total	133	325.8	161	660.5	135	591.2
CPUE		3.8		16.1		41.6

* See Table 1 for list of species.

Table 3. Number of fish caught and catch-per-unit-of-effort (CPUE), by seasonal periods, for the Year 2: November 1985 - October 1986 troll fishing test fishery in American Samoa.

	November - April			May - October		
	Open Water	FAD	BANK	Open Water	FAD	Bank
Trips	15	12	4	14	14	9
Hrs.	47.1	16.8	9.5	46.1	20.7	10.8
Ave.	3.1	1.4	2.4	3.3	1.5	1.2

Species*	No.	kg	No.	kg	No	kg	No	kg	No	kg	No	kg
B.M.	0		1	45.4	0		2	136.0	0	1	37.2	
Df.	4	64.9	2	24.5	0		11	88.9	19	171.9	2	15.8
Yf.	20	125.7	47	237.6	22	120.5	2	18.8	16	48.1	3	7[illegible]
Sj.	37	162.7	128	239.9	8	21.1	13	75.7	58	124.6	12	26.7
Kk.	6	7.8	4	1.8	4	1.8	11	9.8	0		2	2.3
W.	1	8.2	0		4	46.3	1	9.8	2	13.2	3	22.7
D.T.	0		0		16	105.5	0		0		0	
R.R.	1	1.13	0		30	45.0	0		0		0	
Total	69	370.4	182	549.2	84	340.2	40	339.0	95	357.8	23	182.3
CPUE		7.9		32.7		35.8		7.4		17.3		16.9

November 1985 - October 1986

	Open Water	Fad	Bank
Trips	29	26	13
Hrs	93.2	37.5	20.3
Ave.	3.2	1.4	1.6

Species*	No.	kg	No.	kg	No.	kg
B.M.	2	136.1	1	45.3	1	37.2
Df.	15	153.8	21	196.4	2	15.8
Yf.	50	238.3	186	364.5	20	47.8
Sj.	17	7.9	4	1.8	6	4.08
Kk.	2	17.9	2	13.2	7	68.9
D.T.	0		0		16	105.5
R.R.	1	1.1	0		30	45.0
Total	109	699.6	277	906.9	107	522.4
CPUE		7.50		24.2		26.1

* See Table 1 for species list.

Table 4. Number of fish caught and catch-per-unit-of-effort (CPUE), by seasonal periods for the Year 3: November 1986 - October 1987 troll fishing test fishery in American Samoa.

	November - April			May - October		
	Open Water	FAD	Bank	Open Water	FAD	Bank
Trips	3	(no data)	4	11	11	4
Hrs.	11.1		8.7	29.7	11.1	3.5
Ave.	3.7		2.2	2.7	1.0	.9

Species*	No.	kg	No.	kg	No.	kg	No.	kg	No.	kg
B.M.	0		0		0		0		0	
Df.	1	6.1	0		4	27.7	16	112.7	0	
Yf.	0		18	117.6	4	19.7	23	103.5	4	2.3
Sj.	31	77.2	13	54.7	45	108.9	31	88.7	12	27.0
Kk.	0		6	7.8	6	6.6	0		2	3.4
W.	0		3	31.8	1	5.9	4	24.7	2	24.0
D.T.	0		4	29.2	0		0		0	
R.R.	0		7	12.5	0		0		2	2.9
Total	32	83.3	51	253.6	60	168.8	74	329.6	22	59.6
CPUE		7.5		29.1		5.7		29.7		17.0

November 1986 - October 1987

	Open Water	FAD	Bank
Trips	14	11	8
Hrs.	40.8	11.1	12.2
Ave.	2.9	0.9	1.5

Species*	No.	kg	No.	kg	No.	kg
B.M.	0		0		0	
Df.	5	15.3	16	112.7	0	
Yf.	4	19.7	23	103.5	22	143.0
Sj..	76	186.0	31	88.7	25	81.7
Kk.	6	6.6	0		8	11.2
W.	1	5.9	4	11.2	5	55.8
D.T.	4	24.7	0		4	29.2
R.R.	0		0		9	15.4
Total		258.2		316.1		336.3
CPUE		6.32		26.12		27.56

*See Table 1 for species list.

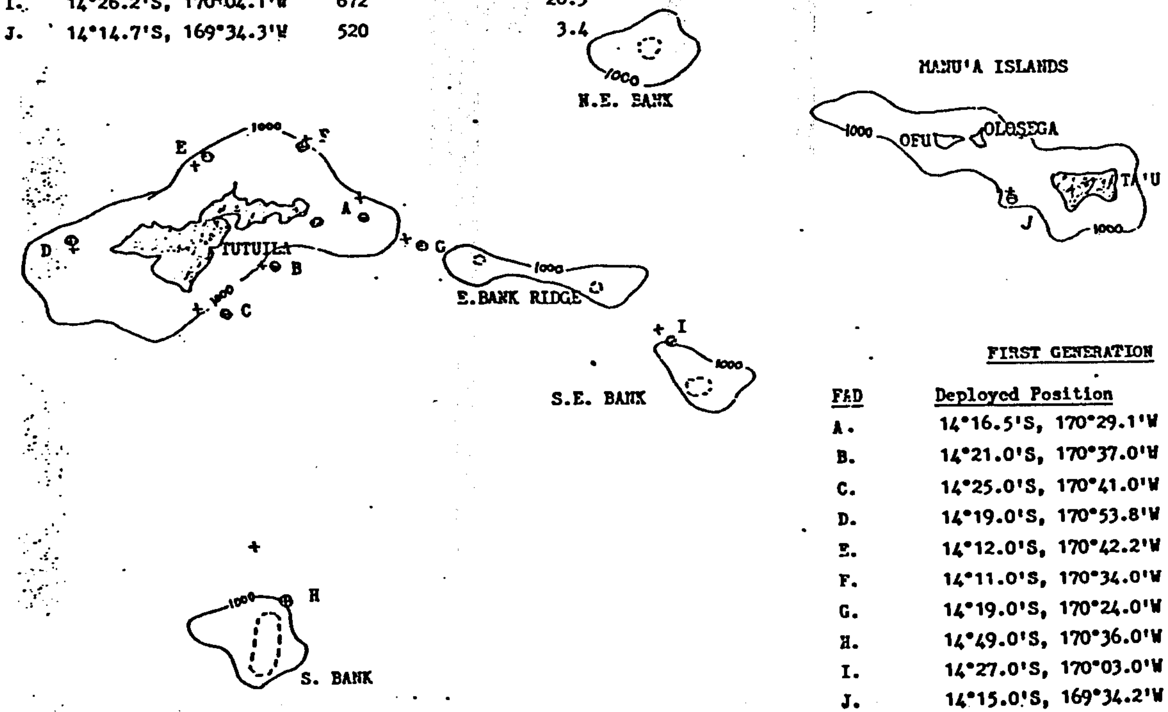
LIST OF FIGURES

Figure 1. FAD locations in American Samoa

FAD	Permit Position	Depth (fathom)	Distance from land (mile)
A.	14°15.2'S, 170°29.0'W	535	4.2
B.	14°21.1'S, 170°37.8'W	900	3.0
C.	14°24.6'S, 170°43.5'W	935	3.0
D.	14°19.2'S, 170°53.9'W	25	3.1
E.	14°12.5'S, 170°43.7'W	500	3.1
F.	14°10.1'S, 170°33.9'W	1,050	4.6
G.	14°18.4'S, 170°25.4'W	520	7.4
H.	14°44.2'S, 170°38.5'W	1,350	23.2
I.	14°26.2'S, 170°04.1'W	672	26.3
J.	14°14.7'S, 169°34.3'W	520	3.4

Figure 1. The permit position and the deployed position of first generation FAD's in American Samoa.

● Indicates the proposed position
\+ Indicates the deployed position



FIRST GENERATION

FAD	Deployed Position	Depth(fathom)
A.	14°16.5'S, 170°29.1'W	100
B.	14°21.0'S, 170°37.0'W	1000
C.	14°25.0'S, 170°41.0'W	1000
D.	14°19.0'S, 170°53.8'W	34
E.	14°12.0'S, 170°42.2'W	500
F.	14°11.0'S, 170°34.0'W	1200
G.	14°19.0'S, 170°24.0'W	500
H.	14°49.0'S, 170°36.0'W	1300
I.	14°27.0'S, 170°03.0'W	700
J.	14°15.0'S, 169°34.2'W	500

November 1984 - October 1987 troll fishing test fisheries in American Samoa (n=106).

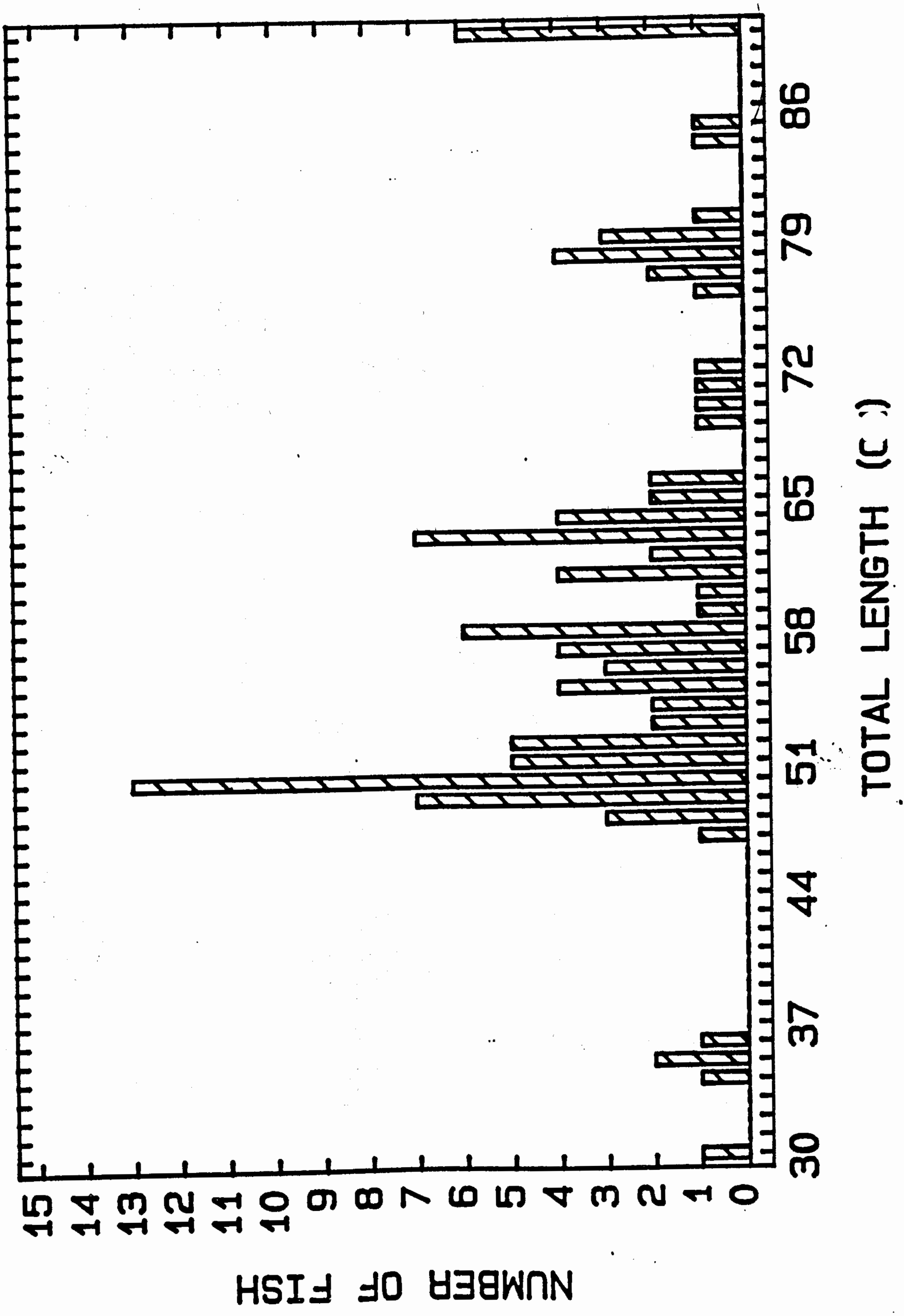
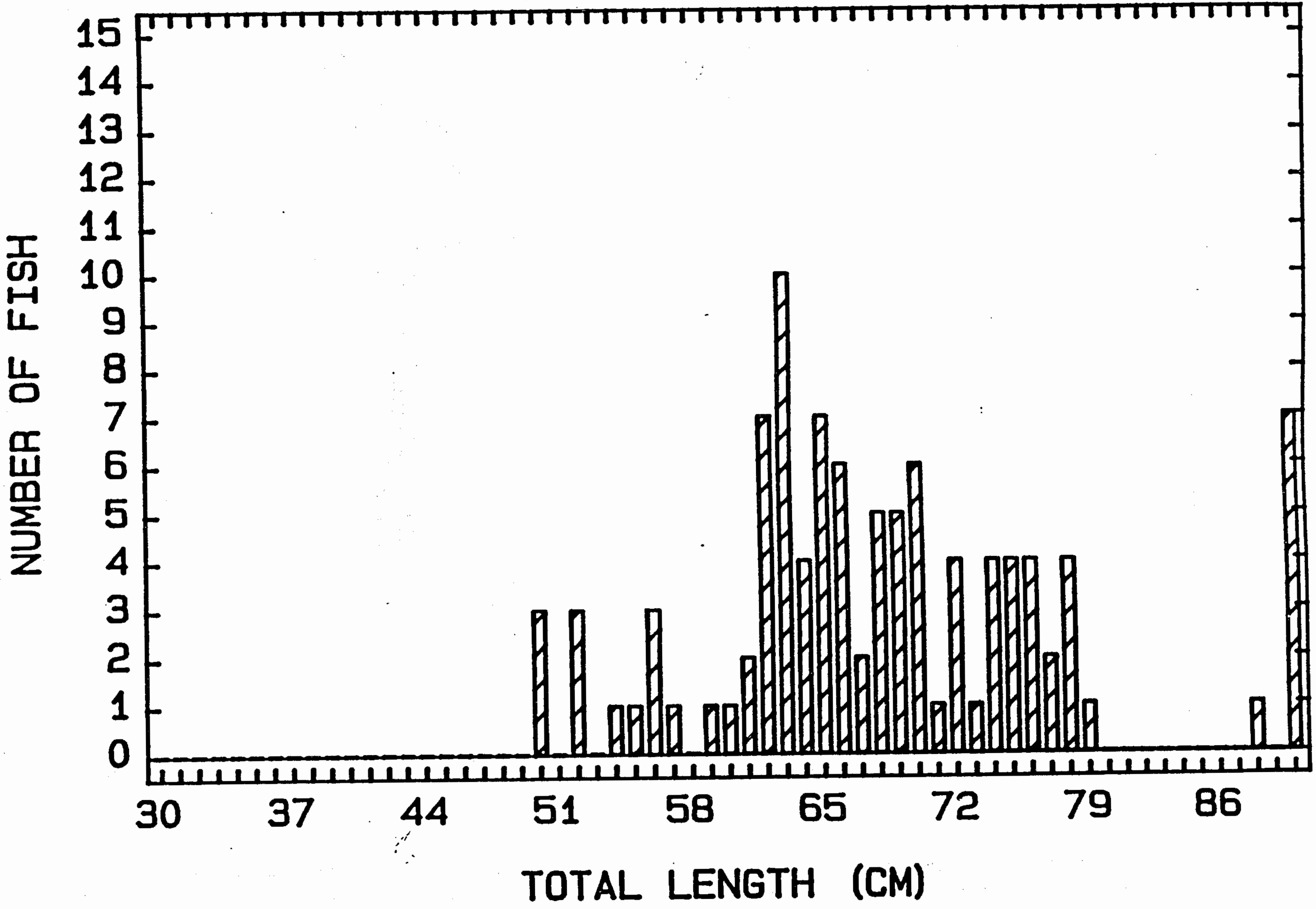


Figure [illegible] Length frequency distribution of yellowfin tuna caught at open water [illegible] during the years 1-3: November 1984 - Octqber 1987 troll fishing test fisheries in American Samoa (n=10).



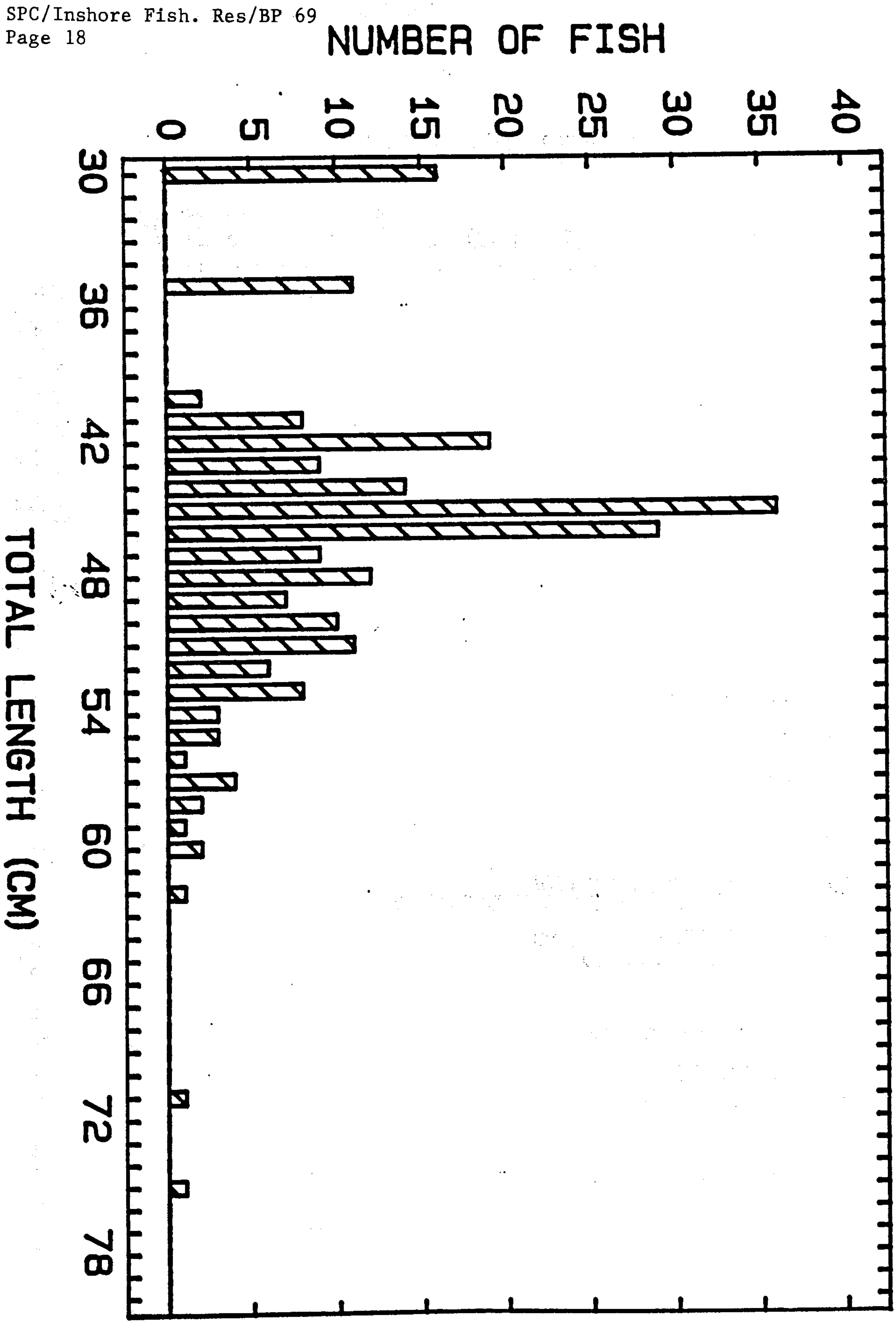


Figure 4 Length frequency distribution of skipjack tuna caught at FAD's during the years 1-3: November 1984 - October 1987 troll fishing test fisheries in American Samoa (n=226).

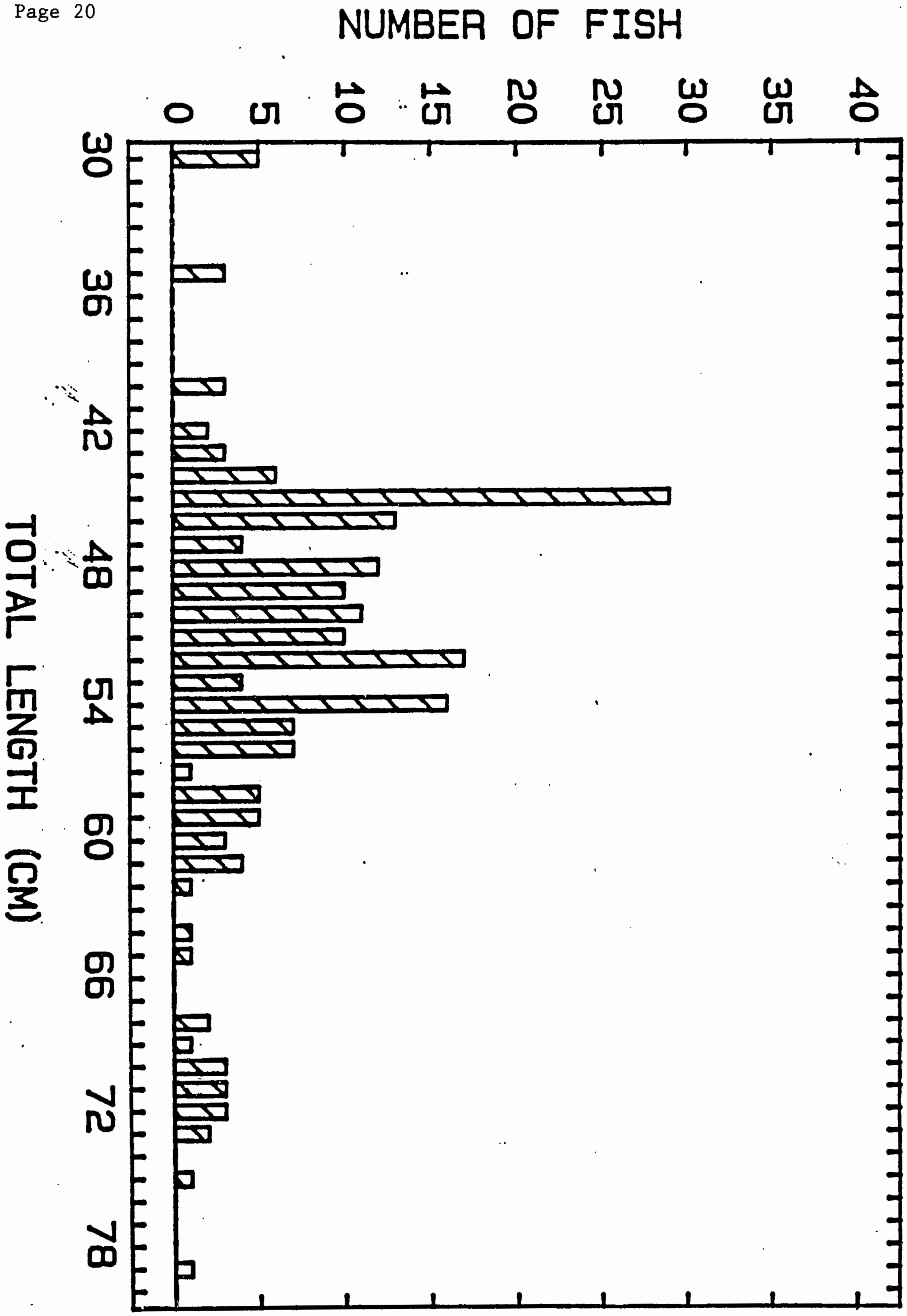


Figure 5 Length frequency distribution of skipjack tuna caught at open-water areas + banks during the years 1-3: November 1984 - October 1987 troll fishing test fisheries in American Samoa (n=200).