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A SOCIOECONOMIC APPRAISAL OF FISH AGGREGATION DEVICES IN HAWAII

Karl C. Samples

University of Hawaii Sea Grant College Program

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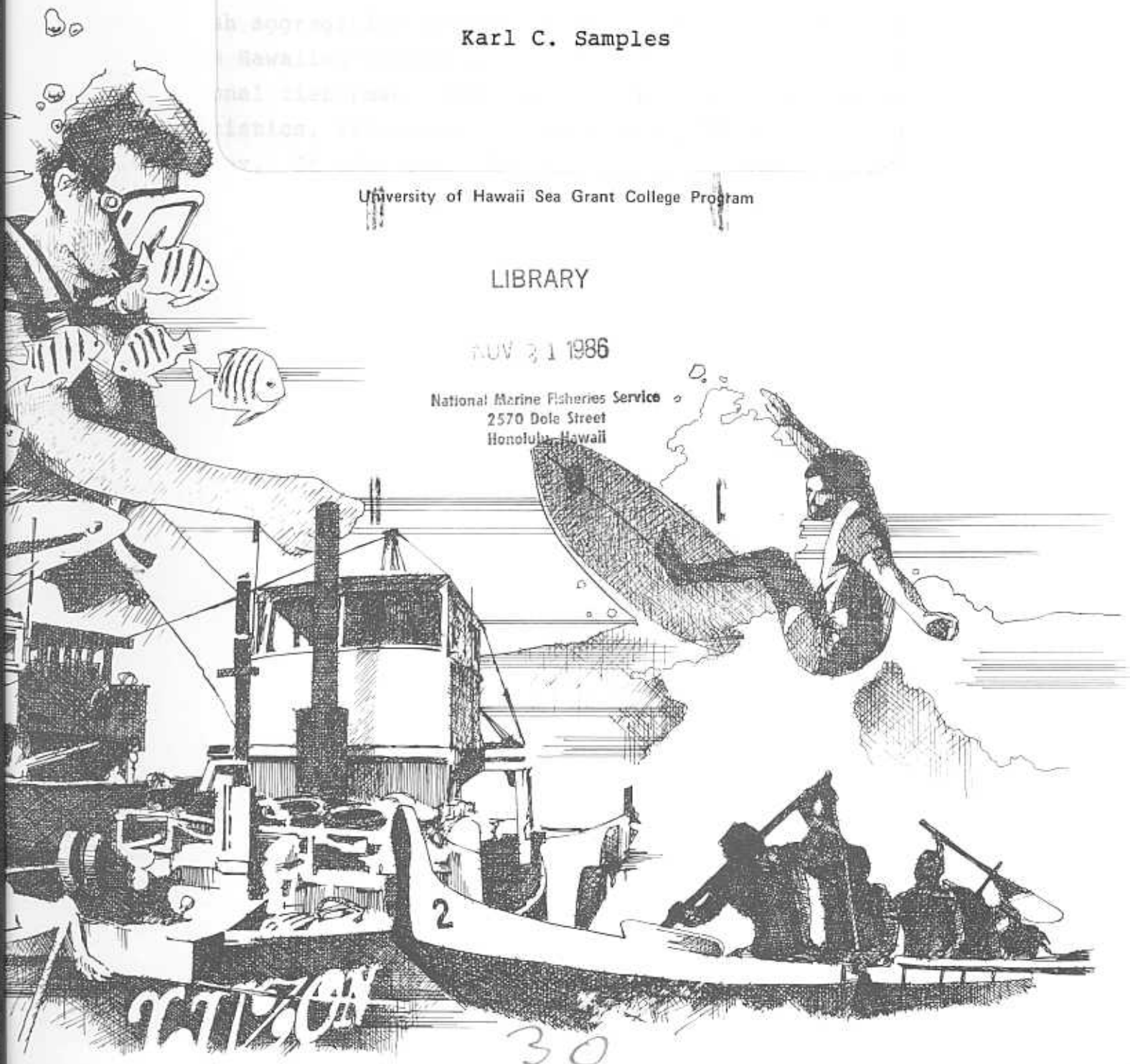

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ABSTRACT

Fish aggregation devices (FADs) have been deployed in nearshore Hawaiian waters for the benefit of commercial and recreational fishermen. This report describes the socioeconomic characteristics, attitudes, and motives of FAD users based on a 1984 survey. It also describes the costs of Hawaii's FAD program and the monetary benefits that accrue to users. The 622 surveyed fishermen made 13,819 visits to FADs, or 26.4 visits each during a 12-month period in 1983-84. An average of 4.4 fish, consisting primarily of various tuna species, were caught per FAD visit. Fishermen generally claimed that fish catch and overall fishing fun were improved around FADs, but they also frequently identified crowding as a detracting factor. Statistically significant differences exist between commercial and recreational fishermen using FADs in terms of their fishing activity, vessel type, catch, and attitudes about the effectiveness of the devices. A benefit-cost analysis of Hawaii's FAD program shows that, on an annual basis, users' willingness to pay for FADs ($184,906) slightly exceeds estimated average annual program costs ($182,000).

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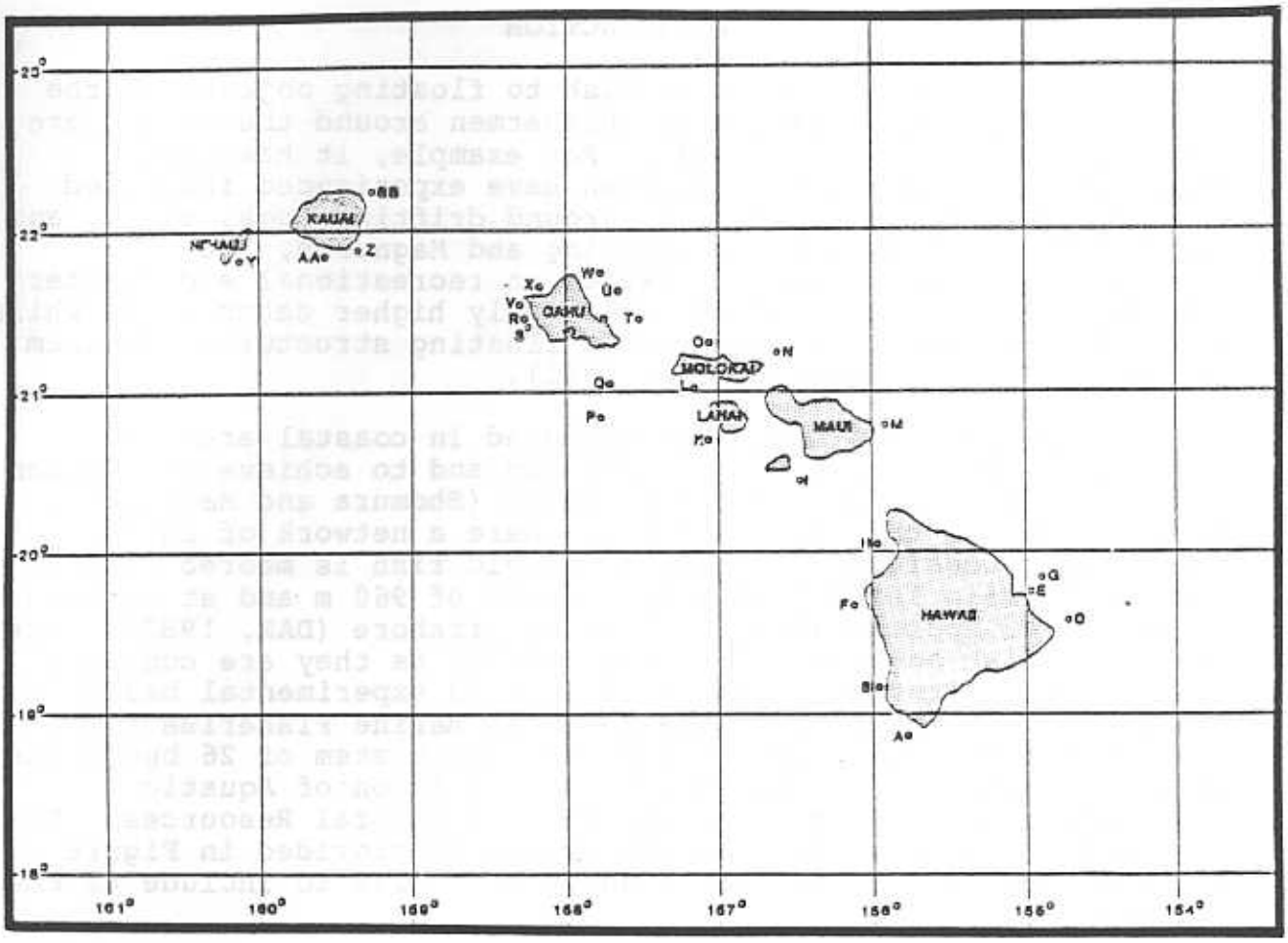
INTRODUCTION

The attraction of pelagic fish to floating objects in the open ocean is well documented. Fishermen around the world have capitalized on this phenomenon. For example, it has been reported that commercial fishermen have experienced increased harvests as a result of fishing around drifting logs, algae, and other free-floating objects (Gooding and Magnuson, 1967; Greenblatt, 1979). Also, fishermen on recreational and charter fishing vessels have realized relatively higher catch rates while fishing in proximity to fabricated floating structures (Wickham et al., 1973; Matsumoto et al., 1981).

Buoys and rafts have been anchored in coastal areas to supplement naturally occurring flotsam and to achieve more human control over fish aggregation behavior (Shomura and Matsumoto, 1982). Such is the case in Hawaii where a network of buoys specifically designed to attract pelagic fish is moored around six of the main islands at a mean depth of 960 m and at varying distances of approximately 8 to 40 km offshore (DAR, 1983). The buoys, or fish aggregation devices (FADs) as they are commonly called, were first deployed in 1977 on an experimental basis by the Honolulu Laboratory of the National Marine Fisheries Service Southwest Fisheries Center. A full-scale system of 26 buoys was deployed beginning in mid-1980 by the Division of Aquatic Resources, Hawaii Department of Land and Natural Resources. The geographic layout of the 26-buoy system is provided in Figure 1. In 1985, the system was nearly doubled in size to include 48 FAD stations.

One purpose of the FAD project was to increase the fishing productivity of commercial and recreational fishermen. In addition, it was anticipated that FAD installation would reduce the fishermen's inputs of time and fuel needed to catch a given quantity of fish. To date, few facts have been assembled about the characteristics of FAD users in Hawaii and the benefits which they derive from fishing around the devices. Scattered information is available about certain small user groups such as charter boat operators (Samples et al., 1984; Samples and Schug, 1985a, 1985b) and pole-and-line tuna fishermen (Sproul, 1984). However, information about the wider population of recreational and commercial fishermen who visit FADs is virtually nonexistent.

The primary objective of this report is to provide baseline documentation concerning the socioeconomic characteristics, attitudes, motives, and user values of fishermen who use FADs in Hawaii. A secondary objective is to provide a comparison between the annual benefits that accrue to fishermen as a result of having access to FADs and the annual costs of the buoy program. It is anticipated that achievement of these objectives will yield information useful for FAD system management in Hawaii, as well as in other localities where FAD deployment is being considered as a fisheries enhancement option.



Source: Division of Aquatic Resources, DLNR (1982)

Figure 1. Geographic Distribution of FADs in Hawaii: 1983-84

SURVEY DESIGN AND FIELDING

Collection of socioeconomic and valuation data is complicated because FAD users in Hawaii are not easily identifiable. Access to FADs is open to anyone willing and able to travel the distance to the site. No special use permits or fishing licenses are required. Licensed commercial fishermen are the only user group required to file reports of fish caught near FADs. However, catch reports filed with the Division of Aquatic Resources are confidential, along with all socioeconomic information included on commercial fishing license applications. Other users, notably recreational and subsistence fishermen, have been asked by the Division of Aquatic Resources to report FAD fishing effort and catch on a voluntary basis. Such voluntary reporting has been sporadic and therefore the data are incomplete.

The best available estimate of the total number of vessels fishing around FADs is from Skillman and Louie (1984). Their 1983 enumeration study of 12,578 registered and documented vessel owners in Hawaii revealed that 1,705 of them fished around FADs.

However, due to survey nonresponse, this figure probably represents a lower-bound estimate. For example, none of Hawaii's 12 pole-and-line tuna boat owners responded to the survey. A reasonable upper-bound estimate can be obtained by extrapolating Skillman and Louie's findings to the population of registered vessel owners in Hawaii. Approximately 72 percent of the respondents used their boats for commercial, recreational, or subsistence fishing purposes. Of these respondents, 35 percent reportedly fished near FADs. By extrapolation, therefore, the population of vessel owners using FADs in recent years could have been as high as 3,170 (0.72 x 0.35 x 12,578).

Lack of existing data sources prompted a mail survey of FAD users to be conducted. A decision was made to draw a sample from the 1,705 vessel owners who identified themselves as FAD users in Skillman and Louie's survey. Use of this sampling strategy was convenient because names and addresses of fishermen who used FADs in 1983 could be readily obtained. The strategy precluded sampling individuals who no longer fished at FADs for whatever reason, as well as those who were planning to use FADs but were not users in 1983. Potential sampling bias due to exclusion of these individuals was deemed unimportant because a sample of active FAD fishermen would likely represent both new and outgoing users.

Determination of the sample size was guided by a concern to represent frequent and infrequent FAD users in correct proportions. Frequency of use was measured in terms of the average number of days per month that fishermen visited FADs. Survey results reported by Skillman and Louie showed that 64 percent of the users fished around FADs 5 days or less per month over the course of a year, while the remaining users averaged over 5 days per month. It was determined that a sample of 682 boat owners would permit 95 percent confidence that the sample proportion of frequent and infrequent FAD users would be the same as that of Skillman and Louie, with an allowable error of 10 percent. The final sample size was thus set at 800 in anticipation of an 85 percent return rate.

A further determination was made to stratify the final sample to account for suspected differences in FAD fishing motivations and behavior between commercially oriented fishermen and recreational fishermen. It was perceived that making this distinction would yield greater insight into how FAD emplacement had affected different types of fishermen. Making the distinction would also indicate whether Hawaii's FAD system should perhaps be modified or reconfigured to better accommodate the fishing needs and practices of special interest groups.

Three different groups of fishermen were identified, based on Skillman and Louie's results. The first group, accounting for 51 percent of the total, included vessel owners who did not sell any of their catch (hereinafter called "recreational" FAD users). Fishermen who sold less than half of their catch (hereinafter

called "mixed" FAD users) comprised the second group, which represented 18 percent of the total. The third group, which comprised 31 percent of the total, were fishermen who reportedly sold over half of their catch (hereinafter called "commercial" FAD users). The 800 fishermen were stratified into three groups to match these percentages using the following procedure. First, the list of 1,705 names and addresses was divided into three sublists according to the commercial orientation of each boat owner. Second, survey participants were selected from each sublist by taking a randomly selected starting point and then selecting every kth name, where the constant "k" varied depending on the number needed to maintain proper sampling proportionality.

The distribution of the randomly selected sample, by island of vessel owner's residence, was as follows: Oahu -- 56 percent, Hawaii -- 27 percent, Maui -- 8 percent, Kauai -- 6 percent, Lanai -- 2 percent, and Molokai -- 2 percent. This sampling proportionality was approximately equal to the geographic distribution of registered vessel owners by island of residence (Skillman et al., 1984). It also was consistent with the relative population size of each island.

A questionnaire was developed to obtain from each respondent information about his or her (1) attitudes about FADs, (2) FAD fishing practices, (3) use rates of different FADs, (4) fish catch at FADs, (5) benefits derived from using FADs, and (6) basic socioeconomic characteristics. The survey instrument was reviewed externally and then pretested using 15 randomly selected FAD users not included in the final sample. A slight modification in format was made to enhance respondent comprehension.

On June 9, 1985, all selected fishermen were mailed the same basic questionnaire (see "Appendix"), a cover letter, and a postage-paid return envelope. After three successive follow-up mailings extending over a 3-month period, cumulative returns reached 691. This represented an overall response rate of 86 percent. However, after discounting for nondeliverable questionnaires and for returns that were blank or incomplete, the response rate dropped to 78 percent (N = 622). No statistically significant differences (at the 0.10 level) were detected in the usable questionnaire response rates for recreational (74 percent), mixed (77 percent), and commercial (83 percent) FAD users.

STATISTICAL PROFILE OF FISH AGGREGATION DEVICE USERS

Survey data revealed that FAD users in Hawaii come from diverse socioeconomic backgrounds. Respondents' ages, for example, ranged from 19 to 80 years, and their annual household income levels varied from less than $4,000 to over $48,000. In terms of occupational backgrounds, farmers, office workers, attorneys, and construction workers were included in the ranks of

those fishermen who visited Hawaii's FADs during 1983-84. Retirees comprised 15 percent of the sample group.

Despite the vast differences in types of FAD fishermen, the following typical characterization emerges. The typical user is a 43-year-old male with a high school education, along with some college training. More than likely he is a skilled worker or a self-employed businessman with an annual household income exceeding $30,000. The typical FAD fisherman is thus in the top 35 percentile income bracket for the state of Hawaii as a whole (DPED, 1985). This profile is quite similar across recreational, mixed, and commercial FAD users.

Total years of offshore fishing experience for individuals ranged from 1 to 76 years. FAD users who responded to the survey averaged 12 years in Hawaii waters up to the time of the survey. The group of mixed FAD users averaged 10.7 years, which was statistically different (at the 0.10 significance level) from that of recreational and commercial FAD users who averaged 12.5 and 12.1 years, respectively. Roughly a fifth of all respondents began offshore fishing since the deployment of the large-scale FAD system in 1980. It could not be determined from the survey results whether the existence of FADs was a factor encouraging these individuals to participate in offshore fishing. For example, a simple user turnover rate of 5 percent would give a similar outcome.

The number of years of FAD fishing experience for survey respondents varied (Figure 2). The average for all respondents was 3.6 years. This implies that the typical user participated in offshore fishing for 7.4 years (12 total years of experience minus 3.6 years at FADs) before the buoy system was deployed. A majority (63 percent) of users had been fishing around Hawaii FADs since 1982, but only 11 percent since the initial deployment on an experimental basis in 1977. No statistically significant differences (at the 0.10 level) could be detected in years of FAD fishing experience among the three groups.

The composition of Hawaii's FAD fishing fleet reflects a predominance of relatively small-sized trailerable boats with short fishing ranges. Boats used by respondents to visit FADs ranged from 10 to 62 m in length, but most were in the 18 to 27-m range and the average was 20 m. Approximately 6 percent of the respondents used boats over 27 m in length. Of these larger boats, 68 percent were owned by commercial fishermen.

Most vessels were powered either by inboard gasoline engines (40 percent) or by outboard gasoline engines (45 percent) with a mean horsepower of 151. Recreational fishing boats tended to be equipped with outboard gasoline engines with lower horsepower than those used by commercial fishermen. Commercial fishing boats were more frequently powered by inboard gasoline or diesel engines.

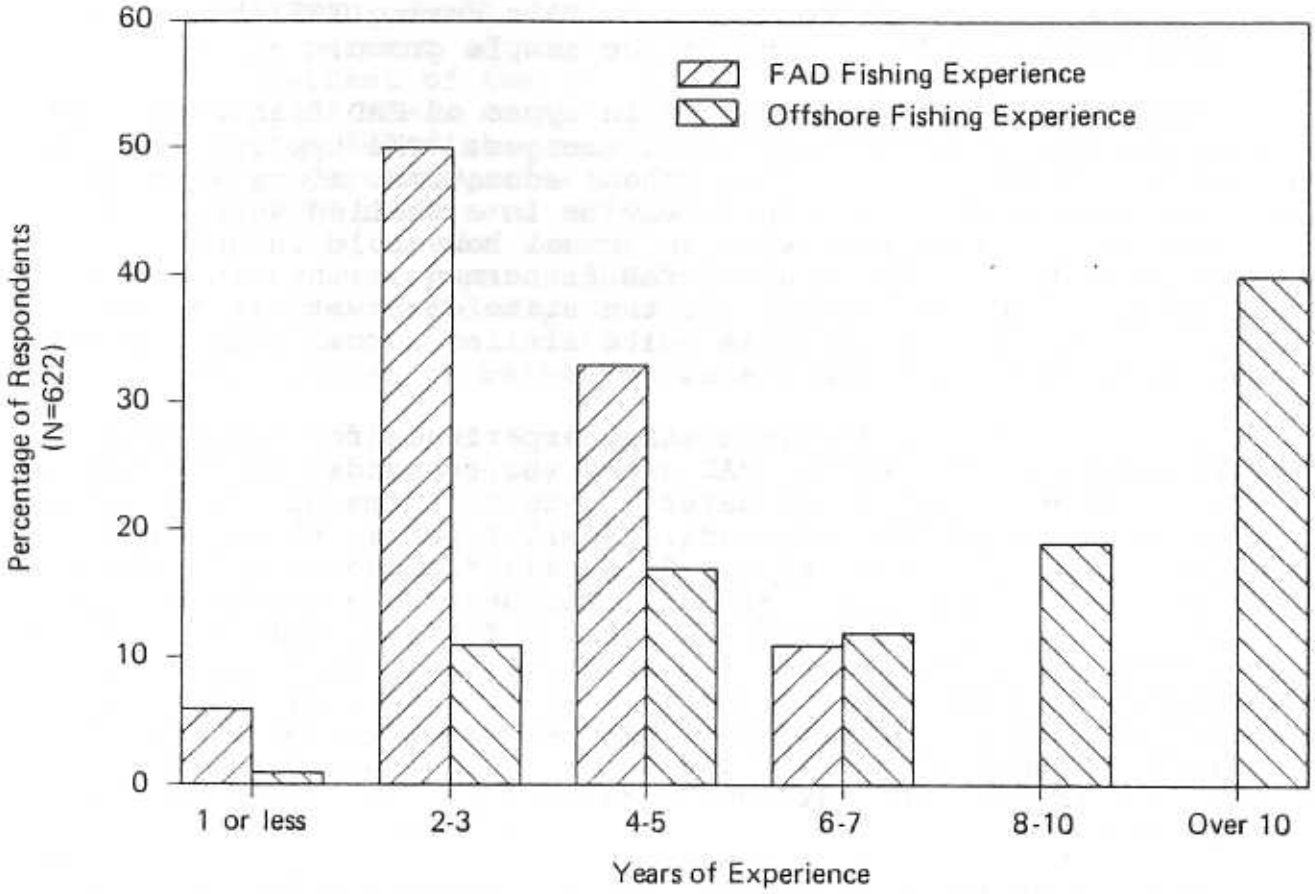


Figure 2. Years of Offshore and FAD Fishing Experience for all Survey Respondents

Overall, vessels were similarly equipped with navigation, communication, and electronic fishing equipment. Almost all FAD fishing boats (94 percent) had a two-way radio and compass. Depth-finders were installed on 57 percent of the boats. Nineteen percent of the respondents indicated that they fished with the aid of electronic fish finders. In terms of sophisticated electronic navigation equipment, only 3 percent of the respondents had Loran and 1 percent utilized radar.

In view of the predominance of relatively small vessels and engines used by FAD fishermen, it was not surprising to find that most respondents confined their offshore fishing excursions to within eyesight of land. There were, however, important exceptions to this general rule. In order to better understand fishermen's willingness to travel offshore to visit FADs, questions were asked about the normal and farthest distance traveled from shore. Although FAD fishermen normally fished at an average distance of 16 km from shore (range was from 1.5 to 967 km), 45 percent of the respondents reported that they normally fished within 8 km from shore. No statistically significant difference (at the 0.10 level) was detected for average distances traveled from shore among the three groups of FAD users. In terms of the

farthest distance from shore fished, the range for all respondents was from 2 to 1,129 km, with the average being 45 km. Commercial fishermen tended to venture significantly farther out to sea. On the average, they reported maximum fishing distance traveled from shore of 53 km, as compared with 45 km for recreational and mixed FAD users. Furthermore, only 10 percent of the commercial fishermen indicated that they traveled no farther than 16 km from shore, as compared with 27 percent of the recreational FAD users.

About one out of every four respondents indicated that they had changed their fishing frequency since FADs were deployed in 1980. A few fishermen reported that they were fishing less frequently, but a greater number indicated that they were fishing more (Table 1). A large majority, however, reported that they have not changed their frequency of fishing, perhaps owing to external constraints on available free time. Statistically significant differences (at the 0.10 level) were observed in responses to this question across the three groups under study. The mixed group contained the largest percentage of fishermen who fished more frequently since FADs were installed. Also, compared with recreational fishermen, commercial fishermen reported fishing more frequently.

TABLE 1. EFFECTS OF FADS ON FISHERMEN'S FREQUENCY OF OFFSHORE FISHING TRIPS: BY COMMERCIAL ORIENTATION OF SURVEY RESPONDENTS

	% of All Respondents (N=622)	% of Recreational Users (N=278)	% of Mixed Users (N=138)	% of Commercial Users (N=206)
Fishing Less Since FADs Installed	2	2	2	1
Fishing More Since FADs Installed	24	19	32	25
Fishing the Same Since FADs Installed	72	76	64	72
No Response	2	3	2	1
Total	100	100	100	99*

*Deviation from 100% due to rounding error

FAD Visitation Practices

Conceivably, a fisherman could have visited at least one FAD on every fishing trip. However, survey data show that 64 percent of all respondents visited FADs on one-half or less of their offshore trips (Table 2). A "visit" as used here is defined as a

period of time, of unspecified duration, spent fishing within 0.8 km of a FAD. Approximately a third of the respondents visited FADs on 20 percent or less of their offshore fishing trips. These fishermen nearly balance in number those who fished around FADs during 51 percent or more of their fishing trips. Only 4 percent of all respondents visited FADs on every fishing trip. No statistically significant differences (at the 0.10 level) were detected in FAD use rates, as a proportion of total fishing trips, across the three groups.

TABLE 2. FREQUENCY OF FISHING TRIPS MADE TO FADS AS A PERCENTAGE OF TOTAL TRIPS

% of Total Trips	% of All Respondents (N=622)
Less Than 10	18
10-20	16
21-30	10
31-40	8
41-50	12
51-60	11
61-70	3
71-80	7
81-90	6
91-99	3
100	4
No Response	2
Total	100

The number of individual FADs visited during 1983-84 was quite large even though fishermen generally do not visit a FAD on every trip. Overall, respondents reported visiting Hawaii's FADs 13,819 times during 1983-84, or an average of 26.4 visits per

respondent annually. These figures include visits to a number of different FADs during a single offshore fishing trip. The annual number ranged from 1 to 720 visits for the 523 respondents who provided information on FAD visitation practices (Table 3). The median number was 15 and the mode was 6. Approximately 40 percent of the total sample group reportedly made 10 or less FAD visits during the 12-month period prior to the survey.

TABLE 3. FREQUENCY OF INDIVIDUAL FAD VISITS MADE DURING 1983-84: BY COMMERCIAL ORIENTATION OF SURVEY RESPONDENTS

Number of Fad Visits Made	% of All Respondents (N=523)	% of Recreational Users (N=229)	% of Mixed Users (N=123)	% of Commercial Users (N=171)
1-10	39	47	31	34
11-20	23	23	23	23
21-30	14	14	15	14
31-40	6	6	3	7
41-50	6	4	11	5
51-100	9	6	11	11
101-150	1	0	3	2
Over 150	2	0	3	4
Total	100	100	100	100

A statistical analysis was conducted to determine if frequent and infrequent FAD users shared similarities in terms of vessel types and years of fishing experience. Respondents who made 29 or more FAD visits were designated as "heavy" users; those who visited 6 or fewer FADs were classified as "light" users. Heavy and light users each comprised 25 percent of all respondents -- for a total of 50 percent of all respondents. However, heavy users accounted for 67 percent of total FAD visits and light users only 4 percent.

Statistically significant differences (at the 0.10 level) existed between mean boat length and engine horsepower for the two groups. Vessels of heavy FAD users were, on the average, 16 percent longer than those of light FAD users and were powered by 11 percent greater horsepower. Differences also existed in terms of years of fishing experience. Light FAD users tended to have less total offshore fishing experience and less experience

fishing at FADs. Heavy users were more likely to have increased their fishing activity because of FADs. Heavy users also visited FADs on a significantly larger proportion of their total trips.

Recreational fishermen had a FAD visitation rate (17.8 times annually) that was significantly lower than averages for the other two groups. The mixed user group averaged the highest FAD use rate (37.1 visits annually), followed by commercial fishermen (31.5 visits annually, on the average). It is suspected that differences in the number of FAD visits made by the three groups simply reflect the fact that commercially oriented fishermen fish more often than recreational fishermen. This supposition is based on the finding, stated above, that fishermen tend to use FADs on a roughly equal proportion of their total fishing trips, regardless of commercial status.

Use of FADs varied among respondents depending on their island of residence. Fishermen residing on Oahu made 60 percent of the total statewide FAD visits, followed by Hawaii-based fishermen with 22 percent. Users on each of the other islands made less than 10 percent of the total number of trips. In large part, this is due to the geographic distribution of the survey sample. Average use per respondent, however, was highest for Maui (31 trips), followed by Oahu (28 trips), Kauai (27 trips), Hawaii (23 trips), Lanai (13 trips), and Molokai (9 trips).

A count was made of the total number of different FADs that surveyed fishermen visited during the 12-month period prior to the survey. Each fisherman visited 2.4 different FADs, on the average. Eighty-five percent visited less than 3 different FADs. Nearly all (99 percent) fished at less than 6 different FADs.

Results of pairwise t-tests support the hypothesis that commercially oriented fishermen visited significantly more FADs than recreational fishermen did. The group of mixed fishermen visited 14 percent more individual FADs than did the group of recreational fishermen, who visited the fewest number. Commercial fishermen also fished at statistically significantly (at the 0.10 level) more FADs than did recreational fishermen, but the difference amounted to only 10 percent. Overall, these results suggest that, compared with recreational fishermen, commercially oriented fishermen tend to be wider ranging in their FAD visitation practices.

The surveyed fishermen were queried concerning the months of the year that their FAD usage was heaviest. The results are summarized in Figure 3. Overall, fishermen visited FADs most frequently during May, June, July, and August. This summer period coincides with the relative increased availability of target pelagic fish. It is also a popular vacation period. The next most important months in terms of heavy FAD usage were November, December, and January. Attraction of fishermen to FADs during this period is probably motivated by high commercial dockside

fish prices during the holiday season. Compared with recreational and mixed fishermen, commercial fishermen use FADs throughout the year more regularly. However, commercial fishermen still report periods of peak FAD usage during summer and winter months. This probably reflects the part-time nature of commercial fishing as an occupation in Hawaii.

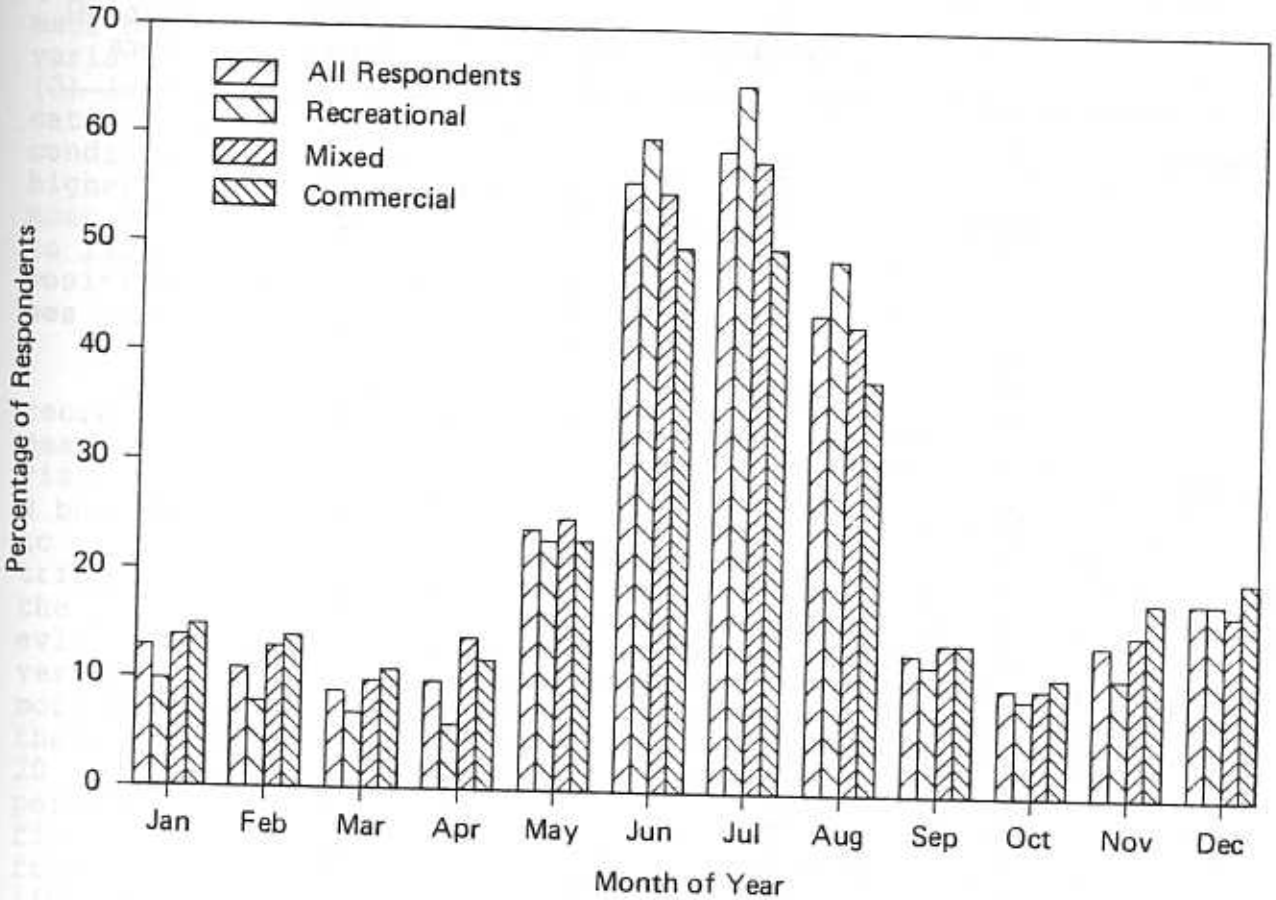


Figure 3. Months of Year Indicated by Respondents as Being Periods of Relatively Frequent FAD Visits

Fishermen's visitation rates for various FADs appeared also to differ. As shown in Table 4, certain FADs seem to attract relatively more fishermen than others. However, this varied according to type of fishermen. A summary of the percentage of total trips made by the three groups to various FADs is also given in Table 4. Overall, the most frequently visited FADs were the R, S, T, U, and V buoys -- all anchored around Oahu. Fishing pressure at these five FADs amounted to 51 percent of all visits reportedly made by the respondents. Other popular FADs were the F, G, and OTEC buoys off the island of Hawaii and the K buoy off the island of Lanai.

TABLE 4. PERCENTAGE OF TOTAL TRIPS TAKEN TO VARIOUS FADS DURING 1983-84: BY COMMERCIAL ORIENTATION OF SURVEY RESPONDENTS

County	FAD ID*	% of Total Trips†			
		All Respondents	Recreational Users	Mixed Users	Commercial Users
HAWAII	A	§	§	2	§
	B	3	1	2	6
	OTEC	4	3	4	6
	ZZ	§	1	0	§
	D	§	§	§	1
	E	2	2	2	3
	F	6	4	5	9
	G	5	2	7	7
	H	2	3	3	§
MAUI	I	2	2	0	2
	K	5	3	0	11
	L	§	0	1	1
	M	§	§	0	§
	N	2	§	0	4
	O	§	§	0	2
HONOLULU	P	2	2	2	2
	Q	§	1	0	1
	R	12	20	11	6
	S	11	19	11	5
	T	7	4	12	5
	U	9	6	13	7
	V	12	19	12	6
	W	5	2	6	6
	X	2	3	1	2
KAUAI	Y	§	0	§	0
	Z	2	2	2	3
	AA	2	1	3	1
	BB	3	§	1	5

*See Figure 1 for FAD locations

†Total trips for the sample group during 1983-84 are as follows: all respondents - 13,819 trips; recreational users - 4,080 trips; mixed users - 4,412 trips; and commercial users - 5,327 trips.

§Less than 1 percent

Exact reasons for the high use rates of certain FADs could not be determined from the survey data, but proximity to population centers is undoubtedly relevant. Nearly all (98 percent) FAD visits were made to buoys anchored off the fishermen's island of residence. This explains why FADs anchored off Oahu received the highest overall visitation rates. Maui-based fishermen were the most willing to travel to other islands to fish at FADs; they reportedly made trips to Hawaii and Oahu for this purpose. However, these trips amounted to only 5 percent of all FAD visits made by Maui residents. Other factors that may help explain variances in use rates include: (1) proximity to launch ramps; (2) level of difficulty in locating at sea; (3) prevailing fish catch rates, sizes, and types; and (4) general weather and sea conditions during the summer months when fishing pressure is highest. All other things being equal, FADs which were visited most frequently were located near population centers, were close to launch ramps, were easy to locate by fishermen, and were positioned on the leeward side of islands where generally calm sea conditions prevail during the summer months.

Visitation rates to individual FADs also differed among recreational, mixed, and commercial user groups. This is measured by observed differences in the proportion of total visits made by each group to the various FADs. For example, the B buoy was used more frequently by commercial fishermen relative to recreational users. Six percent of the commercial group's trips were made to the B buoy, as compared with only 1 percent of the recreational group's trips. A somewhat similar situation was evident for trips to the OTEC, F, K, W, and BB buoys. Conversely, the R, S, and V buoys off Oahu were visited relatively more frequently by recreational fishermen as a proportion of their total FAD fishing trips. For example, the R buoy received 20 percent of the recreational fishermen's FAD visits, but only 6 percent of those of the commercial fishermen. The group of mixed fishermen used the T and U buoys off Oahu with relatively greater frequency than either of the other two groups. This is probably linked to the proximity of these two buoys to windward Oahu launch ramps.

Visitation practices were also investigated. The surveyed fishermen were asked when during their most recent offshore fishing trip had they visited a FAD. A practice of many fishermen (64 percent), regardless of commercial fishing orientation, was to visit FADs at the beginning of their fishing trip (Table 5). Twenty-three percent made visits only at the beginning of their trip and 9 percent only at the end. Multiple FAD visits during a single trip were made by 28 percent of the respondents. Survey data showed that 19 percent used FADs at both the beginning and end of their trips. Very few fishermen fish at the beginning, middle, and end of their trips.

TABLE 5. FISHERMEN'S USE OF FADS DURING VARIOUS STAGES OF LAST OFFSHORE FISHING TRIP: BY COMMERCIAL ORIENTATION OF SURVEY RESPONDENTS

	% of All Respondents (N=622)	% of Recreational Users (N=278)	% of Mixed Users (N=138)	% of Commercial Users (N=206)
FAD Visited at Start of Last Trip				
Yes	64	58	69	68
No	34	39	31	31
No Response	2	3	0	1
FAD Visited at End of Last Trip				
Yes	34	38	31	29
No	65	59	69	70
No Response	2	3	0	1
FAD Visited Several Times During Last Trip				
Yes	28	24	32	32
No	70	73	68	67
No Response	2	3	0	1

Statistically significant differences (at the 0.10 level) were detected in FAD fishing strategies among groups. Compared with recreational fishermen, commercial and mixed fishermen tended (1) to fish at FADs during the early phases of their trips and (2) to visit FADs several times during the course of a trip. One explanation for this behavior is that commercially oriented fishermen who troll for pelagic fish proceed more directly to FAD locations where live baitfish (small tunas) are found. Visits to FADs during the beginning of a trip could also be a way to reduce the downside risk of a zero-catch trip.

Certain FADs tend to be visited more often during the beginning, middle, or end of users' fishing trips. This appears to be closely related to the proximity of the buoy to ports and boat launch areas and accessibility vis-a-vis other buoys. For example, the S buoy is near the Pokai Bay Small Boat Harbor. It was fished frequently at the beginning and end of trips. In contrast, the V buoy was typically visited at the end of most trips, most probably because it is the farthest buoy routinely fished by boats departing from Pokai Bay. The P buoy, located at a considerable distance from other buoys and ports, was fished during the middle of trips only.

The survey data show that a majority of the respondents visited two or more FADs during their last trip (Table 6). Multiple buoy use was significantly higher (at the 0.10 level) for recreational fishermen than for commercial fishermen. The recreational fishermen's willingness to visit a number of FADs during a trip is understandable in view of the sporting nature of

their activity. Commercial fishermen on the other hand, generally have to be more cost conscious. Furthermore, they may have more information about fishing conditions at certain FADs and therefore do not have to spend as much effort visiting several FADs to learn about the types and quantities of fish being caught.

TABLE 6. NUMBER OF FADS VISITED BY FISHERMEN DURING LAST OFFSHORE FISHING TRIP: BY COMMERCIAL ORIENTATION OF SURVEY RESPONDENTS

No. of Fads Visited	% of All Respondents (N=622)	% of Recreational Users (N=278)	% of Mixed Users (N=138)	% of Commercial Users (N=206)
1	45	32	50	56
2	40	45	37	35
3	15	20	13	9
4	*	3	0	0
Total	100	100	100	100

*Less than 1%

Certain FADs tended to be visited in sequence more often than others. Included in this group are the OTEC, D, and E buoys off the island of Hawaii; the R, S, T, V, W, and X buoys off Oahu; and the Z buoy off Kauai. It appears that FADs located close to one another tended to be fished in sequence. Also, FADs which are situated between a port and a popular non-FAD offshore fishing area tended to be visited in conjunction with other similarly placed devices.

On the average, respondents spent about 2.5 hours fishing in proximity to FADs during their most recent fishing trip that involved a FAD visit. This time represented about a third of the 8 hours reportedly spent for their entire fishing trip (Table 7). The range of time spent at FADs was from 0.20 to 12 hours. A series of pairwise t-tests were constructed to test for differences in the average FAD fishing times for the three groups under study. The results support the hypothesis that recreational fishermen spend relatively less time fishing around FADs compared with commercially oriented fishermen. No statistically significant difference (at the 0.10 level) could be found in average fishing time for mixed and commercial FAD users.

TABLE 7. TIME SPENT ON MOST RECENT FISHING TRIP IN TOTAL AND WHILE FISHING IN PROXIMITY TO FADS: BY COMMERCIAL ORIENTATION OF SURVEY RESPONDENTS

	All Respondents (N=591)	Recreational Users (N=261)	Mixed Users (N=132)	Commercial Users (N=198)
Total Hours Spent on Most Recent Fishing Trip*	8.01 (17.17)†	6.20 (5.22)	7.80 (7.00)	10.55 (28.34)
Hours Spent Fishing Near FADs on Most Recent Fishing Trip	2.49 (2.06)	2.22 (1.66)	2.60 (2.33)	2.77 (2.31)
Ratio of Total Fishing Time to FAD Fishing Time	0.31	0.36	0.33	0.26

*Includes transit time to and from fishing areas
†Values in parentheses are sample standard errors

Information was also obtained about the type of fishing techniques employed during the most recent FAD fishing trip taken by respondents. Nearly all (95 percent) of the respondents reported that they trolled. Twenty-six percent engaged in drift fishing or handlining, and 13 percent cast jigs or live bait near FADs. Fifty-two percent of all the fishermen surveyed used only one method; the rest indicated that they used a combination of methods such as trolling and handlining. Seventeen percent said they used three fishing methods. Fishing techniques used by the three groups differed significantly at the 0.10 level. Commercial and mixed fishermen were less inclined to troll relative to recreational fishermen; they more commonly used handline techniques.

User Attitudes and Motives

The survey provided an opportunity to better understand fishermen's attitudes about Hawaii's FAD system and about their motives for visiting FADs. In addition, it was anticipated that insights about the social value of FADs could be ascertained from a broader understanding of users' attitudes and motives. Toward this end, fishermen were first asked to compare the quality of fishing in proximity to FADs with the quality of offshore fishing away from FADs. Respondents were exposed to six different quality indicators and asked to rank each on a three-point scale: "quality better at FADs," "no difference in quality," and "quality worse at FADs." The exact wording of the question can be found in the "Appendix."

A clear majority (70 percent) of the respondents reported that overall fishing fun was of higher quality when fishing near FADs (Table 8). This is probably related to the fact that an almost equal percentage of fishermen thought that fish catch was higher while fishing around FADs. Only 3 percent felt that FAD fishing was inferior to non-FAD fishing in terms of overall fishing fun and number of fish caught. In terms of size and types of fish caught, many respondents believed that FAD fishing either offered no difference in quality or was inferior. The only factor that most respondents reported as being worse was crowding. Seventeen percent of all respondents also indicated that the distance they traveled for fishing was worse for FAD trips.

TABLE 8. FISHERMEN'S ATTITUDES ABOUT THE QUALITY OF FISHING NEAR FADS AS COMPARED WITH OFFSHORE FISHING AWAY FROM FADS

Quality Factor	% of All Respondents (N=622)				
	Better At Fads	No Difference	Worse At Fads	No Response	Total
Overall Fishing Fun	70	23	3	5	101*
Number of Fish Caught	69	23	3	5	100
Size of Fish Caught	31	54	7	8	100
Types of Fish Caught	49	39	4	8	100
Crowding	15	18	60	6	99*
Distance Traveled Before Fishing	41	34	17	8	100

*Deviation from 100% due to rounding error

In general, no statistically significant differences (at the 0.10 level) were observed in responses to these attitudinal questions for the three groups, except for the distance factor. Significantly more commercial and mixed fishermen rated the quality factor, "distance traveled before fishing," as being better at FADs. This appears to be consistent with the finding that commercially oriented fishermen tended to visit FADs at the beginning of their trips. They also tended to spend less time traveling between FADs during the course of a fishing trip.

Respondents were further asked to indicate whether they agreed, disagreed, or had no opinion about a series of five general statements concerning FAD locations, numbers, and productivity. The results, summarized in Table 9, indicate that 35 percent of the respondents felt that FADs are located too far from shore, whereas 15 percent believed that FADs are too close. Presumably, the remaining respondents, amounting to a simple majority, are satisfied with FAD locations. Response to the crowding question verified that a large majority felt that FADs are getting more crowded. The crowding problem could likely explain why 9 out of 10 fishermen agreed that more FADs are needed.

TABLE 9. FISHERMEN'S ATTITUDES ABOUT FAD LOCATIONS, NUMBERS, AND PRODUCTIVITY

Statement	All Respondents (N=622)				
	% Agree	% Disagree	% No Opinion	% Blank	Total
FADs Are Too Far From Shore	35	47	15	3	100
FADs Are Getting Crowded	78	11	9	2	100
FADs Have Made My Fishing More Productive	58	16	23	2	99*
FADs Are Too Close to Shore	15	61	20	4	100
More FADs Are Needed	87	4	8	2	101*

*Deviation from 100% due to rounding error

A series of statistical tests were conducted to measure whether the three groups shared similar attitudes about FAD locations, numbers, and productivity (Table 10). The results suggest that statistically significant differences (at the 0.10 level) exist in attitudes about crowding and FAD locations. Commercially oriented fishermen, as compared with recreational fishermen, generally felt that FADs are placed too close to shore. Furthermore, commercial and mixed fishermen appeared to

TABLE 10. STATISTICAL TESTS OF RELATIONSHIP BETWEEN COMMERCIAL ORIENTATION OF FAD USERS AND THEIR ATTITUDES ABOUT FAD LOCATIONS, NUMBERS, AND PRODUCTIVITY

Statement	Recreational Users			Mixed Users			Commercial Users			Calculated Chi-Square Statistic
	% Agree	% Disagree	% No Opinion	% Agree	% Disagree	% No Opinion	% Agree	% Disagree	% No Opinion	
Most FADs Are Too Far From Shore	40	41	19	33	54	13	33	54	12	11.2*
FADs Are Getting More Crowded	75	14	11	84	9	7	85	9	6	7.3*
FADs Have Made My Fishing More Productive	56	18	26	56	20	24	65	13	22	5.6
Most FADs Are Too Close To Shore	9	69	22	16	64	20	23	56	21	18.4*
More FADs Are Needed	91	3	6	87	4	9	86	5	9	2.8

*Significant at 0.1 level

be more concerned about the increased crowding problem at FAD locations.

Fishermen's reasons for using FADs were studied by determining their motives for making their last FAD visit. Overall, a majority were motivated by the improved chances of catching fish and other catch-related factors such as past fishing success at FADs (Table 11). Ease of locating a good fishing spot motivated

TABLE 11. FACTORS MOTIVATING FISHERMEN TO VISIT A FAD DURING LAST FISHING TRIP: BY COMMERCIAL ORIENTATION OF SURVEY RESPONDENTS

Motivating Factor	% of Respondents Indicating Motivating Factor Was Important			
	All Respondents (N=622)	Recreational Users (N=278)	Mixed Users (N=138)	Commercial Users (N=206)
Better Chance to Catch Fish	65	63	74	62
Easy to Locate	31	31	33	29
Reports of Good Fishing	51	50	54	51
Past Experience at FADs	54	46	59	62
Save on Costs	16	9	21	23
Opportunity to Fish by Other Boats	3	3	2	2

roughly a third of the respondents, regardless of their commercial orientation. In general, respondents from all groups rated each motivating factor similarly. However, statistically significant differences (at the 0.10 level) were observed between commercial and noncommercial fishermen regarding cost-savings motives. Apparently, recreational FAD users deemed cost-savings potential less important than commercial users did.

Fishermen's attitudes about the impact of FADs on fishing costs were explored in a series of questions where respondents compared the cost of fishing in proximity to FADs vis-a-vis fishing away from FADs. The surveyed fishermen were asked to consider costs for fuel, oil, fishing gear, ice, and bait. They generally felt that costs associated with fishing gear replacement, ice, and bait were not affected by FAD use (Table 12). Those who reported these costs as being reduced were counterbalanced by others who thought the costs were increased. Less consensus existed with regard to fuel cost. Overall, more respondents felt that their fuel costs were reduced, but 36 percent indicated no change. Statistically different (at the 0.10 level) responses to the fuel and bait cost questions were provided by commercial, mixed, and recreational fishermen (Table 13). Relatively more commercial and mixed fishermen tended to think that FADs usage had decreased fuel costs compared with recreational fishermen. This difference in outlook may be directly related to the tendency of recreational fishermen to

TABLE 12. FISHERMEN'S ATTITUDES ABOUT THE EFFECT OF FADS ON FISHING COSTS PER TRIP

Trip Cost Item	All Respondents (N=622)				Total
	% Increased	% No Change	% Decreased	% No Response	
Fuel	18	36	43	4	101*
Oil	12	48	34	7	101*
Fishing Gear	6	75	13	6	100
Ice	9	73	12	6	100
Bait	14	63	17	7	101*

*Deviation from 100% due to rounding error